Summary and Analysis of Comments on the Notice of Proposed Rulemaking for Revised Gaseous Emission Regulations for 1984 and Later Model Year Light-Duty Trucks and Heavy-Duty Engines

July 1983

Standards Development and Support Branch
Emission Control Technology Division
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I. Introduction

On January 13, 1982, the Environmental Protection Agency (the Agency) published a Notice of Proposed Rulemaking (NPRM) in which the Agency considered revised gaseous emission regulations for 1984 and later model year light-duty trucks and heavy-duty engines. Although the major thrust of this action was to propose non-catalyst emission standards for heavy-duty engines, the Agency also requested and received comment on a large number of other issues related to the 1984 emission control requirements for light-duty trucks and heavy-duty engines.

To seek further clarification and comment on issues raised by the initial NPRM, several opportunities were offered for comment, including a further request for comments published in the *Federal Register* on March 12, 1982. A final rule was published in January 1983. Also, to achieve final resolution on the useful-life requirement, a further NPRM on the 1985 light-duty truck and heavy-duty engine useful-life requirements was published in January 1983.

This document presents a Summary and Analysis of Comments received in response to the NPRM and the subsequent requests for comment mentioned above. The useful-life discussion presented as Primary Issue 2 serves as the study of the useful-life requirements discussed in the *Federal Register* Notice of April 13, 1981. The transient test study undertaken as a result of the same *Federal Register* notice is included as Appendix B.

II. List of Commenters

1. American Motors Corporation (AMC)
2. Caterpillar Tractor Company
3. Chrysler Corporation
4. Cummins Engine Company
5. Engine Manufacturers Association (EMA)
6. Ford Motor Company
7. Freightliner Corporation
8. General Motors Corporation (GM)
9. U.S. Senator Gary Hart
10. Hino Motors, Limited
11. International Harvester Company (IHC)
12. League of Women Voters of Carson City, Nevada
13. League of Women Voters of the Doyleston Area
14. League of Women Voters of the United States
15. Mack Trucks, Inc.
16. Manufacturers of Emission Controls Association (MECA)
17. Mercedes-Benz of North America (MB)
18. Mrs. W. H. Morse
19. Motor Vehicle Manufacturers Association (MVMA)
20. National Association of Van Pool Operators (NAVPO)
21. National Automobile Dealers Association (NADA)
22. Natural Resources Defense Council (NRDC)
23. New York City League of Women Voters
24. Regional Air Pollution Control Agency, Dayton, Ohio
25. Frances Scherer
26. Toyota Motor Company
27. Western New York Allergy and Ecology Association
28. Volkswagen of America (VWoA)

A. Primary Issues

1. Issue: Technological Feasibility

Summary of the Issue

This analysis addresses the technological feasibility of emission standards for heavy-duty engines (HDEs) for 1985 and later model years. Two separate analyses are contained herein: an analysis and derivation of hydrocarbons (HC) and carbon monoxide (CO) emission standards for 1985 which are achievable without catalysts, and an analysis of the feasibility of catalyst-based standards for 1987 and later model years.

A. NON-CATALYST STANDARDS FOR 1985

Summary of the Comments/Synopsis of Events

There have been several iterations of EPA action and public reaction as this issue has developed over time. For purposes of clarity, a brief synopsis of significant events is appropriate; public comments to each iteration will be summarized as they chronologically occurred.

On January 21, 1980, EPA promulgated final regulations for the control of gaseous emissions from HDEs applicable to the 1984 and later model years.[1] The regulations included the new EPA transient test cycles, the full useful-life concept, and statutory emission standards of 1.3 grams per brake horsepower-hour (g/BHP-hr) HC, 15.5 g/BHP-hr CO, and 10.7 g/BHP-hr oxides of nitrogen (NOx).* Compliance with these emission standards on the transient test almost certainly requires the use of oxidation catalysts on heavy-duty gasoline engines (HDGEs).

On April 6, 1981, the Vice President's Task Force on Regulatory Relief announced that EPA would propose emission standards for 1984 which would not require the use of catalysts. It was intended that this action defer the capital investments required for catalyst development, and thus provide economic relief to an industry beset by recession and decreased sales. On January 13, 1982, EPA officially proposed non-catalyst emission standards of 1.3 HC/35.0 CO/10.7 NOx for 1984 HDEs.[2]

The associated Draft Regulatory Analysis[3] tentatively concluded that emission standards of 1.3 HC/35.0 CO were feasible without catalysts. The analysis discussed the transient test in great detail, and presented modal emissions

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* All standards are based upon the EPA HDGE transient cycle.

from 12 1979 model year HDGEs. Emission levels for current technology were discussed, as were the emissions impact of specific operational modes of the transient test. By comparing low to high emitting engines and by identifying specific technologies and calibrations, EPA made the judgment that 1.3/35.0 appeared feasible for 1984 non-catalyst HDGEs.

In public comments to the Notice of Proposed Rulemaking (NPRM) received by April 1982,[4,5] only Ford Motor Company (Ford) and General Motors (GM) submitted transient test emissions data. Chrysler and International Harvester Company (IHC) did not comment on technological feasibility, and in fact, indicated that they were leaving the HDGE market for reasons unrelated to these regulations. (Both Chrysler and IHC have since indicated that they may reverse these decisions.)

In its comments, Ford stated its position as follows:

"Ford believes that its recommended 3.3 HC and 42 CO g/BHP-hr standards for the 1985 model year HDGEs represent the lowest levels achievable without unreasonable sacrifices in performance, fuel economy, or driveability."

General Motor's comments stated that:

"Review of available 1984 prototype HDGE development data indicated that most GM HDGEs could achieve <u>low-mileage</u> emission levels of approximately 2.0 HC and 32 CO g/BHP-hr."

General Motors subsequently recommended emission standards of 2.9 g/BHP-hr HC and 43.0 g/BHP-hr CO, on the basis of increased certification deterioration factors and assumed production variability. GM also argued that standards of 3.5 g/BHP-hr HC and 70 g/BHP-hr CO were justified on the basis of air quality needs, fuel economy, and cost. In comments and later discussions, GM also raised the point that the emission control strategies required to reduce HC and CO emissions to EPA's proposed standards could severely degrade engine durability. GM claimed that the need for full-power mixture enleanment and increased oxidation of pollutants in the exhaust system will raise in-cylinder and exhaust system temperatures to excessive levels. GM said that this will not necessarily be seen on EPA's transient test procedure, but more than likely will be seen in severe in-use applications for engines calibrated to meet EPA's proposed requirements.

Emissions data for 1984 prototype HDEs, as submitted by GM and Ford in April of 1982, are listed in Table 1-1.

Table 1-1

Manufacturers' 1984 Prototype Heavy-Duty Engine Data (submitted by April 1982)

Manufacturer	Engine Displacement	Emission Control System	g/BHP-hr* HC	g/BHP-hr* CO	g/BHP-hr* NOx	BSFC lb/BHP-hr
Ford	4.9L	AIR/EGR/EFE	1.66	23.2	7.68	0.560
Ford	6.1L	AIR/EGR	2.33	28.8	7.25	0.654
Ford	7.0/7.5L	AIR/EGR	2.21	24.3	4.82	0.633
GM	292 in^3	AIR/EGR	1.65	17.42	6.52	--
GM	350 in^3	AIR/EGR	1.76	25.07	5.25	--
GM	366 in^3	AIR/EGR	1.33	20.19	6.91	--
GM	454 in^3	AIR/EGR	0.90	20.93	7.42	--

* EPA cycle based.

In reviewing these comments, EPA staff felt that additional engineering data were required to determine the lowest emission standards achievable without catalysts. Specific requests for more detailed information were made to HDGE manufacturers on June 17, 1982;[6] Ford provided additional engineering data, GM provided a more detailed qualitative discussion and emission data (see Table 1-2) but declined to submit detailed engineering data, and Chrysler and IHC were unable to provide any additional data or information. At a meeting with EPA staff on January 28, 1983, representatives of GM again made the claim that 1.3/35.0 non-catalyst emission standards would adversely affect engine durability and fuel economy.

In a Federal Register notice of January 12, 1983, EPA officially delayed the 1984 model year emission requirements until 1985. This revision of the 1985 standards was justified on the basis of leadtime,* economics,* and the number of other issues yet to be resolved (i.e., alternative test cycles, useful life, etc.).

Reviewing all comments and data available at the time, and taking into account the additional year of development leadtime, EPA then analyzed the level of non-catalyst emission standards achievable for 1985. This analysis[8] went hand-in-hand with an EPA staff paper[7] in which both short and long-term strategies for the control of HDGE emissions were discussed. The staff paper, which was released for public comment on March 16, 1983, developed a control scenario whereby lighter heavy-duty gasoline trucks (HDGTs) would be equipped with catalysts in the 1987-88 time frame, and heavier gasoline truck engine standards would remain at non-catalyst levels.** At the same time, the staff paper summarized EPA's most recent analysis of 1985 standard feasibility, which had recommended non-catalyst standards of 2.5/35.0 g/BHP-hr.

This feasibility analysis,[8] the summarized results of which were discussed at an April 6, 1983 Public Workshop, was also distributed for public comment on April 12, 1983. The analysis recommended that non-catalyst emission standards of 2.5/35.0 g/BHP-hr be promulgated for 1985. This recommendation revised EPA's earlier conclusion that a 1.3 g/BHP-hr HC was feasible for 1984 without catalysts.

* See appendix, Chapter 3 of the Transient Test Study.

** See the POST-1985 EMISSION STANDARDS section of this issue.

Table 1-2

Additional Emission Data
Provided by GM in August of 1982[5]

Low-Mileage Emissions*

Engine	HC	CO	NOx	BSFC
GM 292	2.17	24.9	6.80	.639
GM 350-2V	1.57	28.2	6.11	.604
GM 350-4V	1.99	27.2	5.14	.649
GM 366	.75	17.9	3.57	.582
GM 454	1.01	22.2	4.28	.666

* EPA cycle-based g/BHP-hr. GM claimed that these data are representative of heavy-duty gasoline engine emission control systems and calibrations which, in August of 1982, were believed to be "at least plausible for production." None of these engine configurations had been durability tested, but all had been driven in a small sample of vehicles and had been determined to provide commercially acceptable performance and driveability.[5]

EPA's more recent conclusion that the non-catalyst HC standard must be relaxed was based upon several considerations. A review of the actual development data submitted by Ford and GM in April 1982 (see Table 1-1) indicated that substantial progress had been made in reducing emissions. However, all but one engine family were still well above the low-mileage target emission levels needed to assure compliance with a 1.3 g/BHP-hr HC standard. (All engine families were very close to the low-mileage target level for CO more than two years before required compliance, hence no relaxation of the CO standard was recommended.) EPA's analysis then discussed the remaining technology which could be applied to reduce HC emissions further. Since only Ford supplied detailed engineering data in response to EPA's June 17, 1982 request, only an analysis of Ford's product line was possible. (Since GM's engines in Table 1-1 all exhibited HC emission rates less than most Ford engines, it was judged that GM would have no problem complying with an HC emission standard based upon Ford's higher emitting engines.) Using data provided by Ford, EPA concluded that further reductions in HC were certainly possible, and that compliance with a 2.5 g/BHP-hr HC standard in 1985 would be possible even for Ford's highest emitting engine. HC standards less than 2.5 g/BHP-hr were considered, but were rejected on the basis of reasonable risk of non-compliance and fuel economy penalties for higher emitting engines. In summary, 2.5/35.0 were recommended as reasonable interim emission standards.

In comments[5] received by May 6, 1983, the conclusions and methodology of EPA's latest feasibility analysis[8] were again disputed. These comments are summarized below for each commenter.

Chrysler

Chrysler again commented that it was in no position to recommend specific interim standards, primarily because its transient test facility was not yet operational. Based upon testing performed for it under contract, however, Chrysler did not believe that the 35.0 g/BHP-hr CO standard was feasible even with a catalyst. Chrysler recommended continued provision of the 9-mode steady-state option until 1986.

Engine Manufacturer's Association (EMA)

The EMA and its member companies have not disputed the feasibility of the 1.3/35.0 g/BHP-hr standards for heavy-duty diesel engines (HDDEs).

Ford

Ford provided a comprehensive review of the emissions status of its HDGE product line. Ford's data showed that significant progress has been made in reducing emissions. However, Ford disputed EPA's feasibility analysis, characterizing it as overly optimistic. "EPA's suggestion that manufacturers not only can meet 2.5/35.0 but can also achieve substantial further reductions is overstated." Ford also argued that "EPA has overestimated the capabilities of some heavy-duty engines," notably Ford's 6.1L-4V (Ford's largest seller and occupant of the heaviest gasoline vehicle weight classes). The major problem associated with feasibility, according to Ford, is not so much the effectiveness of technology but rather the relatively low target levels which are forced upon a manufacturer by the full useful-life and Selective Enforcement Audit (SEA) requirements. Ford recommended half-life standards of 2.19/42.6 based upon the MVMA cycle; according to Ford, these are equivalent to full-life EPA cycle standards of 3.07/47.8.

General Motors

General Motors vigorously disputed the conclusions of EPA's feasibility analysis, characterizing the analysis as "entirely inadequate," and mostly "guesswork." GM insisted that EPA's engineering judgment was based upon limited and outdated emission data, very few research studies, and limited, incomplete data supplied by manufacturers. GM also criticized EPA for "engineering on paper," for failing to construct and evaluate through testing, any engine conforming to EPA's design recommendations, and for failing to generate any current data.

General Motors qualitatively discussed several engineering aspects of achieving low levels of HDGE emissions without catalysts. GM also discussed durability, driveability, and fuel economy problems associated with "unreasonably stringent standards." In GM's opinion, forced compliance with the 35.0 g/BHP-hr CO standard would preclude the production of reasonably durable engines. Indeed, GM argued that the poor performance of engines produced under these emission constraints would invite tampering in the field.

General Motors questioned EPA's apparent policy of establishing stringent interim standards, especially given the major changes occurring in the 1987-88 timeframe, the "risk to the heavy-duty industry," and "the lack of demonstrated feasibility." GM recommended half-life non-catalyst emission standards of 2.9/43.0 (EPA cycle) for 1985.

With respect to data, GM submitted a large confidential discussion of various aspects of its development work. Included were qualitative discussions of GM's calibration strategies and hardware for complying with 1.3/35.0 g/BHP-hr standards, qualitative discussions of GM's engine durability experience, a description of GM's in-house durability test procedures, comparisons of 1983 versus 1985 prototype timing and air/fuel (A/F) calibrations, actual test reports from characterizations of wide-open throttle (WOT) timing versus detonation requirements, on-road fuel economy data, and actual test reports from exhaust system temperature and durability studies.

On the other hand, no new emission data were submitted by GM; the latest data indicating the position of GM's product line with respect to compliance was that submitted by April and August of 1982 (see Tables 1-1 and 1-2). GM went on to characterize the April 1982 data as being unrepresentative of its true compliance capability, having been acquired long before subsequent testing discovered durability problems. Furthermore, GM stated that its test experience and comments only address the feasibility of the 1.3/35.0 standards. GM claimed that it had only just begun to evaluate the implications of the 2.5/35.0 standards. Nevertheless, GM recommended that EPA promulgate half-life standards of 2.9/43.0 (EPA cycle) g/BHP-hr for 1985.

Analysis of Comments

Overview

This analysis will develop and recommend non-catalyst standards for 1985 and later model year HDGEs. Aside from the specific hardware and applicable emission control techniques to be addressed, it is equally important to address the effect of other factors on the stringency of the interim emission standards. The most important of these other factors are the full useful-life concept, the SEA requirements, and the correlation between the EPA and MVMA test cycles. These issues will be discussed first, because of their inherent impact on standard stringency.*

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* The relationship of two of these factors to low-mileage emission targets and emission standards is typically expressed as:

$$\frac{1}{AQL}\,[\text{Emission Standard} - \text{DF}] = \text{Low-mileage target.}$$

The analysis will then review the status of the HDGE manufacturers with respect to current emission levels of their "best effort" engines, where possible. As in earlier analyses, judgments will be made whether further reductions can be made for the 1985 model year.

Deterioration Factors

Manufacturers are required to correct "low-mileage" emission levels from certification engines for expected in-use deterioration. Current requirements, and those applicable for 1985, require that deterioration be assessed in an additive fashion. Current deterioration factors (DFs) have largely been derived from durability testing performed on engine dynamometers. Very little, if any, data exists on the degree of deterioration which actually occurs in use. Dynamometer durability testing results have never been validated, and there is substantial uncertainty as to the magnitude of true in-use DFs for all HDEs.

On the other hand, the process of compliance in 1985 will be based upon DFs derived and supplied by the manufacturer in whatever manner they deem appropriate. Techniques of DF derivation can range from simple engineering judgment to continued use of dynamometer testing to actual in-use tests. Given the lack of an officially imposed method, one would expect manufacturers to base their DF determinations upon past practice and experience.

Certification DFs for HDGEs have typically been quite small. Table 1-3 presents a summary of official certification DFs for Ford's and GM's HDGEs for the 1983 model year. In almost all cases, emissions decreased after completion of durability test runs on the engine dynamometers. Substantial changes, however, are being made to engine hardware for the 1985 model year. This new hardware will also be required to maintain compliance for a full useful life (110,000 miles), as opposed to the previous half-life (50,000 miles) requirement. Therefore, the DFs in Table 1-3 may be somewhat less than DFs derived and used for 1985.

In past analyses, EPA has converted from half- to full-life DFs by assuming linear deterioration (i.e, the full-life DF is equal to the half-life DF multiplied by 110,000/50,000, or 2.2). This methodology is straightforward, and fits the general trend of deterioration observed in dynamometer testing of non-catalyst engines. While EPA has confidence in this adjustment, assessing the deterioration rates of new engine hardware not yet in production is more problematic.

Based upon current prototypes, 1985 HDGEs will likely be equipped with the following hardware: large dual air pumps,

Table 1-3

1983 Model Year Certification
Deterioration Factors (DFs) for Ford and GM HDGEs

Manufacturer/Engine Family	Certification DFs* HC	CO
Ford 4.9L "Q"	0.00	0.00
Ford 6.1L "E" - 2V	0.00	1.91
Ford 6.1L "E" - 4V	0.00	1.91
Ford 7.0L "E"	0.00	0.00
Ford 7.5L "E"	0.00	0.00
Ford 5.8L (W) "E"	0.00	0.48
GM DGM07.0ABB4:		
- L86 (366 CID)	0.00	0.00
- L43 (427 CID)	0.00	0.00
GM DGM07.4ABB9:		
- LF8 (454 CID)	0.00	0.00
GM DGM04.8ABA6:		
- L25 (292 CID)	0.00	0.00
GM DGM05.7ABB9:		
- LF5 (350 CID - 2V)	0.00	0.00
- LS9 (350 CID - 4V)	0.00	0.00

* Additive g/BHP-hr, half-life basis.

EGR, early fuel evaporation systems, heated air intake systems, and automatic chokes. Carburetor and ignition timing calibrations will be different from current models, as will manifold designs and air injection systems. In-cylinder and exhaust system temperatures will be hotter than those of current engines because of leaner mixtures and increased thermal reaction. As a total package, these modifications are uncharacterized in heavy-duty engine applications with respect to deterioration and long-term performance. Given the significant changes from 1984 to 1985, it is reasonable to expect that manufacturers will run at least some dynamometer durability tests out to the full useful-life equivalent of 3,300 hours.

Quantification of expected deterioration is by necessity somewhat speculative, but there are a number of reasons why 1985 DFs should not be exceptionally high:

1. No inherent increase in deterioration rates should be expected from recalibrations of ignition timing or carburetors. Deterioration rates of this hardware have been previously established, and simple changes to timing settings or fuel flow rates should not alter the functional durability of the hardware.

2. Catastrophic or significant causes of deterioration to minor components will be identified during accelerated durability testing, at which time corrective redesign can take place.

3. If problems arise with component-related durability, especially during dynamometer testing corresponding to the second half of the useful life, new maintenance provisions can be specified to alleviate the problem.

4. Prototype air injection systems are merely larger versions of existing systems whose durability performance have already been characterized. Other changes simply represent changes to static piping and manifolds; these hardware experience minimal emission-related deterioration.

5. Finally, most of the hardware new to HDGEs have already been successfully used on production LDVs and LDTs for several years. EPA expects the manufacturers to have acquired considerable experience with the design, maintenance, and in-use durability of such hardware. This experience is directly relatable to HDGEs.

Given the above, and given the DFs presented in Table 1-3, EPA does not expect large DFs to be used or needed for 1985.

Referring to Table 1-3, only two engine families exhibited a non-zero CO DF for 1983 (the Ford 6.1L and 5.8L). EPA does not expect CO deterioration rates to be significantly different from 1983; CO emission control is primarily a function of leaner carburetor calibration and improved air injection, neither of which should affect durability to any great extent. For purposes of this analysis, EPA will use the worst case DF from 1983 (1.91 for the Ford 6.1L), corrected from half- to full-life (i.e., 1.91 multiplied by 110,000/50,000 or 2.2 to equal 4.20).

Quantification of HC deterioration is more speculative. All 1983 Ford and GM engine families exhibited HC DFs of 0.00 or less, but there is some reason to believe that HC DFs may increase in 1985. Cold start emission control apparatus is new, as would be more elaborate ignition timing controls (if used). These systems will primarily affect HC emissions. On the other hand, systems of this type have already been used for several years on production LDVs and LDTs, and EPA presumes that the manufacturers have well characterized their performance. For purposes of this analysis, EPA will use the same additive DF used in the earlier analysis,[8] a DF of .25. This is likely to be a representative DF, given the performance of current engines, the existing experience with such equipment on LDTs and LDVs, and EPA's assumption of a moderate increase in DFs for 1985.

SEA Requirements

SEA testing requirements are scheduled to take effect in the 1986 model year. Therefore, a manufacturer cannot be subjected to the jeopardy of failing a production line audit until 1986. For this reason, it is entirely reasonable to ignore SEA requirements in establishing emission target levels for 1985. On the other hand, it is also reasonable to expect that a manufacturer would wish to conclude development work prior to 1985, and rely upon carryover for the next year to avoid continued recertification expenses. This feasibility analysis will include the effect of SEA requirements in establishing feasible emission standards for 1985, since recertification in 1986 would not be desirable from the manufacturers' standpoint. However, in the event that one or two engines may appear to be having difficulty in achieving SEA-based low-mileage target levels for 1985, EPA cannot ignore the additional flexibility provided manufacturers by the effective relaxation of low-mileage target levels afforded by EPA's deferral of SEA requirements.

Production line emission variability is fairly well characterized. EPA's earlier analysis[8] and Ford's May 6, 1983 comments[5] used numerical values of 1.136 and 1.200, respectively, for HC, and 1.266 and 1.300, respectively, for CO. (GM has previously used a 40 percent AQL factor of 1.10 for all gases.[5]) EPA's and Ford's values are essentially in agreement; for purposes of this analysis, arithimetic averages of Ford's and EPA's numbers will be used (i.e., 1.168 for HC and 1.283 for CO), and represent conservative values in EPA's judgment. For worst case engines, however, a value of 1.000 would be available for the 1985 model year.

Alternative Test Cycles

EPA's earlier analyses[3,7,8,9] were all based upon EPA cycle test results, and the emission standards discussed were also based upon the EPA cycle. All of the latest "best effort" emission data, however, is MVMA cycle based. For purposes of this analysis, MVMA cycle-based standards will be developed from this "best effort" data. For purposes of comparability with previous analyses, equivalent EPA cycle-based standards will also be presented.*

Only Ford gave EPA specific information on the current emissions status of their product line. As in its earlier analysis,[8] EPA will evaluate the feasibility of emission standards for HDGEs based largely upon Ford's data. In the absence of any specific emissions data to the contrary, and by reviewing the latest GM emission data made available to EPA in August of 1982, EPA will assume that the emissions capabilities of GM's engines are not substantially different from Ford's. The emissions capabilities of Chrysler's and IHC's engines are unknown, however, the necessary technologies are widely available and well understood. EPA does not expect the emissions capabilities of Chrysler's or IHC's engines to be fundamentally different from those of Ford or GM.

Current Status of HDGE Emission Levels

Tables 1-4, 1-5, and 1-6 present EPA's evaluation of Ford's "best effort" data; Table 1-5 also includes GM's most recent data. Clearly, significant improvements have been made since 1979 and earlier model years (see Figures 1-1 and 1-2). Using Ford's recent MVMA cycle-based low-mileage results, these levels have been converted to equivalent emission standards, both in terms of the MVMA cycle and the EPA cycle (see Tables

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* Equivalent EPA cycle-based emissions will be based upon the following equations (derived in Issue A.3. of this Summary and Analysis of Comments):

HC: MVMA = .886 (EPA) - 0.318
CO: MVMA = 1.03 (EPA) - 4.04

Table 1-4

Review of Ford's "Best Effort" Data,[5] Estimated Current Attainable MVMA Cycle-Based Emission Standards*

May 1983 Data

Ford Engine Model	Low-Mileage Emission Results* HC	Low-Mileage Emission Results* CO	Equivalent Deteriorated HC Emission Standard*	Equivalent Deteriorated CO Emission Standard*
4.9L-1V	1.21(1.72)	25.0(28.2)	1.66(2.26)	36.3(40.4)
6.1L-2V	1.08(1.58)	23.4(26.6)	1.51(2.09)	34.2(38.4)
6.1L-4V	1.70(2.28)	28.5(31.6)	2.24(2.91)	40.8(44.7)
7.0L-4V	1.50(2.05)	17.7(21.1)	2.00(2.65)	26.9(31.3)
7.5L-4V	1.36(1.89)	23.6(26.8)	1.84(2.46)	34.5(38.6)

* MVMA cycle based, g/BHP-hr; the numbers in parenthesis are EPA cycle based, g/BHP-hr.

Table 1-5

Currently Attainable
EPA Equivalent Emissions Standards

Engine Family	Equivalent, Deteriorated EPA Cycle-Based HC Emission Standard*	Equivalent, Deteriorated EPA Cycle-Based CO Emission Standard*
May 1983 Data (derived from Table 1-4)**		
Ford 4.9L-1V	2.26	40.4
Ford 6.1L-2V	2.09	38.4
Ford 6.1L-4V	2.91	44.7
Ford 7.0L-4V	2.65	31.3
Ford 7.5L-4V	2.46	38.6
August 1982 Data (derived from Table 1-2)		
GM 292	2.78	36.1
GM 350-2V	2.08	40.4
GM 350-4V	2.57	39.1
GM 366	1.13	27.2
GM 454	1.43	32.7
April 1982 Data (derived from Table 1-1)		
Ford 4.9L	2.19	34.0
Ford 6.1L	2.97	41.2
Ford 7.0/7.5L	2.83	35.4
GM 292	2.18***	26.5***
GM 350	2.31***	36.4***
GM 366	1.80***	30.1***
GM 454	1.30***	31.1***

* EPA cycle-based, g/BHP-hr, assumes deterioration and includes SEA requirements.

** Calculated by first correcting MVMA to EPA low mileage emissions, then adjusting for SEA and deterioration.

*** These emission levels were claimed by GM in May of 1983 to have promoted unacceptable engine durability and performance, and were reported to EPA before discovery of such problems.

Table 1-6

Compliance Ability of Ford's Product Line at Various Levels of EPA Cycle-Based Emission Standards (May 1983 data)

EPA Cycle-Based Emission Standards		Number of Engine Models in Compliance by May 1983*
HC	CO	
1.3	35.0	0 out of 5
2.5	35.0	1 out of 5
2.5	40.0	3 out of 5
2.6	40.0	4 out of 5
2.9	45.0	5 out of 5

* Assumes deterioration; includes 1986 SEA requirements.

Figure 1-1

CO Emissions (EPA Cycle-Based) from Ford HDG Engines
(Note: Engines of similar displacement over time are considered to be in the same "family.")

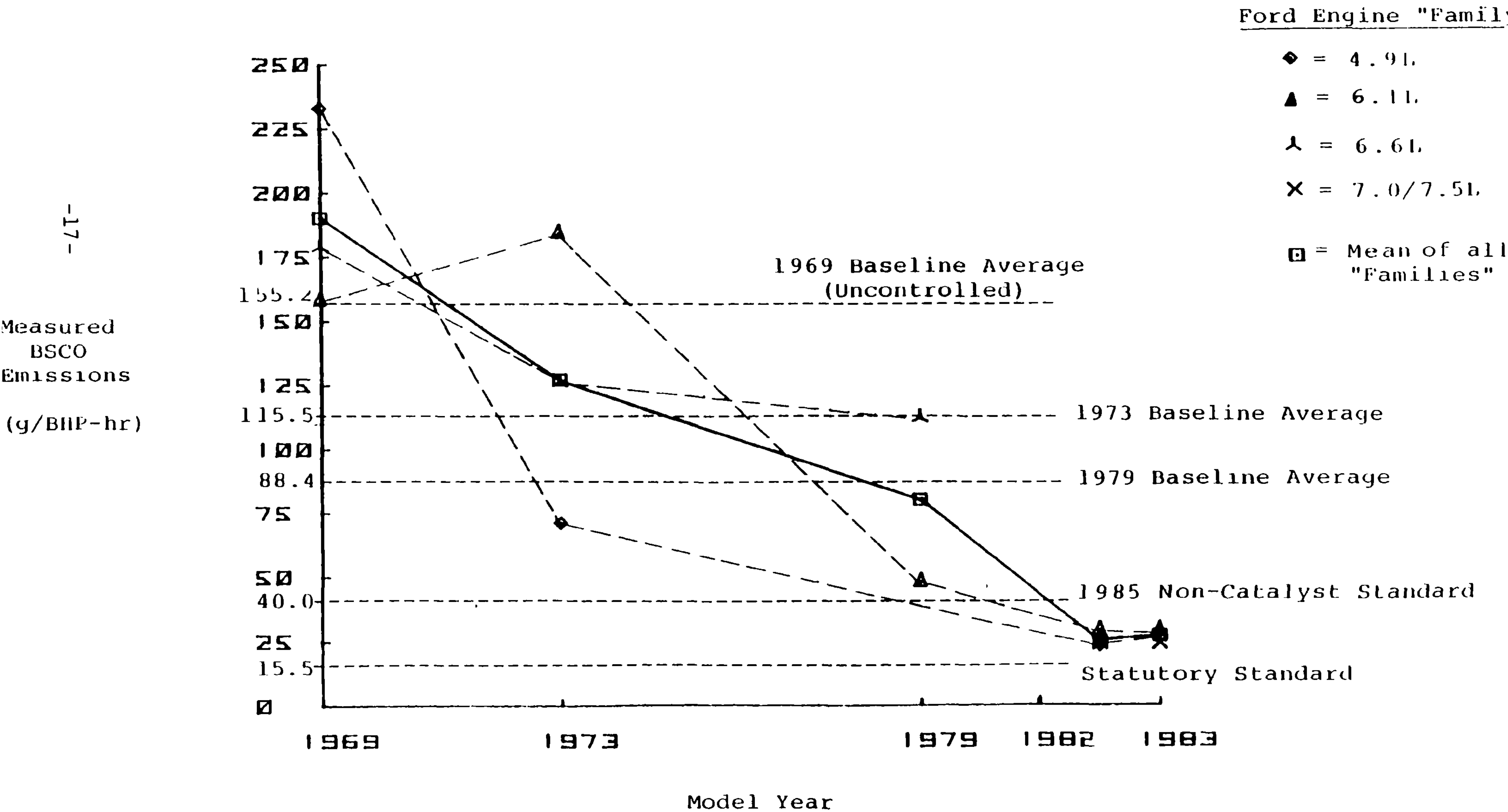
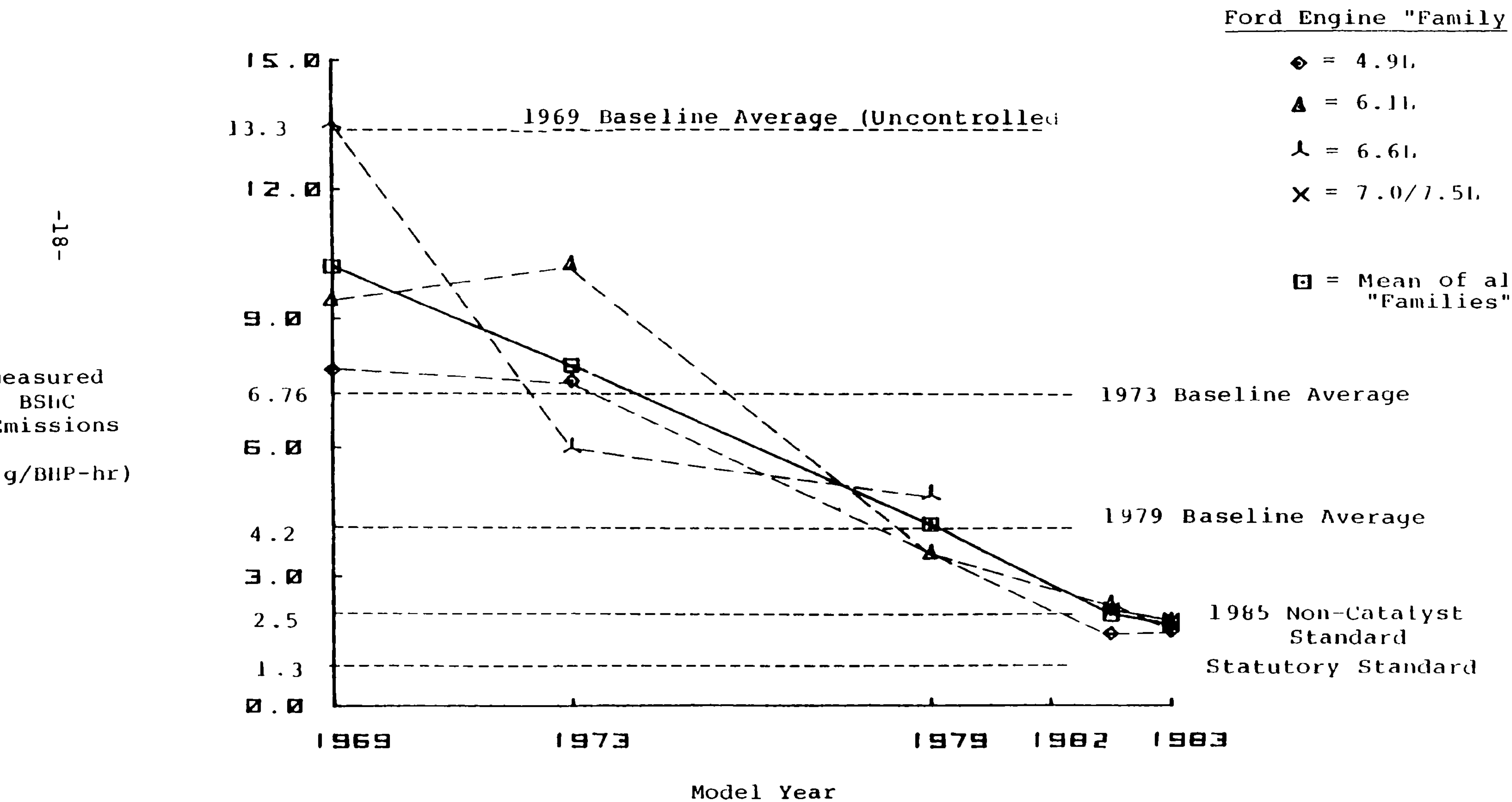


Figure 1-2

HC Emissions (EPA Cycle-Based) from Ford HDG Engines
(Note: Engines of simialr displacement over time are considered to be in the same "family.")



1-4 and 1-5). Table 1-6 summarizes the ability of Ford's engines, in May of 1983, to comply with a variety of potential emission standards.

Tables 1-5 and 1-6 indicate that only two of Ford's five engine models would today exceed an HC standard (EPA cycle based) of 2.5 g/BHP-hr (and one marginally so), whereas four out of five would exceed the 35.0 g/BHP-hr CO standard. An important observation to make is the fact that very little has changed in Ford's compliance ability between April 1982 and May 1983 (see Table 1-5). Ford made the statement in their comments of May 6, 1983 that significant progress had been made relative to Ford's reported status of April 1982. However, EPA's present analysis indicates that much of the reported progress was illusory, arising primarily from a change in test cycles. (The April 1982 data were EPA cycle-based; the May 1983 data were MVMA cycle-based.)

Based solely upon Ford's May 1983 data, the current critical range of feasibility apparently lies between 2.5-2.6 g/BHP-hr HC and 35.0-40.0 g/BHP-hr CO (EPA cycle based). Assuming for the moment that there is little practical difference between a 2.5 and 2.6 HC standard, then relaxing the proposed CO standard of 35.0 to 40.0 would allow all but one of Ford's engines to comply with 1985 requirements in May of 1983, taking into account deterioration and 1986 SEA requirements for 1985. Reviewing GM's latest data (presented in Table 1-5), this relaxation would also allow all but one of GM's engines to comply, even if no improvement in emission levels have been made since August of 1982.

1985 Standards Derivation

EPA's draft feasibility analysis[8] attempted to evaluate the detailed calibrations, hardware, and associated emission levels of Ford's April 1982 engines. Using these facts as starting points, EPA surmised how additional emission reductions could be made for the few engines which the April 1982 data indicated actually required further work to meet 2.5 g/BHP-hr HC and 35.0 g/BHP-hr CO (see Tables 1-1 and 1-5). Emission reductions were predicted based upon established principles of emissions engineering, whereby given changes of calibrations produce predictable trends in emissions.

Both Ford and GM took issue with EPA's analysis. Criticism of EPA abounded, but no approaches for further emission control were recommended as having promise. GM harshly criticized EPA for drawing conclusions from a limited data base, despite its refusal to provide EPA with specific calibration information. Ford was less critical than GM, discussing several of EPA's evaluations and indicating where Ford thought they were incorrect or why they would prove ineffective. Despite Ford's presentation on the emissions status of their product line, EPA still has only generalized information as to the specific emission control techniques attempted, which were discarded, and which remain available (with and without trade-offs). Furthermore, without specific engine calibration information it is difficult for the Agency to identify which levels of emission standards represent the most stringent standards possible without unreasonable impacts on cost or fuel economy, as EPA is required by law to promulgate. Commenters are correct in maintaining that EPA is not close enough to engine development efforts to anticipate engine specific problems which arise as each control technique is applied to each engine. For this reason alone, the manufacturers are responsible for providing EPA with the detailed, unbiased information it needs to make reasoned decisions.

Without such information, EPA can only review the best available data, and make a judgment as to what represents reasonable interim standards, given the state of current engine development and given the remaining leadtime until 1985.

As shown in Table 1-6, only one of Ford's engines would significantly exceed an HC standard of 2.5 g/BHP-hr. The remaining engine, the 6.1L-4V, would require a 16 percent reduction in low-mileage emissions to meet the 2.5 standard (see Table 1-7). If Ford takes advantage of the certification flexibility provided by EPA for 1985 (SEA requirements do not apply), the 6.1L-4V would already meet a 2.5 standard if only deterioration is included with the low-mileage emissions to determine compliance. In short, one extra year of leadtime is available, if necessary, for attaining what appears to be a modest reduction in HC emissions. EPA will not speculate as to which technologies will be used to achieve the reduction, although in the worst case ignition timing retard is available. More importantly, EPA cannot allow the technological laggard to set the pace for standard setting; to do so surrenders the gains already achieved with the majority of engines, and does little to motivate a manufacturer to lower emissions from its engines.

To some extent, the same argument holds true in determining a feasible CO standard. However, as shown in Table 1-6, the majority of Ford's product line will require additional work to achieve the 35.0 g/BHP-hr CO standard. Some reduction in low-mileage emissions will be necessary for four out of five engines, including a substantial reduction (26 percent) for the 6.1L-4V family (see Table 1-7). Given the

Table 1-7

Percentage Reductions in Low Mileage Target (LMT) Emissions Required to Comply With Emission Standards of 2.5 g/BHP-hr HC and 35.0 g/BHP-hr CO (EPA cycle based)

Engine Family	Required HC LMT Reductions (%)	Required CO LMT Reductions (%)
Ford 4.9L-IV*	0	16
Ford 6.1L-2V*	0	10
Ford 6.1-4V*	16	26
Ford 7.0L-4V*	5	0
Ford 7.5L-4V*	0	11
GM 292**	9	2
GM 350-2V**	0	13
GM 350-4V**	1	10
GM 366**	0	0
GM 454**	0	0

* May, 1983 data.
** August, 1982 data.

industry's claims of decreased engine durability with further enleaned fuel mixtures at WOT, and given the remaining leadtime, there appears to be some risk in a 35.0 g/BHP-hr CO standard. If, on the other hand, the emissions from Ford's worst emitter (again the 6.1L-4V) were to be reduced to the level of the remainder of Ford's fleet, an emission standard of 40.0 g/BHP-hr would be required. Again, EPA rejects the idea that the technological laggard set the pace of emissions reduction; therefore, a standard greater than 40.0 g/BHP-hr would be unjustified.

Selecting a CO standard between 35.0 and 40.0 g/BHP-hr then becomes an exercise in evaluating trade-offs. Promulgation of 35.0 g/BHP-hr, or any standard which requires the majority of the product line to achieve further reductions, will increase the risk of durability problems, and at the same time direct development efforts away from the 1987 standards. Requiring the highest emitters to achieve further reductions, however, is both appropriate and necessary to retain reductions already achieved. From Table 1-5, EPA notes that the majority of Ford's engines (according to the latest data) lie at the high end of the 35.0-40.0 g/BHP-hr range.

EPA does not believe that compliance with a 35.0 g/BHP-hr CO standard is infeasible. However, some additional development work would be necessary for four of Ford's five families, and significant work for one family. Given the fact that some development work is still required to meet both the 2.5 g/BHP-hr HC standard and a 40.0 g/BHP-hr CO standard, given EPA's desire not to preempt significant development efforts from the 1987 model year, given the fact that many of the engines for which data is currently available exhibit CO emissions closer to 40.0 g/BHP-hr than 35.0, and given the risk to engine durability entailed in meeting a 35.0 g/BHP-hr CO standard within short leadtimes, EPA believes that 40.0 g/BHP-hr would be a reasonable non-catalyst CO standard for 1985.

EPA's evaluation of the latest GM data leads it to the same conclusions. As can be seen in Table 1-5, GM's August 1982 data indicates that only a single engine would significantly exceed standards of 2.5/40.0, and it would only exceed the 2.5 HC standard. GM has repeatedly expressed concern about the durability implications of stringent non-catalyst CO standards. As noted in Table 1-7, some of GM's engines still require reductions in low-mileage CO emissions to meet a 35.0 g/BHP-hr standard. However, the lack of specific calibration information for GM's engine has made EPA's review of the reasonableness of GM's claims difficult, at best. (For example, EPA would not consider durability data taken on engines with WOT A/F calibrations leaner than stoichiometry to be at all representative; such calibrations would be unnecessary for compliance and understandably severe on durability.) EPA notes that GM's criticism of EPA's earlier feasibility analysis only addressed GM's concern with complying with 1.3/35.0 standards. The latest GM and Ford data indicate that low-mileage compliance with standards of 2.5/40.0 g/BHP-hr represents no problem whatsoever for almost all engine families; the feasibility issue essentially breaks down to the level of emission standards which would not degrade engine durability or performance. EPA believes that relaxation of the proposed 1.3 HC standard to 2.5 will preclude the need for substantial ignition timing retard, both preserving fuel economy and precluding increased exhaust temperatures. EPA also believes that relaxation of the proposed 35.0 CO standard to 40.0 will also preclude the need for A/F calibrations lean enough to promote excessively high temperatures and durability problems. EPA bases these judgments on the current performance of Ford's product line, upon Ford's claims that these emission levels will not impair engine durability, upon GM's own test data, and upon the lack of GM's comments and data to the contrary for engines designed to meet emission standards at these levels.

Conclusion

Revised gaseous emission standards of 2.5 g/BHP-hr HC and 40.0 g/BHP-hr CO (or 1.9 g/BHP-hr HC and 37.1 g/BHP-hr CO based upon the MVMA cycle) are feasible without catalysts, will not degrade engine performance or durability, and therefore should be promulgated for the 1985 model year.

B. POST-1985 EMISSION STANDARDS

Summary of Comments/Synopsis of Events

Soon after the decision was made to propose non-catalyst standards for the 1985 model year, EPA began evaluating when further progress towards the statutory standards would be appropriate for gasoline engines. It is generally accepted that compliance with the statutory 1.3 HC/15.5 CO standards will require oxidation catalysts. (Diesel engines easily comply with the statutory HC and CO standards.)

EPA has never altered its conclusions of January 21, 1980[1,9] that catalysts are ultimately feasible for use on HDGTs. The justification for deferring catalyst-based standards beyond 1984 was based principally upon economic grounds and leadtime concerns, not technical feasibility.

On March 16, 1983, EPA distributed a staff paper[7] for public comment, and subsequently held a Public Workshop on

April 6, 1983. The staff paper presented options for the long-term control of HC and CO emissions from heavy-duty trucks. The major provision of the recommended option was that HDGTs would be split along traditional class lines. Vehicles up to 14,000 lbs. gross vehicle weight (GVW) would be required to meet statutory standards (and thus have catalysts); all heavier gasoline vehicle engines would continue to meet non-catalyst standards. This approach attempted to capitalize on the transferability of light-duty truck (LDT) catalyst technology to the largest fraction of HDGTs (the lighter classes), while acknowledging the decreasing number of heavier HDGTs on which catalyst application would be most expensive (on account of the need to design increased survivability into catalyst systems used in the more extreme heavier truck environment). In short, emission reductions were hoped to be achieved in the most cost-effective fashion. The suggested implementation date for this strategy was the 1987-88 timeframe. Public comments on the staff paper were solicited and accepted up until May 6, 1983.

Prior to the May 6 close of comments, GM advanced an alternative approach at an April 13, 1983 meeting with EPA staff.[5] GM proposed that most* HDGTs under 10,000 lbs. GVW ("light heavy-duty vehicles") be required to meet emission standards similar to those required for LDTs, and be certified on the light-duty chassis dynamometer test procedure. Vehicles above 10,000 lbs. would continue to have their engines certified on EPA's heavy-duty engine test at non-catalyst emission levels. GM proposed that the scenario take effect in 1987.

Public comments received by May 6, 1983[5] addressed both the EPA and GM scenarios and are summarized by commenter below.

Chrysler

Chrysler cannot support the GM proposal, because of the proposed more stringent standards for LDTs below 6,000 lbs. GVW and proposed relaxation for LDTs between 8,500 and 10,000 lbs. GVW. Chrysler also opposes the creation of the light heavy-duty class, arguing it would require an additional test fleet for durability testing, thereby increasing costs.

Chrysler also claimed that EPA's engine dynamometer test is not representative of vehicles less than 10,000 lbs. GVW. Chrysler implied that another test would be better, but did not specify any particular test.

* Some exemptions would be allowed on the basis of larger frontal area, etc.

Ford

Ford argued that catalysts are not feasible for all trucks, but may be feasible on trucks in the 8,500-14,000 lb category. Ford argued that catalyst standards should not be implemented before 1988, because of production leadtimes and the required 4-year leadtime provisions of the Clean Air Act.

Ford suggested that the heavy-duty class be split at 10,000 lbs., primarily because there are not many Class III trucks. Ford did not disagree, however, with EPA's concern about potential migration, should HDTs be split at 10,000 lbs. Indeed, if EPA does split HDTs at 14,000 lbs., Ford recommended specific vehicle types for exemption. These vehicles are those which see the most severe operation, and thus, would be those vehicles most difficult to equip with durable catalysts. Ford also agreed with GM that the LDT chassis test procedure would be appropriate for trucks under 10,000 lbs. GVW. Ford urged EPA to consider this testing alternative seriously.

With respect to catalyst feasibility and the feasibility of the 15.5 g/BHP-hr CO standard, Ford argued that temperatures above 1,600°F will cause thermal degradation of the catalyst. Catalyst protection systems are possible, but an overtemperature protection system of air injection cutoff at full load also cuts off CO control at its most significant mode. This trade-off between catalyst durability and CO control has not been characterized. Ford did claim, however, that their experience with LDT truck catalyst technology will be applicable to the 8,500-14,000 lb vehicle classes.

General Motors

General Motors argued that EPA's split-class approach was flawed. Specifically, EPA's approach does not make compliance any different for lighter HDTs because they would still be certified on the HDE test. GM argued that the test procedure itself will determine which technology is applied for emission control. In fact, much more than minor modifications to LDT systems would be required for usage on the heavy-duty test. GM argued that catalyst-equipped HDGEs will exhibit unacceptable durability and performance if certified on the transient engine test procedure. GM claimed that they were unable, based upon the lack of data, to define regulatory requirements based upon the engine dynamometer test procedure.

General Motors also took issue with EPA's rationale for splitting the classes. GM disagreed with EPA's conclusion that LDTs and lighter HDTs were not significantly different; GM argued that EPA has not proved that they are sufficiently similar to permit "easy" transfer of LDT control technology.

General Motors did agree that the heavier the total vehicle weight, the higher the catalyst temperatures were likely to be over the road. GM did not address the feasibility of catalyst protection systems.

Manufacturers of Emission Controls Association

The Manufacturers of Emission Controls Association (MECA) stated that EPA's split-class approach better balanced the needs and costs of controlling emissions from HDGTs. MECA further stated that if the operating environments of Classes IIB and III trucks are "...not significantly different both in terms of emission levels and thermal exposure from that experienced with vehicles currently equipped with catalysts, then it is expected that conventional light-duty truck catalyst technology could be applied with relatively minor modifications to trucks in those classes."

MECA also stated that several of its member companies are already working to develop catalysts for the Classes IIB and III trucks, and also to develop catalyst components that will withstand higher temperatures.

With respect to leadtimes, if LDT catalyst technology is readily transferable, MECA claims that adequate quantities of catalysts "...could be produced well within the timeframe needed to supply 1987 model year trucks." "If more heat resistant systems are needed for certain Class IIB and III vehicles, some additional development time will be necessary."

Natural Resources Defense Council

The Natural Resources Defense Council (NRDC) took strong exception to EPA's performance on the regulation of HC and CO emissions from HDTs. NRDC stated that EPA's split-class approach should mandate the entire 90 percent reduction in HC and CO emissions for the lighter class by 1985, instead of 1987-88 as EPA's staff paper suggested. NRDC supported the provision of a 1-year "safety valve" exemption for vehicles subjected to more severe operating conditions, if a need for such could be publicly demonstrated. NRDC also recommended that EPA seriously consider extending the lighter class upper weight limit from 14,000 to 20,000 lbs. GVW to prevent vehicle migration to higher weight classes.

NRDC also argued that the heavier classes should not be given a permanent exemption from the 90 percent reduction standards, even if such an exemption were technically justified for 1985 or 1986. NRDC claimed that a permanent exemption is not only detrimental to air quality, but also beyond EPA's legal authority.

Analysis of Comments

There are four basic questions concerning the issue of catalyst feasibility for HDEs: 1) can the catalyst-based standards be met at low mileage, 2) what type of catalyst system and hardware are needed to allow compliance, 3) what type of overtemperature protection is necessary for a catalyst operating at HDE conditions, and 4) how much leadtime is required for the development and production of such systems? These questions will be addressed in the following analysis, along with public comments to EPA's March 16, 1983 staff paper wherein EPA originally proposed the "split-class" approach.

Low-Mileage Feasibility of Catalyst-Based Standards

EPA's decision to defer catalyst-based standards beyond 1984 was not a technical one, but based primarily upon economic grounds and leadtime concerns. EPA concluded on January 21, 1980[1] that catalysts are feasible for use on HDGEs, and this analysis will not reiterate the detailed findings of that rulemaking. The associated Summary and Analysis of Comments document, published in December 1979,[9], discussed a limited test program which had been conducted by EPA during which the statutory standards had been achieved at low mileage on two test engines using catalysts. The conclusion of feasibility was, therefore, supported by actual testing conducted by EPA.

Since that time, EPA has collected data from three additional catalyst-equipped heavy-duty gasoline engines. (All five catalyst-equipped heavy-duty gasoline engines and their weighted cold/hot start transient test emissions are listed in Table 1-8.) In this more recent testing, EPA retrofited an IHC 404 CID engine with two three-way catalysts and two oxidation catalysts. A Ford 1985 prototype 7.5L HDE equipped with oxidation catalysts was also tested at the EPA facility. Finally, a GM 350-CID engine, with both a three-way and an oxidation catalyst, was tested at Southwest Research Institute. In addition, EPA notes that GM has tested a 1985 prototype 350-CID engine equipped with oxidation catalysts, and submitted that data to the Agency as part of the cooperative effort to determine the correlation between EPA and MVMA test cycles. All engines yielded emissions well below the 15.5 g/BHP-hr CO and 1.3 g/BHP-hr HC standards (see Table 1-8). Thus, laboratory testing of heavy-duty gasoline engines equipped with catalyst systems has established that these engines can comply with the statutory standards at low mileage.

Likely Emission Control Stategies

EPA believes that LDTs and most lighter HDTs are not subjected to significantly different operational environments, and that existing LDT catalyst technologies and strategies can be modified for use by HDEs (see below). The only significant difference affecting compliance technology between LDTs and the HDEs for which catalyst stanc ds will apply is, as properly noted by GM, the larger engin exhaust mass flow induced by the heavy-duty transient engine t t. This difference should only be manifest in the CO emissions. Necessary modifications to LDT control technology to permit compliance with the CO standard on the heavy-duty test include both changes to the air injection system and to the catalyst system itself.

Adding air to the catalyst ensures that there is sufficient oxygen to allow the oxidation of CO emissions. Air injection is most important, and potentially problematic, at full-power modes when the engine is operating under relatively richer mixtures. Most of the CO emissions generated on the transient test arise during these modes, and therefore high-power CO emission control is critical. Given the already high exhaust temperature at full power, substantial oxidation of the relatively abundant concentrations of CO could potentially raise catalyst temperatures to unacceptable levels. It has been argued by manufacturers that this fact may be the most difficult development problem to solve: any emission control system with sufficient air injection to permit CO compliance on the heavy-duty test, if that calibration is carried through to the in-use vehicle operating for sustained periods at full power, will create catalyst overtemperature problems in-use. In turn, catalyst durability could be severely impaired.

EPA's testing of the Ford 7.5L (see Table 1-8) examined the relationship between CO emissions and the injection of air to the catalyst. (Evaluations of catalyst temperatures were also made, and are discussed below with respect to catalyst protection systems.) Solenoid valves were installed in the engine's air injection system so that complete control of when air was being injected into the catalyst was achieved. Testing was conducted such that different amounts of air were added to the catalyst at wide open throttle (WOT). (WOT was defined as the condition when the manifold vacuum was equal to or less than 2 inches Hg, the point at which power enrichment was observed to substantially begin.) Figure 1-3 shows the observed trade-off between hot start CO emissions and the diverted air; Table 1-9 lists the hot start emission data. Even though WOT represents only a small amount of the total test time (4.5 percent), the CO emissions attributable to this fraction of operation are relatively high. By allowing more air to reach the catalyst, (i.e., air was injected a greater percentage of the time the engine was at WOT), there was a dramatic reduction in CO emissions. In fact, with full-time air injection, CO emissions were virtually eliminated. EPA's

Table 1-8

Catalyst Feasibility Testing on the EPA Transient Test Cycle

Engine	Test Facility	Weighted Emissions (g/BHP-hr)* HC	CO	Comments
1979 GM 292	EPA	.58	12.25	Dual 50 g/ft^3 catalysts, 2:1 ratio of platinum palladium
1978 Production IHC 404	EPA	.28	8.98	Dual air pumps, 4-113 in^3 oxidation catalysts.
	EPA	.32	3.74	Extrapolated emissions with fourfold increase in air injection, four oxidation catalysts.
	EPA	.68	3.6	Dual-bed system and EGR, closed loop feedback carburetor, 2-151 in^3 TWC and 2-173 in^3 oxidation catalysts.
1975 GM 350	SwRI	.39	5.6	COC/TWC pelletized catalysts, closed-loop feedback carburetor.
1985 Prototype Ford 7.5L	EPA	.72	7.22	4-150 in^3 COC LDT catalysts in parallel, dual air pumps.
Prototype GM 350	GM	.53	5.62	2-260 in^3 COC new pelletized catalysts.

* EPA cycle based.

Table 1-9

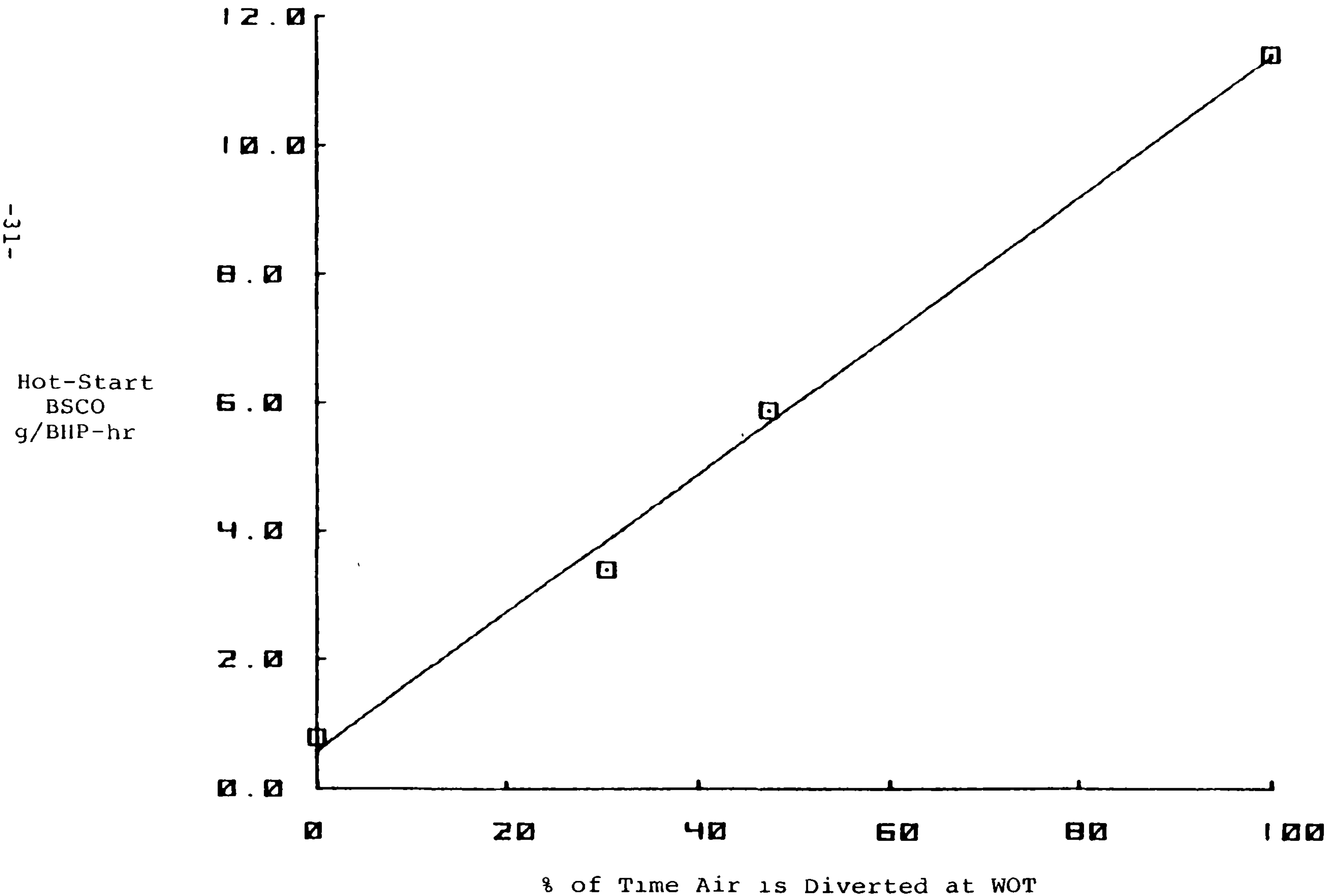
Hot Start CO Emissions As A Function Of Air Diversion at WOT

% Time at WOT	Air Dumping % Time of Complete Transient Test	CO Hot Start Emissions (g/BHP-hr)
0	0	.79
30.4	[illegible]	3.40
47.4	2.2	5.88
100.0	4.5	11.40

Note: Maximum catalyst bed temperature did not vary significantly between any of these tests, and never exceeded 1,600°F.

Figure 1-3

Hot-Start CO Emissions As a Function of Diverted Air From the Catalyst



testing also indicated that as much as 60 percent of the air can be diverted from the catalyst at WOT while still attaining a target CO emission level of 7.1 g/BHP-hr (EPA cycle based).* This ability to "by-pass" air, while still attaining required emission levels, has important implications for catalyst protection systems, as discussed later in this analysis. In summary, however, EPA sees no obstacle which would prevent modification of existing LDT or HDE air pump systems for usage with HD catalysts.

With respect to catalyst design, the two most important factors with respect to catalyst application to HDGEs are the noble metal loading and catalyst size. Location and geometry of the catalyst also affect its efficiency, as does substrate and noble metal material and density. Due to the higher mass flow of exhaust observed at full power on the HD test cycle, some changes may need to be made to existing LDT catalyst systems to maintain adequate CO oxidation efficiencies at these modes. In the worst case, larger, more heavily loaded catalysts may be needed. In other cases, changes to the exhaust and catalyst system geometry to increase gas residence time and eliminate "break through" at maximum exhaust flow will be necessary.

To evaluate how changing the geometry of the catalyst system affects its efficiency, EPA recently tested a Ford 7.5L engine with two catalyst configurations: 1) four catalysts in parallel, and 2) two sets of two catalysts in series. The brake specific carbon monoxide emissions for the parallel version were 59 percent lower than the emissions for the series version. By splitting the exhaust four ways instead of two, the exhaust flow velocity decreased, thereby increasing the residence time of the gas in the catalyst. This presumably allowed more time for the oxidation reaction to occur (eliminating "breakthrough"), and thus yielded lower overall CO emissions.

In summary, industry has several design options to maintain the required catalyst efficiency at full-power modes and to ensure that catalyst-equipped HDGEs meet the required CO target level. (EPA's earlier analysis[5] concluded that HC emissions will be reduced as a matter of course, and will be achieved primarily by assuring sufficiently prompt catalyst light-off on the cold start; EPA's recent data substantiated these earlier conclusions.) EPA believes that these

* Target CO Emission Level = 1/DF X 1/AQL X Emission Standard, where AQL = 1.283 (from above), and the multiplicative DF = 1.7 (from Reference 9).

modifications to air injection and catalyst systems are possible. Moreover, EPA believes that they represent the transfer of known emission control technology to different applications, and do not represent fundamental technological unknowns.

Catalyst Survivability

High operating temperatures create problems for maintaining catalyst efficiency over time:

> "The primary material used currently to support the noble metal catalyst in automotive converters is gamma alumina, in the form of either pellets or a washcoat on cordierite monoliths. At elevated temperatures, a phase change to alpha alumina begins which is accompanied by a reduction in the structural strength and surface area of the material. Active catalyst sites tend to diffuse and agglomerate as well as become inaccessible due to the loss of porosity; this process effectively reduces the number of sites available for catalysis and hence lowers the efficiency of conversion. Finally, the magnitude of the physical changes which occur in the alumina above the safe operating temperatures is a function of temperature, time of exposure, and the presence of certain ions which stabilize the gamma lattice."[9]

Due to the time and condition dependency of catalysts, there is no exact temperature above which a catalyst will suddenly fail. It is generally accepted that above 1,800°F, a catalyst will suffer serious damage. Operation between 1,600°F and 1,800°F is possible, but thermal degradation increases with time spent within that temperature range.

While none of the manufacturers in their comments disputed that the emissions from a heavy-duty engine can be reduced below the standards, they argued that catalysts are not feasible for all trucks. They argued that heavier trucks cause special problems for catalysts, such as the continually higher temperatures and greater mass flow of emissions from vehicles which spend a large percentage of operational time at full or very high power. They contended that these conditions seriously threaten the durability of currently available catalysts. EPA has since recognized the manufacturers' concerns of increased difficulty and cost of protecting catalysts under these circumstances, and thus EPA proposed the split-class approach as a solution.[7] In essence, the split-class approach allows more time for application of catalyst technology to worst case operational applications. The heaviest HDGVs (above 14,000 lbs. GVW), and also a limited number of lighter vehicles intended for the most severe applications, would continue for now to meet non-catalyst standards of 2.5/40.0. For these reasons, EPA believes that catalysts would not see extended service in severe operating temperatures if the "split-class" approach were adopted. This "split-class" approach is therefore the most important factor in assuring catalyst durability, presuming the use of existing catalyst materials and substrates.

Recent testing at EPA also included examination of the catalyst temperatures under various types of operation. The catalyst bed temperature of the Ford 7.5L heavy-duty engine never rose above 1,600°F during the transient test cycle for the parallel catalyst version; the version with series catalyst had maximum bed temperatures approximately 50°F higher in the catalysts closest to the exhaust manifold. A Ford 302 LDT engine that was tested on the HDE transient cycle by EPA had a maximum catalyst temperature of 1,640°F. Catalyst temperatures were also observed under conditions more severe than the transient test. Table 1-10 lists the maximum catalyst temperatures during WOT engine maps for two engines tested by EPA. Mapping conditions are extreme, and as expected, the catalyst temperatures are higher. Indeed, catalyst temperatures typically reach a maximum after the engine operates for sustained periods of time at WOT. Protection of the catalyst from too much oxidation of CO would be necessary at these conditions, if such conditions were expected to routinely occur in-use. (Note that these conditions are not seen on the transient test.) Again, however, EPA believes that the "split-class" approach would virtually eliminate sustained full-load operation from the vehicles required to use catalysts.

Aside from the elimination of the applications most detrimental to catalyst survivability, there are other strategies available to protect catalysts on HDGEs.

With increased air injection, the catalyst bed temperature increases as more oxidation occurs. One obvious means of protecting the catalyst at WOT is to divert the injected air from the catalyst mechanically, thus precluding increased oxidation. However, air injection cutoff at full load also may cut off CO control at the most significant moment. This creates an inherent trade-off between catalyst temperature and CO emissions.

This trade-off, however, is not significant enough to preclude compliance with the statutory CO standards. EPA bases this judgment on the test data discussed above, with which it was demonstrated that, for at least one engine, air injection could be completely diverted for up to 60 percent of the time spent at WOT on the transient test, and sufficiently low CO emission levels could still be maintained (see Figure 1-3 and

Table 1-10

Maximum Catalyst Temperature During WOT Engine Map

Engine	Catalyst Configuration	Temperature, °F
1980 GM 305-CID LDVE equipped with air/ oxidation catalyst/ EGR	One catalyst, stock location	1,734
"	4.5 feet downstream	1,660
"	6.5 feet downstream behind muffler	1,402
1985 Ford 7.5L HDE, equipped with air/ oxidation catalyst	4 catalysts in parallel 6 feet downstream	1,650

Table 1-9). This indicates to EPA that some form of the WOT air injection cutoff presently found on LDTs could be applied to HDGEs. In short, additional catalyst protection can be provided while still maintaining acceptable emissions levels.

Over-temperature protection systems, particularly for non-catalyst engines, have been discussed at some lenth by GM in earlier submissions. GM discussed several concepts, including one which would completely cut off full-power air injection after a certain amount of time (e.g., one minute) at sustained full power. GM noted that maximum temperatures require a certain amount of time to build up, and that such a system would protect the engine, and at the same time would be required very little in typical urban driving. GM's apparent concern, however, is that EPA may rule such a system to be a "defeat device" and forbid its use. EPA at this time cannot specifically approve or disapprove any system described to the Agency in a cursory or qualitative fashion; indeed, EPA's "split-class" approach should eliminate the need for such a system for now. However, past EPA policy with respect to the determination of defeat devices does not necessarily preclude the use of such a system. In general, EPA policy has been not to classify a technology as a defeat device if it can be demonstrated that such a device is essential for protecting the integrity of the engine, the integrity of the emission control system (e.q., catalysts), or the safety of the vehicle. In short, provided that such demonstrations can be made (for either catalyst or non-catalyst engines), additional flexibility could be available for protection from excessive temperatures, despite EPA's present belief that such protection is not currently necessary.

An additional means of providing temperature protection for the catalyst system has been discussed in earlier EPA analyses[9]--the ability to relocate that catalysts further downstream in the exhaust system. There are limitations to the degree of relocation protection available, primarily because HC emissions tend to increase dramatically as catalyst light-off time is sufficiently increased. However, a limited amount of temperature protection should certainly be available through relocation of the catalyst.

Finally, one additional measure providing major flexibility for certification will be available to the industry; EPA intends to retain the option of allowing a manufacturer to certify any vehicle of 10,000 lbs. GVW or less on the LDT chassis test procedure to LDT emission standards. Whether or not this option is exercised will be based upon the manufacturer's judgment of relative compliance costs; it is an option, however, which remains available.

In summary, EPA does not expect HDGE catalyst durability to represent a major problem. The "split-class" approach eliminates the most problematic applications. Several other techniques of catalyst and engine temperature protection are available. Air injection diversion at full load would be a technical derivative of systems already in production for LDVs and LDTs, and can be calibrated in such a way to both provide protection and achieve required emission levels. Catalyst relocation can also provide additional minor protection. Other protection systems could be used, if EPA were convinced that they were truly necessary for engine or catalyst survival.

Leadtime

This discussion focuses on the technical leadtime necessary to allow compliance with the "split-class" approach; legal issues regarding leadtime are specifically addressed in the Preamble of this rulemaking.

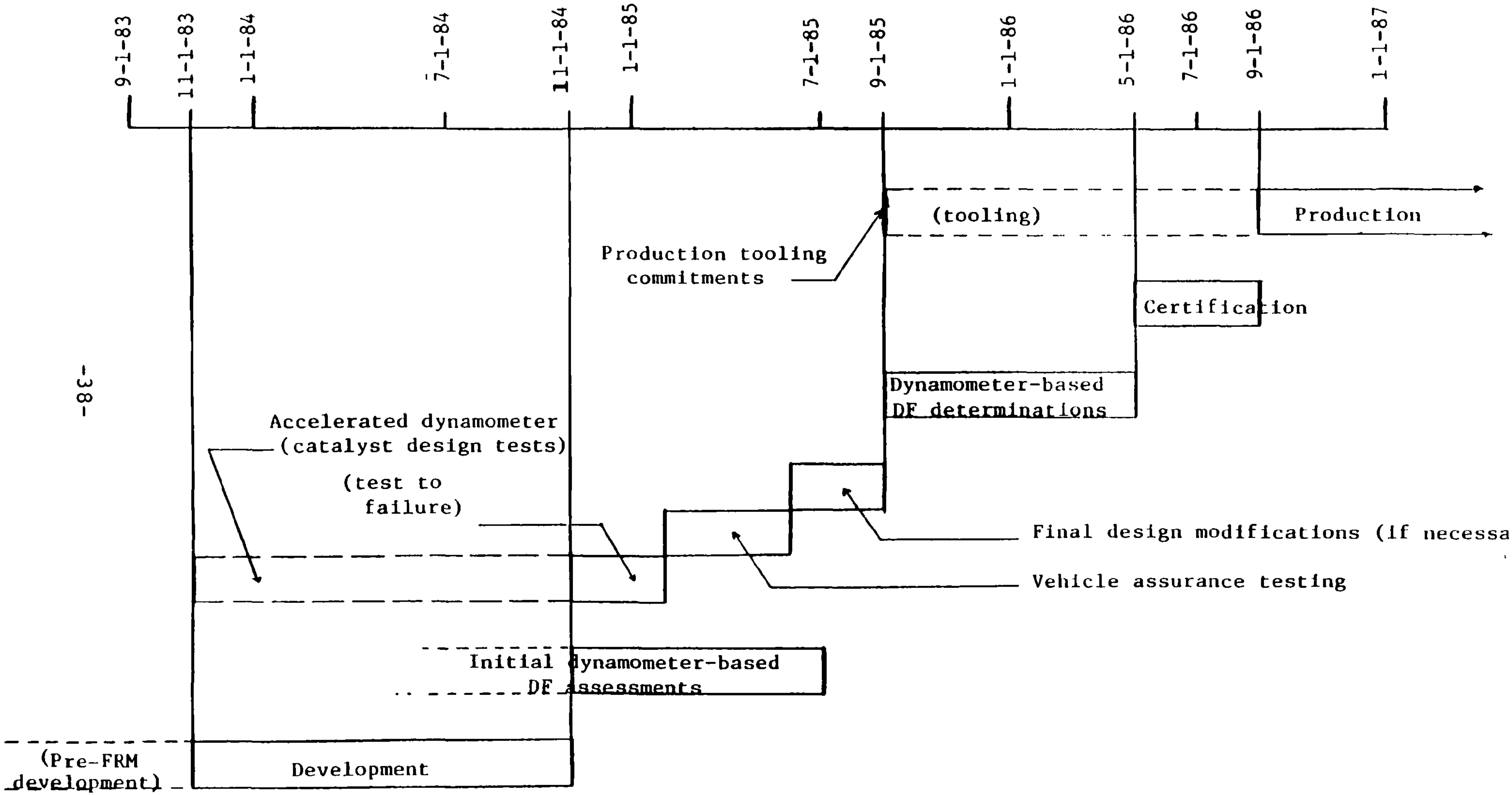
An outline of the technical ability of the manufacturers to comply with the statutory standards for HDGEs in Classes IIB and III applications is presented below. This general schedule (Figure 1-4) assumes a significant, although certainly attainable, compliance effort by the manufacturers. Of course, the specifics of the situation facing each manufacturer will determine exactly how much time is necessary for each phase of the effort and what sequence will be followed. The schedule in Figure 1-4 and the discussion below are intended to illustrate what needs to be known and what needs to be done; by allowing a reasonable amount of time for each phase, the feasibility of compliance is demonstrated.

The work can be viewed as phases of development, dynamometer and vehicle assurance testing, dynamometer-based DF determination, and certification. These phases are not necessarily sequential; in fact, there is certain to be a considerable amount of overlap. Assumptions that have been made in developing this schedule are noted where appropriate.

There are a few decisions that will be made, at least on a tentative basis, early in the development process. Under the split-class approach, where all worst case HDGEs (in terms of difficulty of catalyst application) are certified to non-catalyst standards, manufacturers are expected to divide their HDGEs into families on the bases of displacement and catalyst use. The families will be divided in such a way as to minimize disruption to the manufacturer's product line and inconvenience to the consumer. In addition, manufacturers will avoid situations that could result in competitive disparities; for example, a manufacturer would not want to use catalyst-equipped engines in vehicles that are in direct competition with similar vehicles without catalysts from

Figure 1-4

General Leadtime Schedule - MY87 HDGE Standards



a different manufacturer. In short, the manufacturers will substantially determine the structure of their 1987 product lines. The manufacturers will also make tentative judgments of likely DFs and the impact of the SEA requirement (effective in the 1986 model year), and thereby estimate target emission levels and the likely hardware and engine calibrations needed to begin development.

The most important phase, which EPA expects to last until October 1984, is for development work. It is clear from the history of this action and from manufacturer comments that preliminary development work has already been underway for some time, that a significant portion of the necessary work (i.e., reduction of engine-out emission levels) will have been performed in complying with the 1985 model year interim standards, and that early catalyst testing has been in progress since January 21, 1980. (For example, in comments submitted to EPA in April of 1982, GM provided a lengthy submission covering their heavy-duty catalyst development work to date.) EPA believes that the most significant problem to be solved during development is determining the catalyst configurations and engine calibrations that will be needed in order to demonstrate compliance on the HDGE transient test. Technically, this is a relatively straightforward engineering problem of applying known technology to new applications. As noted earlier in this chapter, the same generic technology will be used, with problems and engineering parameters similar to those encountered in applying catalysts to LDTs.

It is assumed that accelerated dynamometer testing, a fundamental part of engine and catalyst development, will occur during the development phase. Limited dynamometer-based DF assessments can also be conducted as part of the development phase in order to provide preliminary DFs. Following this, worst case durability assessments will be run to check for catastrophic failures. Such failures will become apparent in accelerated dynamometer testing, the last round of which is estimated by EPA to extend three months beyond actual development. (For mileage/service accumulation purposes, this testing may proceed 24 hours a day under automatic control. Thus the 1,500-hour half-life equivalent could be reached in as little as 2.4 months, assuming operation for six days per week. Note that GM's standard corporate durability test generally runs about 200 hours.) Approximate DF determinations based on dynamometer operation for the equivalent of the full-life (3,300 hours) could therefore be completed conservatively within eight months after the development phase is concluded.

After the worst case durability assessments are completed, EPA estimates that basic vehicle assurance testing could be done in about four months. This vehicle assurance testing will allow comparison of in-vehicle and dynamometer-based DFs, as well as assessment of the effectiveness of vehicle modifications (heat shields, catalyst location and mounting), system reaction to on-road phenomena (vibration), and overall effect on performance characteristics (driveability). Four months is adequate time to accumulate at least 25,000 miles of in-vehicle use, assuming 10 hours per day on the road for 5 days per week at an average speed of 30 mph. Vehicles in this program could be left in service; only the catalysts need to be switched periodically for inspection and oxidation efficiency testing on well-characterized engines. Assuming that the in-vehicle testing conditions are appropriately planned, four months should be more than enough time for identification of any vehicle-related flaws.

EPA assumed three months beyond the work described above for final design modifications to be implemented, if any are found to be necessary. All of this could be completed by September 1985, at which time production tooling commitments could be made. At this point a full year would remain before model year 1987 "Job 1" production must begin.

Although EPA considers the possibility to be remote, any fundamental problems that may arise should be evident after the completion of vehicle assurance testing and dynamometer-based preliminary DF assessments. Existing regulatory provisions would allow a manufacturer to petition EPA for relief in the event a serious risk of non-compliance appeared likely at this time. EPA does not believe, however, that such relief will be necessary on the basis of all information available at this writing.

The remaining 12 months before "Job 1" would be used for final dynamometer-based full-life DF determinations, which should take eight months or less, and certification. Under procedures applicable for 1985 and later model years, durability testing is not required to be a part of the formal certification process. If further changes to calibrations or hardware appear necessary, manufacturers would have the option of foregoing the eight month durability assessment, and merely use engineering judgment or use predetermined DFs for certification. Certification should then begin no later than May 1, 1986, and should take no longer than four months.

In summary, EPA estimates that compliance with the "split-class" approch is feasible for the 1987 model year.

Having outlined a general schedule that demonstrates the feasibility of compliance by model year 1987, EPA takes issue with the technical leadtime estimates supplied by Ford in its comments. Ford considerably overstated the amount of time necessary, and seemingly disregarded the considerable progress that has already been made. Where Ford has included three complete iterations of designing, building, and testing, EPA believes that at most two iterations will be required, particularly because of existing experience with LDT technology and because all worst case applications are excluded under the split-class approach. Ford also estimated the certification process to last for three years, which EPA finds unreasonable and unlikely.

On the other hand, the EPA leadtime estimates allow for little slack time. Despite EPA's judgment that legal authority exists for requiring compliance by model year 1986, the elimination of 12 months from the time estimates discussed above would preclude orderly development and make the risk of non-compliance for 1986 unacceptably high. With respect to 1987, EPA again stresses that all truly worst case HDGE applications, in terms of catalyst use, are excluded from the statutory standards by the split-class approach. In addition, catalyst-forcing emission standards for HDGEs were first promulgated in 1979. The interim standards for 1985-86 were never intended to defer catalyst standards permanently, but merely to provide short-term economic relief. Thus the Agency is confident that implementation of this approach by 1987 poses no insurmountable difficulties for the industry.

Conclusions

Statutory emission standards (1.1 g/BHP-hr HC and 14.4 g/BHP-hr CO based upon the MVMA cycle) for Classes IIB and III HDGEs should be promulgated for the 1987 model year. All heavier HDGEs should continue to meet non-catalyst standards, as would the small number (5 percent of total Classes IIB and III sales; see the "migration" issue, Section B.12, for further information) of lighter vehicles allowed to certify to non-catalyst standards on the basis of application.

References

1. "Gaseous Emission Regulations for 1984 and Later Model Year Heavy-Duty Engines," Federal Register 4136, Vol. 45, No. 14, Monday, January 21, 1983.

2. "Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines; Revised Gaseous Emission Regulations for 1984 and Later Model Year Light-Duty Trucks and Heavy-Duty Engines," Federal Register 1642, Vol. 47, No. 8, Wednesday, January 13, 1982.

3. "Revised Gaseous Emission Regulations for 1984 and Later Model Year Heavy-Duty Engines and Light-Duty Trucks, Draft Regulatory Analysis," U.S. EPA, OANR, OMSAPC, ECTD, SDSB, Chapter II, September 1981.

4. Derived from comments submitted to EPA Public Docket No. A-81-20.

5. Derived from comments submitted to EPA Public Docket No. A-81-11.

6. Letter from Charles L. Gray, Jr. to Ford Motor Co., General Motors, Chrysler, and International Harvester, June 17, 1982, EPA Public Docket No. A-81-11.

7. "Issue Analysis - Final Heavy-Duty Engine HC and CO Standards," EPA Staff Report, March 1983, EPA Public Docket No. A-81-11.

8. Letter to commenters from Charles L. Gray, Jr., plus attachment, EPA Public Docket No. A-81-11, April 12, 1983.

9. Summary and Analysis of Comments to the NPRM, "Gaseous Emission Regulations for 1984 and Later Model Year Heavy-Duty Engines and Light-Duty Trucks," EPA, OANR, OMS, ECTD, SDSB, December 1979.

2. Issue: Useful Life

Summary of the Issue

This issue addresses the useful-life provisions that will apply to 1985 and later model year light-duty trucks (LDTs) and heavy-duty engines (HDEs). On January 12, 1983, EPA proposed a revised full-life useful-life approach and an alternative for comment (48 FR 1472). This section of the Summary and Analysis of Comments deals with the responses to the proposal and the selection of the appropriate useful-life approach in response to those comments.

Summary of the Comments

Introduction and Synopsis of Events

Useful life is the period, expressed in terms of time or vehicle miles, over which in-use vehicles/engines are required to demonstrate compliance with the applicable emission standards and the period for which they are required to warrant the emissions performance of their products. In 1979 and 1980 EPA promulgated regulations effective for 1984 and later model years that contained revised useful-life periods for LDTs and HDEs. Useful-life periods were changed from fixed intervals, representing periods representing somewhat less than half the service life of these vehicles/engines, to manufacturer-determined periods representing the full average period to engine retirement or rebuild.

EPA adopted these reguations over concern about the in-use performance of HDEs. Half-life regulations provided no incentive for manufacturers to be concerned about the long term emissions durability of their engines, since they had no liability for their performance past the half-life certification period. This problem could be only partly dealt with by establishment of lower emission standards. Lower standards would lower overall average emissions, but would not control departures from standards during the second half of a vehicle's life due to what are often know as "gross emitters". Gross emitters are those vehicles whose emissions are increased severalfold above normal due to the failure of emission control hardware. The in-use failure of emission control components could completely eliminate the improvements gained by lower standards. Indeed, indications are that as more advanced technology comes into use for control of emissions, the effects of in use failure becomes much more pronounced.

The goal, then, was to focus manufacturer efforts more toward in-use performance and durability of their engines and to insure that emission control systems were fully capable of lasting as long as the average engine. Full-life useful life provided that incentive, and gave EPA enforcement authority to deal with problems in the second half of a vehicle's life. It helped insure that durability would not be sacrificed in an effort to minimize costs. EPAs analysis of both the costs and air quality impacts of full-life useful life indicated that it was a beneficial and cost effective program.

Subsequent to that rulemaking, LDT and HDE manufacturers raised a number of issues relating to the practical problems of useful-life determinations and possible high costs of implementing a full-life useful-life approach. As a result, in April of 1981 EPA agreed to undertake a further study of the useful-life issue as a part of the President's program to provide regulatory relief to the automotive industry.

Comments received during the several comment periods and public hearings held during the course of this study led to the January 13 proposal. EPA offered two useful-life options in the NPRM: 1) a modified full-life requirement designed to address previously expressed concerns regarding full-life implementation, and 2) an extended half-life proposal with slightly more stringent emission standards to compensate as well as possible for the reduced stringency of half life. A formal durability testing program accompanied the half-life proposal, whereas the full-life allowed manufacturers to design their own programs. EPA's stated preference was for the modified full-life option; the half-life plan was provided only in the event of unforeseen problems with resolving full-life implementation issues.

The majority of the manufacturers favored a half-life useful-life definition; however, none found the EPA half-life proposal with the adjusted standards and extended durability testing to be acceptable. Although some manufacturers were willing to accept a longer useful-life period than presently exists none was willing to also accept the downward adjustment in the emission standards. Rather, they advocated a half-life useful life with no adjustment of the standards or durability testing requirement. However, acceptability of the half-life plan to EPA was fully contingent upon the adjusted standards to account for the decrease in the compliance period and upon extended durability testing requirements to increase the focus on emission control performance at higher mileages. The Agency felt that without those compensating qualifications, all of the environmental benefits of full life would be lost and such a change would effectively reduce the stringency of the standards. Since no commenters supported the provisions of the extended half-life approach as proposed by EPA, and since three commenters expressed a preference for modified full life, it is EPA's intention to retain the modified full-life approach. Therefore, the half-life plan will not be analyzed further, and the remainder of the analysis will concern itself only with comments pertinent to modified full life.

Before turning to analysis of specific comments it is important to reaffirm EPAs belief in the value of full-life useful life. EPA continues to hold to its original justification for this program as outlined above. Commenters have argued that EPA has not conclusively demonstrated that the in-use need exists to an extent which justifies taking action. While it is true that there is not a large body of data to demonstrate the need, EPA believes that the logic of the situation, along with what data is available argues strongly for the establishment of full-life useful life. Indeed, the very vigor of much of the opposition to extending manufacturers' responsibilities into the second half of the useful life argues in favor of the need for this action. If, as argued by manufacturers, the current durability of emission control components is adequate, then there is little risk involved in extending the useful life period. EPA believes that full-life useful life is needed to insure durable components and to provide an enforcement mechanism for in-use problems.

The comments have been divided into major and minor issues for convenience of analysis. Within the group of major issues, five significant areas have been identified. These include: 1) legal objections to EPA's modified full-life approach, 2) concerns related to the recall provisions, 3) the heavy-duty diesel engine subclasses, 4) the assigned useful-life periods, and 5) the air quality benefits associated with full life. In response to the last issue, an update of the environmental impact and cost effectiveness of useful life was undertaken which forms a part of the Regulatory Support Document. Briefly, since it will not be considered further here, this analysis shows that the adoption of EPA's modified full-life approach will produce up to a 1 percent improvement in air quality for ozone and CO in the mid-late 1990s. The analysis further shows that full life is very cost effective in comparison with other emission control strategies, projecting costs-effectiveness values of $206-484 per ton for HC and $12-24 per ton for CO. Interested parties are referred to Chapter 3 of the Support Document for further analysis in this area. Discussions of the other four main issues and several minor issues are presented below.

Legal Issues

Summary of the Comments

A large number of comments were received concerning EPA's legal authority for implementing the modified full-life approach. Comments fell in four major areas: 1) statutory authority for the full-life concept, 2) authority to establish different useful-life periods for purposes of certification, warranty and recall, 3) authority to group LDTs under 6,000 lbs. GVW with heavier LDTs and HDEs for the purposes of useful life, and 4) the appropriate period of recall liability for in-use vehicles and engines. These are discussed below.

Many comments were received that reiterated (either directly or by reference) claims made during the original rulemaking that EPA does not have the statutory authority to implement a full-life useful-life definition. A substantial number of commenters addressed the issue of Congressional intent with respect to a half-life versus a full-life definition, and cited portions of the legislative history of the Clean Air Act which they believed demonstrated that Congress intended that the half-life concept be retained for LDTs and HDEs, regardless of the actual language in the Act.

Second, comments were received on the modified full-life proposal which argued that the Act limits EPA to a single useful-life period for both certification under Section 202(a), and the in-use programs contained in Section 207 (warranty and recall). The commenters therefore concluded that EPA was precluded from establishing a useful-life period for warranty that was different from the useful-life period for certification and recall liability.

Third, Volkswagen of America (VW) stated that EPA had no statutory authority to create a separate LDT class for useful-life purposes for LDTs under 6,000 lbs. GVW. VW argued that the court decision which initially led to the creation of the LDT class by EPA (International Harvester vs. Ruckelshaus, 478 F. 2d 615, D.C. Circuit, 1973) applies only to the level of the emission standards, and does not extend to other regulatory requirements. Based on this premise, VW took the position that LDTs of less than 6,000 lbs. GVW may not be required to conform to a period longer than the statutory period for light-duty vehicles (LDVs) (i.e. 5 years/50,000 miles).

Fourth, several commenters expressed concern about the scope of their liability during a recall action. They believed that the full-life recall provisions would force them to "fix" all the vehicles/engines in the recalled group regardless of their age, mileage, or condition. The comments took the position that their recall liability should end with the assigned useful life and that they should not be responsible for any vehicle engine which has been rebuilt, regardless of mileage.

Analysis of Comments

The question of Congressional intent and EPA's statutory authority to adopt a full-life useful-life definition for LDTs and HDEs was also raised when the full-life concept was first proposed for these vehicle/engine classes. During those rulemakings, EPA prepared two separate Summary and Analysis of Comments documents on the full-life useful-life proposals, one each for LDTs and HDEs, and these are herein incorporated by reference.[1,2] These analyses concluded, as EPA still concludes, that the Clean Air Act as amended in 1977 provides the Administrator full authority to set the LDT and HDE useful life at any period of time and/or mileage longer than 5 years/50,000 miles if it was determined to be appropriate.

Manufacturers based their findings of Congressional intent for half life on the differences between the Senate version of the Clean Air Act Amendments of 1977 (S.252) and the final version that emerged from the conference committee and was later enacted. In the Senate version, the useful life for a "motorcycle or any other motor vehicle or motor vehicle engine would be a period of use the Administrator shall determine."[3] In the Amendments as they were enacted, however, "motor vehicle and motor vehicle engine" were removed from this clause and placed in a new clause which read that useful life for "any other" (than light duty) "motor vehicle or motor vehicle engine (other than motorcycles or motorcycle engines)" was to be a period of 5 years/50,000 miles "unless the Administrator determines that a period of use of greater duration or mileage is appropriate."[4] From this change in language, and the past use of the half-life concept for LDVs, LDTs, and HDEs, the commenters inferred that Congress intended EPA to retain the half-life concept for LDTs and HDEs.

First, it should be noted that EPA's authority to establish longer useful-life periods for LDTs and HDEs was established in 1970. The 1977 amendments did not address LDTs and HDEs directly, but were concerned with the problems of existing law created with respect to motorcycles. Thus, the 1977 amendments are not directly relevant to EPA's authority to set useful-life periods for LDTs and HDEs.

Moreover, in EPA's view, setting "any other motor vehicle or motor vehicle engine" apart from motorcycles and light-duty vehicles/engines simply retained a minimum 5 year/50,000 mile useful life for LDTs and HDEs and did not alter the Administrator's specific authority to set a period longer than 5 years/50,000 miles if it was determined to be appropriate. Congress was aware of the ongoing litigation between Harley Davidson and EPA on the issue of motorcycle useful life, and specifically provided statutory language to permit EPA to establish a useful life other than 5 years/50,000 miles for motorcycles in Section 202(d)(3).[5] Had this change not been made, and the Senate version retained, the 5 year/50,000 mile minimum would have been lost for LDTs and HDEs. Congress desired to keep that minimum, which led to the creation of Section 202(d)(2), which also contains EPA's authority to set a useful-life period longer than half-life. Therefore, Congress's action in 1977 can be understood best as an effort to address particular problems for motorcycles without disturbing existing authority for LDTs and HDEs.

This authority for a full-life useful-life definition is perhaps best seen in a simple "plain meaning" reading of the pertinent language in the Act, as shown below (Section 202(d)(1)&(2)) (emphasis added):

> "(d) The Administrator shall prescribe regulations under which the useful life of vehicles and engines shall be determined for purposes of subsection (a)(1) of this section and section 207. Such regulations shall provide that useful life shall:
>
> (1) in the case of light-duty vehicles and light-duty vehicle engines, be a period of use of five years or of fifty thousand miles (or the equivalent), whichever first occurs;
>
> (2) in the case of any other motor vehicle or motor vehicle engine (other than motorcycles or motorcycle engines) be a period of use set forth in paragraph (1) <u>unless the Administrator determines that a period of use of greater duration or mileage is appropriate</u>;"

Moreover, the pertinent legislative history of the 1970 amendments supports the plain meaning of the Act. The brief legislative history addressing LDTs and HDEs shows that Congress rejected approaches that would have limited LDT and HDE useful life to 5 years/50,000 miles, instead giving EPA flexibility to deal with useful life for these vehicles. Given the broad language of the statute and the lack of any discussion demonstrating Congress' desire to restrict LDTs and HDEs to half life, EPA remains convinced that the statutory authority exists for the full-life useful-life requirement for LDTs and HDEs.

Turning now to the comments on separate useful-life periods, the broad authority given to the Administrator to promulgate regulations defining useful life under Section 202(d) and the Agency's general rulemaking authority provide sufficient flexibility to allow the establishment of a reduced useful-life period for warranty liability, provided that the period is at least 5 years/50,000 miles. In fact, there is also some precedent for a reduced warranty period. In the Clean Air Act Amendments of 1977, for example, Congress itself recognized that reduced warranty requirements were appropriate under certain circumstances. Warranty periods of less than the useful life as stated in Section 202(d) were established in the case of certain emission control components. Aftermarket parts that are not intended "for the sole or primary purpose of reducing vehicle emission," but are emission-related, have to be warranted for only 2 years/24,000 miles under Subsection 207(a)(2).[6] Nevertheless, Section 202(a)(1) refers to "a period of use" for light-duty vehicle useful life; Congress evidently believed varying useful-life periods could exist notwithstanding the apparent reference to a single period. Since Congress was clearly aware of the possibilities involved and yet did not specifically prohibit the Administrator from making similar determinations for LDTs and HDEs, EPA concludes that authority exists under the general and specific authority mentioned above to allow the establishment of reduced warranty periods, and that the Administrator is not restricted to only one useful-life period for certification, warranty, and recall purposes.

It should be kept in mind that the reduced useful-life period for warranty is an attempt to be responsive to manufacturers' valid concerns with having to warrant LDTs and HDEs for their full useful lives, while not sacrificing the air quality and durability benefits of the earlier full-life useful-life requirement. EPA could have promulgated more stringent half-life standards with increased durability requirements, but opted instead for an approach that at least was favored by some manufacturers.

Finally, although EPA believes, for the reasons set forth above, that it would have authority to establish a different useful-life period for purposes of recall, that is not what the Agency has done. As discussed below, manufacturers in a recall will be required to repair non-conforming LDTs and HDEs regardless of age or mileage at the time of repair. EPA, as part of this rulemaking, has simply established a policy that LDTs and HDEs will not be tested for purposes of recall if they exceed 75 percent of their useful life. Indeed, even in the established LDV recall program EPA typically tests cars that are only two to three years old, notwithstanding a 5-year useful-life requirement. The recall policy established today for LDTs and HDEs is an attempt to be responsive to manufacturers' concerns that wornout or otherwise unrepresentative engines may inadvertently be selected for recall testing.

Turning to the issue raised by VW, EPA cannot accept VW's contention that the decision of the Court of Appeals in International Harvester v. Ruckelshaus was applicable only to compliance with emission standards. The decision of the Court led EPA to initiate a rulemaking which ultimately established the definition of a new LDT class and an entire set of emission regulations for new 1975 and later model year light-duty trucks. (85 CFR - Subpart C)(See 38 FR 21362, August 7, 1973). Since that time LDVs and LDTs have shared common requirements only when it was found to be technologically appropriate (e.g., test cycle). Beginning in 1979 the LDT class was expanded from 0-6,000 lbs. GVW to 0-8,500 lbs. GVW, and in subsequent regulatory actions EPA has used the general authority of Section 202(a)(1) to group the lighter weight LDTs with the heavier LDTs for purposes of complying with mandates of other portions of Section 202. In 1977, when Congress added language to the Act authorizing EPA to establish classes and categories for setting standards for HDEs, it specifically ratified EPA's approach for LDT regulations.[7]

Given that the Court of Appeals ordered EPA to remove light-duty trucks from the light-duty vehicle class in 1973, and that EPA has operated with a distinct set of LDT emission regulation and standards since 1975, EPA sees no merit in VW's argument. EPA believes that setting LDT useful life under Section 202(d)(2) is consistent with the past practice of establishing separate LDT provisions, and is a correct usage of Section 202(d)(2) since LDTs are neither LDVs nor motorcycles.

Finally, EPA recognizes the manufacturers' comments on recall liability. Current EPA policy is that all non-conforming vehicles/engines in a recalled family must be "repaired" regardless of their mileage, age, or condition at the time of repair. Recall evaluation testing will not be conducted past 75 percent of the assigned useful life; however, if a defect is discovered during such testing, it must be remedied for all non-conforming vehicles/engines in that family.

The Agency is now involved in litigation over this requirement (General Motors v. EPA, No. 80-1868, D.C. Circuit, 1980), so it is subject to possible revision based on the outcome. Final EPA response to these concerns is therefore not possible at this time.

Conclusion

The Act contains the necessary authority to establish the certification, recall, and warranty provisions embodied in the modified full-life useful-life approach. EPA has significantly revised these provisions in a way that should alleviate the manufacturers' most pressing concerns, while preserving the benefits of a full-life useful life-approach.

Recall Provisions

Summary of the Comments

A number of manufacturers have anticipated problems with the three-quarter-life recall provisions proposed by EPA as part of the modified full-life approach. The Engine Manufacturers Association (EMA) and several industry commenters stated that limiting recall evaluation testing to 75 percent of the assigned useful life would not fully address the problem of including rebuilt and wornout engines in a sample selected for recall testing. The commenters claimed that due to the variability found in actual engine service lives, it was quite possible that a substantial percentage of engines would be rebuilt before reaching the 75 percent of assigned useful-life cut-off point. For example, EMA estimated that 22-36 percent of heavy-duty diesel engines would have been rebuilt and an additional unspecified percentage would be in need of rebuild. Commenters believed that the difficulties in screening such engines would add to the cost of recall testing and might lead EPA to "cut corners" by basing a recall on too small a sample or by including marginal engines in the test program.

The commenters also expressed several other concerns related to the recall program. Mack Trucks, Inc. expressed concern over the potential impact of the 40 percent Acceptable Quality level (AQL) of EPA's Selective Enforcement Audit program on the recall evaluation program, stating that as a result of the 40 percent AQL, there is a near 40 percent chance that an engine taken randomly for recall evaluation may have been above the standard when it left the production line.

Mack Trucks also stated that laboratory-to-laboratory variability must be considered in any recall evaluations, since results of the EPA/EMA round-robin test program indicated that up to a 25 percent variation existed between certain test facilities.

Mack also requested that EPA provide a three model year "grace period" from recall liability for newly introduced engine lines. Mack was concerned that even the best engineering practices may not allow them to predict their in-use emissions deterioration accurately for these new engine lines, and that their in-use engines may exceed the emission standards as a result.

Some manufacturers wanted EPA to limit recall liability to a select list of emission control components only, although the American Trucking Association (ATA) doubted that EPA had the authority to do so.

Analysis of the Comments

The problem of screening vehicles/engines for improper maintenance, abuse, rebuild, wearout, etc., prior to inclusion in a recall sample is not new. Such screening is now successfully conducted in the LDV and LDT recall programs, and EPA expects to use a similar approach under full life for LDTs and in the recall program currently being developed for HDEs. The manufacturers are given several opportunities for participation in the recall program. Under the current program manufacturers are given the opportunity to comment or otherwise respond to the Maintenance/Use Criteria questionaire which serves as the first level of screening for prospective vehicles. The second level of screening is a physical inspection of those prospective vehicles/engines which pass the first level of screening. At this point, the manufacturers are invited to be present at the inspection and to provide input to EPA as to why a given vehicle may or may not be representative for recall evaluation testing. Should any disagreement arise, the current recall program allows manufacturers a full opportunity to challenge vehicle selection. And, of course, the manufacturers are involved in the recall provisions as discussed in Subpart S of 40 CFR Part 85. Finally, in the unlikely event that disagreements with the recall sample remain, manufacturers are given an opportunity, in an adjudicatory hearing, to contest EPA's determination that the class is in non-conformity. The results of that hearing are, of course, judicially appealable.

The above procedures involving recall screening ensure that the manufacturers are indeed involved in the current recall screening process, and EPA fully expects that such involvement will continue in the full-life LDT program and the developing HDE recall program. EPA expects considerable dialogue with the industry on the implementation details of these new programs, and in fact some preliminary discussions have been held. EPA presented a brief synopsis of the current LDV/LDT recall program at the Useful-Life Workshop on February 18, 1983, and a subsequent meeting was held between EPA and EMA representatives on June 2, 1983.[8]

In any event, EPA and the industry are in agreement on the need to develop procedures and implementation approaches for minimizing the possibility that a rebuilt or wornout engine might be included in a recall evaluation sample. Since few LDTs are rebuilt and no HDE recall program currently exists, EPA believes that the full-life useful-life requirement can be implemented now, and the details for implementing the provisions of the recall program for LDTs and HDEs can be refined in the future, through discussions between EPA and the industry.

Although EPA can understand how Mack might make a connection between the 40 percent AQL and its impact on the recall program, there simply is none. SEA and recall are two distinct EPA programs, addressing compliance on the assembly line and in use, respectively. The AQL in SEA testing was not established at 40 percent to condone nonconformance, but was set at that level in recognition of manufacturing practicalities and economic and other negative impacts of an SEA failure (i.e., lost production, lost wages while a fix for the problem is implemented, etc.). In fact, any vehicle/engine which fails during an SEA must be fixed before it can be sold.

It is still the Agency's desire and should also be the manufacturers' goal, that every vehicle/engine produced meets the emission standards when produced. Therefore, EPA does not feel constrained by the 40 percent figure for the recall program, since the goals of the two programs are different. EPA also notes that the LDV SEA program includes a 40 percent AQL and the LDV recall program has not suffered as a result.

In response to Mack's comments concerning laboratory-to-laboratory variability and also as a partial response to Mack's concern over the impact of the 40 percent AQL, it should be noted that the lack of rigidly defined procedures for recall evaluation and for determining that a substantial number of vehicles/engines are in nonconformity, provides EPA some flexibility for accounting for the impact of such factors. EPA expects to continue judicious use of this flexibility in the future to account for factors such as these.

EPA cannot agree to Mack's request for a 3-year grace period from recall liability for new engine lines, while the manufacurer gathers in-use data on the performance of its new engines. Manufacturers do not introduce new engine lines to the marketplace without extensive durability and assurance testing both on engine dynamometers and in actual vehicles before production begins. Given this practice, and EPA's provisions which allow manufacturers to determine their deterioration factors by any means they deem appropriate, the manufacturers should be able to utilize the results of such durability and assurance testing to determine a reasonably accurate deterioration factor. To account for unforeseen problems in use, the manufacturer can always build a cushion into the certification deterioration factor or decrease low-mileage targets and thereby minimize in-use noncompliance risk. Manufacturers cannot be spared the liability of not complying with the emission standards in use. This is a central and important part of the mobile source control program; it ensures that manufacturers build engine/vehicles that perform well in use.

Regarding the idea of limiting recall liability to a specific list of emission control components, EPA cannot accept the manufacturers' position. The industry has argued that emission-related components (i.e., those that affect emissions, but are not specifically designed for emission control--fuel injection systems, for example) should be excluded from recall liability becuase they will be kept in good repair to avoid degradation in performance and fuel economy. This may be true, and, if so, defects uncovered in emission-related components would be rare and should pose no problem to the manufacturers. Conversely, recall evaluation testing may find that there are significant problems with emission-related components, and a recall program would assure correction of these problems.

Publishing a list of select emission control components would preclude the possibility of correcting such problems should they be uncovered. Finally, in the recall provision of the Act, Congress did not limit recalls to non-conformities caused by certain components, but rather required remedial action when a class of vehicles fails for any reason to conform to the applicable emission standards.

Conclusions

EPA will work closely with the LDT and HDE manufacturers to ensure that the new recall programs are implemented in an equitable and reasonable manner, and that manufacturers' concerns over wornout and rebuilt engines are properly addressed. These implementation provisions will be developed with public involvement, and will be modified in the future as experience dictates. There is every reason to believe that these new recall programs can work as smoothly as the current LDV and LDT programs. EPA concludes that no additional recall provisions are required at this time to implement the modified full-life useful-life approach for 1985.

Heavy-Duty Diesel Engine Subclasses

Summary of the Comments

EMA and several manufacturers did not agree with EPA's approach of subdividing the heavy-duty diesel engine (HDDE) class on the basis of gross vehicle weight (GVW). In the proposal, EPA subdivided the HDDE class into three distinct subclasses based on a range of GVWs and then assigned useful-life periods to each subclass. Under the EPA approach, an engine's assigned useful-life period would then be derived from the GVW of the vehicle in which the engine was installed. EMA commented that this approach was flawed because a given engine line might be sold for use in applications which encompassed more than one HDDE subclass. EMA also did not like the nomenclature which EPA used to identify its three HDDE subclasses (i.e., medium, light heavy, and heavy heavy).

As an alternative approach, EMA suggested splitting the HDDE class into three subclasses based on the primary intended service application for which the engine was designed and sold. These three subclasses would be called light heavy-duty diesel engines (LHDDEs), medium heavy-duty diesel engines (MHDDEs), and heavy heavy-duty diesel engines (HHDDEs). The LHDDE subclass would cover applications such as motor homes, multi-stop vans, large utility vehicles, pickup trucks, and delivery vans. The MHDDE subclass would cover engines that were designed for short haul or intracity operation such as van trucks, stake trucks, single axle tractor/trailers combinations, and school buses. The HHDDE subclass would primarily entail engines designed for full-load, long haul intercity operation, such as those used in over-the-road tractor/trailer trucks and intercity commercial buses. EMA further recommended that EPA review each manufacturer's primary service category designation to ensure that engines were properly classified for regulatory purposes.

Virtually all of the HDDE manufacturers concurred with EMA's comments. However, Daimler-Benz and ATA suggested engine horsepower as another plausible approach since it would also allow the manufacturers to characterize the engines in the manner in which they were normally used.

Analysis of Comments

The HDDE classification approach suggested by EMA has considerable merit. Basing the HDDE subclasses on primary intended service applications is preferable to the GVW-based approach by EPA, because it avoids two potential problems of the GVW-based approach. First, it avoids the potential design, certification, and recall complications which arise if an engine model would be used in more than one of the GVW-based subclasses proposed by EPA. This problem is avoided simply because GVW is removed as a useful-life determinant. Second, it avoids the potential problems associated with atypical applications within the GVW-based subclasses proposed by EPA. For example, even though garbage trucks fall in GVW Classes VII and VIII (HHDDE under the EPA GVW-based approach) their engine requirements and vehicle usage patterns are not typical of most Class VII and VIII vehicles. Under EPA's proposed approach these engines would have been assigned the same useful-life period as over-the-road trucks, which probably would not be appropriate. The primary intended service application approach avoids this GVW-based complication, and recognizes that a typical MHDDE may be efficient in this application, and would have a useful life typical of MHDDEs, not HHDDEs.

The HDDE classification approach suggested by EMA is preferable to that proposed by EPA. For those engines which do not readily fall into either the light, medium, or heavy heavy-duty subclass, EPA is retaining the provisions which allow the manufacturer to petition the Administrator for a different useful-life period.

At this time, EPA foresees no need to review the manufacturers' primary intended service determinations as suggested by EMA, and does not desire to establish the need for additional approvals during certification. EPA believes that a labeling requirement could be used to assure that engines are not misclassified. Under this approach, manufacturers will be required to label HDDEs as to the subclass for which they are certified. The label will also include alternative assigned useful-life periods, if applicable, as described above. Market forces should then help ensure proper engine classification by the manufacturer, and selection of the appropriate engine by the purchaser. Although this approach should guard against abuses, EPA retains the right to challenge any manufacturer's practice in determination of subclasses should misclassifications occur.

The horsepower-based approach proposed by two commenters may also be plausible, because there is generally a relationship between engine horsepower and other parameters such as the load factor which could in turn adequately delineate an engine's application. However, this approach is not preferable to that proposed by EMA because no body of data is readily available which could be used to develop an appropriate relationship between engine horsepower and average useful life.

Conclusions

The HDDE class will be split into three subclasses on the basis of primary intended service application, as suggested by EMA. Each engine will be labeled with the subclass for which it is certified. The provision allowing a manufacturer to request a different useful-life value under special conditions will also be retained. However, these values will have to be printed on the label.

Assigned Useful-Life Periods

Summary of the Comments

All of the manufacturers claimed that one or more of EPA's proposed assigned useful-life periods (period to engine retirement or rebuild) as too long. Since the comments pertaining to the various assigned useful-life periods are fairly specific and detailed, they will be grouped by vehicle/engine class and each will be prefaced by EPA's rationale for establishing the useful-life value which was originally proposed. The development of the assigned useful-life periods is more fully documented in an EPA memorandum which was released concurrent with the proposal.[13]

a. Light-Duty Trucks

EPA's proposed assigned useful life of 12 years/130,000 miles was based on an average of the following data:

Engine rebuild surveys

Survey Data Research (SDR) "maximum likelihood"	171,000 miles

SDR "median ranks"	141,000 miles
Scrappage data	
DOE	124,000 miles
Michigan Technological University (MTU)	120,000 miles
Engineering Estimate	
Myers, SAE 750128	100,000 miles
Average	131,200 miles

The two Survey Data Research (SDR) survey numbers were based on the same set of survey data, aggregated and analyzed in two different ways. Ford Motor Company stated that this was inappropriate because if the data set forming the basis for the two analyses were biased in any way, the effect of the error would be doubled (since it would constitute 40 percent of the average, rather than 20 percent). Ford believed that the data were biased, because the two projected engine rebuild mileages were higher than the mileage at which the average vehicle would be scrappped by roughly 20,000 and 50,000 miles, respectively. Ford claimed that this was contrary to the common sense conclusion that the miles to rebuild should be less than the mileage at the vehicle scrappage point.

EMA and GM stated that the use of scrappage data in developing useful-life mileage values for LDTs and HDEs was inappropriate because the data included engines that had been rebuilt, therefore raising the average scrappage point mileage. They also asserted that use of scrappage-rate data represented a departure from the Agency's original regulatory intent of basing useful life on mileage to engine rebuild. GM carried this argument one step further, saying that useful-life periods should be based on the need for rebuild rather than on "owner action," (i.e., actually having the engine rebuilt). GM did not offer any suggestions, however, as to exactly how this determination was to be made, other than to say that they felt EPA's previous effort to provide objective end-of-life indicators for screening wornout engines out of recall samples (the rebuild criteria in 40 CFR §86.084-21) was "unworkable" in terms of accomplishing the stated objective.

VW argued that the data used by EPA to develop the LDT assigned useful life did not include the smaller 4-cylinder pickups that have been introduced in the last few years and which they felt are not designed for a useful life of 130,000 miles.

b. Heavy-Duty Gasoline Engines

EPA averaged the following data in proposing an assigned useful life of 120,000 miles for HDGEs:

Rebuild surverys	
SDR "maximum likelihood"	134,000 miles
SDR "median ranks"	124,000 miles
Fleet Maintenance and Specifying magazine[9]	100,000 miles
Scrappage rate data	
DOE	129,000 miles
MTU	114,000 miles
Average	120,200 miles

Ford, GM, and EMA all felt that the useful life for HDGEs should be 100,000 miles or less. This contention is based on the arguments mentioned above for LDTs regarding scrappage data versus rebuild data and also on their belief in the possibility that the SDR survey data overstated mileage to rebuild. EMA suggested the inclusion of data from a rebuild survey conducted by the ATA and also engineering estimates from a draft study done under EPA contract by Arthur D. Little, Inc.[10,11]

c. Heavy-Duty Diesel Engines

In the proposal, EPA split the HDDE class into three subclasses based on GVW, and proposed useful-life periods based on the general design and usage characteristics of each. The "medium-duty diesel" subclass, all HDDEs in vehicles less than 19,500 lbs. GVW (Classes IIB-V), represented a relatively new diesel application in a field heretofore dominated by gasoline engines and there were few data available regarding average service life. However, EPA reasoned that since these engines introduced as a replacement for HDGEs, they should last as long as the gasoline engines they were designed to replace in order to be competitive, and so a similar useful-life period of 120,000 miles was proposed.

The second subclass proposed, "light heavy diesel," (19,501-26,000 lbs. GVW - Class VI) had a useful-life period of 200,000 miles, which was determined by averaging the following data:

Rebuild Surveys	
SDR (Class VI engines)	203,000 miles
Fleet Maintenance and Specifying Magazine	229,000 miles*
Engineering Estimate	
Myers	162,500 miles**
Average	198,167 miles

* Average of values for sleeved and non-sleeved bus engines.
** Midpoint of range.

The third subclass was called heavy heavy-duty diesel (GVW above 26,000 lbs. - Classes VII-VIII). Since the data available indicated that virtually all heavy heavy-duty diesel engines were rebuilt, the proposed useful-life value was based on an average of two rebuild surveys:

SDR	267,000 miles
Fleet Maintenance and Specifying Magazine	281,000 miles
Average	274,000 miles

Since most manufacturers supported the EMA alternative HDDE classification scheme discussed earlier, their comments concerned both the methodology used by EPA to develop the proposed useful-life values and EPA's methodology and its results as they applied to the HDDE subclasses suggested by EMA. Since EPA has accepted the EMA classification system, the summary and analysis of comments for HDDEs will focus on those comments pertaining to EPA's methodology for estimating useful-life periods and the relationship between the assigned useful-life periods proposed by EPA and the EMA HDDE subclasses.

For the sake of clarity, further references to the HDDE subclasses will use the EMA terminology (LHDDE, MHDDE, and HHDDE). When the subclasses proposed by EPA are mentioned, their full names with be used (medium-duty diesel, light heavy-duty diesel, heavy heavy-duty diesel).

Having presented the necessary preliminary information, we turn now to the comments. First, no significant comments were received on EPA's proposal that the medium-duty diesel assigned useful-life period should be the same as that used for HDGEs. Ford agreed with this approach.

For the next subclass, EMA disagreed with EPA's use of the vocational groupings in the Fleet survey as being representative of LHDDE and MHDDE usage for establishing useful-life periods. The Fleet survey aggregated the data on the basis of vocational application (e.g., bus fleet, utility) as well as on the basis of some significant engine design characteristics (sleeved versus non-sleeved engines). EMA suggested that since most MHDDEs are non-sleeved, the MHDDE assigned useful-life period should be based on the Fleet rebuild mileage for non-sleeved engines (175,000) rather than on vocational categories.

EMA and Ford suggested that the SDR survey rebuild mileage for Class VI engines used in the EPA calculation of the useful-life period proposed for light heavy-duty diesels was inappropriate for use in calculating the useful-life for MHDDEs under the EMA classification system. Even though the light-heavy-duty subclass proposed by EPA and the MHDDE subclass proposed by EMA are quite similar, it was thought that the SDR sample for Class VI engines likely included a number of premium HHDDEs which would raise the average rebuild mileage. Thus, EMA and Ford believed that the MHDDE useful life should be less than that determined for EPA's GVW-based light heavy-duty diesel subclass.

It was also suggested that data from the ATA maintenance survey and from the draft study by Arthur D. Little be added to the data used for calculating the average useful-life periods. Given this information, EMA, Ford and GM felt that the MHDDE average full-life value should be 170,000 miles, based on the change in methodology. Caterpillar felt the MHDDE figure should be 150,000 miles, based on an average value of different applications of their 3208 model.

There was not significant disagreement on the assigned useful-life period of 275,000 miles EPA proposed for heavy heavy-duty diesel engines, although several commenters noted that operation of Class VII trucks is not typical of that of Class VIII trucks. In their view, the 275,000 miles was far more representative of Class VIII operation than Class VII operation.

EMA also suggested that the EPA assigned useful-life year values were not equivalent to the mileage values for the various classes/subclasses. They argued that equivalency should be maintained.

Analysis of the Comments

a. Light-Duty Trucks

EPA accepts the Ford comment regarding the use of two different numbers resulting from alternative analyses of the same set of data in the SDR survey. EPA intended to use the SDR data as a rebuild mileage survey, and to let the scrappage rate data serve for high-mileage non-rebuilds. Since the SDR "maximum likelihood" figure in question includes non-rebuilt engines in determining average lifetime mileages, it would be inappropriate to include it as a rebuild figure. Therefore, EPA has dropped the SDR "maximum likelihood" value from the averaging total and has used only the "median ranks" value, which is limited to rebuilt engines.

Regarding the comments on including scrappage data in the useful-life calculation, EPA believes the manufacturers have misinterpreted the Agency's intent regarding what constitutes useful life. In the original full-life useful-life regulations, useful life was defined as "the average period of use up to engine retirement or rebuild, whichever occurs first" (emphasis added).[12] Under the modified full-life definition it is the Agency's intent to retain this concept. Thus, it is not EPA's intent that useful life should be only mileage to rebuild when establishing the assigned useful-life values in the modified full-life plan but rather that it should also consider vehicle scrappage. Moreover, both "rebuild" and "retirement" (scrappage) can be described as "owner actions" and there is no mention of "need" for a rebuild in the above definition. Available data indicate that the average LDT is far more likely to be scrapped than to be rebuilt. An analysis of the SDR survey data indicate that only about 12 percent of all LDTs are ever rebuilt.[13] Thus, for 88 percent of the vehicles in question, useful life is the mileage to "retirement" rather than the mileage to rebuild, and exclusion of scrappage data would overlook a significant body of data in the calculation of average useful life.

While EPA acknowledges the point made by EMA and GM that there may be some bias introduced into the scrappage rate data by the presence of high mileage rebuilt engines, the percentage of rebuilds (about 12 percent) is not large enough to have a significant effect. Also, it should be recognized that there are also biases in the other direction. Scrappage totals include many low-mileage wrecks, for example, which tend to lower the average. A major driveline failure may also result in scrappage of a vehicle with additional miles remaining in the engine because retirement and replacement would be more cost-effective than repair. None of the available data on average useful-life periods are without some drawbacks. With the exception of HHDDEs where virtually every engine is rebuilt at least once, neither rebuild data nor scrappage data is adequate in and of itself to unequivocally establish useful-life periods. Therefore, in light of these unavoidable uncertainties, EPA has averaged data from a wide variety of sources to minimize the effect of the deficiencies in the data bases. These deficiencies were judged to be minor, and in some cases offsetting, thus allowing EPA to derive a representative useful-life value.

While VW is correct that the data used in deriving the LDT useful-life value do not include the newer, smaller light-duty trucks, EPA sees no reason why the service lives of these latter vehicles should differ significantly from those of the standard size LDTs. While the lighter LDTs are powered by smaller, less powerful engines, usually of 4 cylinders, and operate at somewhat higher engine revolutions than conventional LDTs, the trucks themselves are also lighter in weight and have less payload and frontal area than their standard-size counterparts. Few if any of these small pickups are likely to be loaded to maximum capacity with any degree of regularity and, as VW's comments indicated, the vast majority will in fact be used for personal transportation, as are many standard LDTs. EPA, therefore, concludes that there is no need for a shorter assigned useful life for these vehicles. Since neither VW nor any of the other commenters submitted any data to substantiate the need for a shorter useful life for the smaller LDTs, EPA will continue a common useful-life period for all LDTs. LDT manufacturers also have the option of requesting an alternative useful-life value in cases where the assigned useful-life value is significantly unrepresentative of the useful life for a particular engine family.

Therefore, the only change necessary to the LDT assigned useful-life period calculation is to drop the SDR maximum likelihood rebuild number, and reaverage the remaining four sources. An average of the four sources remaining yields a figure of 121,000 miles, so EPA will reduce the assigned useful life for LDTs from 130,000 miles to 120,000 miles.

b. Heavy-Duty Gasoline Engines (HDGEs)

EPA rejects the arguments advanced by EMA and others regarding the exclusion of scrappage-rate data in the HDE useful-life calculation for the same basic reasons outlined above in the LDT discussion. The SDR survey data indicate that only 28 percent of the HDGEs are rebuilt or replaced, so again, for the vast majority of HDGEs, useful life is the mileage to retirement.

Although the above-mentioned Ford comment regarding SDR survey data was made in reference to LDTs, the same general considerations hold for HDGEs as well. The two HDGE rebuild mileages from the SDR survey are not as disparate as the LDT figures. However, if the SDR data are to be representative of engine rebuild data in the HDGE average useful-life calculation, the "maximum likelihood" value should be dropped, since it includes non-rebuilt engines.

EPA will also include rebuild data from the American Trucking Association survey and estimates from the Arthur D. Little draft truck usage study as suggested by EMA. Although the contract under which the latter study was done was terminated prior to completion, the useful-life estimates in the report are reasonably consistent with other engineering estimates, and EPA has no objection to inclusion of the A. D. Little figures in the useful-life calculation. As shown below, an average of the two scrappage rate values, the three rebuild survey mileages, and the two engineering estimates results in a useful-life period of about 108,000 miles. Therefore, EPA will assign a value of 110,000 miles for HDGEs, rather than the proposed value of 120,000 miles, based on the following calculation:

Scrappage Rate Surveys:	
Michigan Technological University	114,000
DOE	129,000
Rebuild Surveys:	
SDR	124,000
Fleet	100,000
ATA	89,000*
Engineering Estimates:	
Little	100,000
Meyers	100,000
Average	108,000

* Sales-weighted average of trucks under 20,000 lbs. GVW (73 percent of sales) and of trucks over 20,000 lbs. GVW (27 percent of sales). These projected sales percentages were multiplied by ATA mean survey mileages of 91,447 and 82,450 miles, respectively. If the modal or median values are used, the sales-weighted rebuild mileages are 94,600 and 90,950 miles, respectively.

c. Heavy-Duty Diesel Engines

As in the Summary of the Comments, the EMA subclass designations will be used throughout this section of the analysis to avoid the confusion that would result from use of both EPA and EMA terminology. The analysis will also be oriented toward the EMA subclasses, since EPA is adopting them over the subclasses as defined in the proposal. EPA agrees with EMA that the Fleet vocational based rebuild figures used in the MHDDE and LHDDE useful-life calculation may have deficiencies. In any event, as stated in the above-mentioned support memorandum concerning useful-life derivation, the LHDDE subclass was assigned the same useful-life period as HDGEs, on the judgment that LHDDEs should last about as long as the HDGEs they were designed to replace.[14] The Ford comments and a request by EMA to certify these engines to the HDGE useful life provide additional support for this position.[15,16] Since the HDGE useful-life period is based in part on the use of scrappage-rate data, the EMA objection to its use also carries over to the LHDDE subclass value. There are relatively few data on the subject for LHDDEs. However, the Fleet survey found that 43 percent of the non-sleeved engines in the survey (the vast majority of which would be classified as MHDDEs) are never rebuilt.[17] Most of the new LHDDEs are also non-sleeved and are less expensive than MHDDEs, being designed to compete with HDGEs. Since they are less costly to replace, and in some cases are not designed to be rebuilt, it is likely that even fewer LHDDEs than MHDDEs would be rebuilt. EPA will therefore continue the linkage between LHDDEs and HDGEs, and establish the assigned useful-life period for LHDDEs at 110,000 miles.

Turning now to MHDDEs, EMA felt that the figure of 203,000 miles quoted in the SDR survey for Class VI vehicles was too large for the MHDDE subclass, because the Class VI vehicles probably used some engines which would be considered as premium HHDDEs. EPA concurs with EMA's assessment. Second, although data in the Fleet article indicated that buses are typically powered by MHDDEs, this application may not be representative of MHDDE usage. Therefore, EPA accepts EMA's suggestion that MHDDE useful life should be based in part on the average non-sleeved engine mileage to overhaul reported in the Fleet survey (175,000). The ATA survey rebuild mileage of 176,000 for diesel straight trucks also lends support to this figure. An average of the sources suggested by EMA (including the SDR, ATA, and Fleet, rebuild surveys and engineering estimates by Little and Myers) yields an average rebuild mileage of 173,300 miles.

However, while EPA accepts the average of these data as valid for the MHDDEs that are rebuilt, the Fleet survey also indicates that an average of 43 percent of the non-sleeved engines do not get rebuilt. This is a significant percentage and must also be factored in to the determination of the useful-

* The straight truck data in the ATA survey included both gasoline and diesel trucks. The median was 150,000 miles and the mean was 170,470 miles. The relative values of the median and the mode depict a disjointed data set. Based on the HDGE analysis above, it was concluded that the median value was relatively low due to the HDGEs. So the modal value probably represented the diesel straight trucks. Therefore, the 200,000-mile value was used.

life period for MHDDEs. EPA expects that non-rebuilt engines would be operated somewhat past the point where the average rebuild would normally occur, as owners attempted to extract the maximum service. The ATA survey provides a modal value of 200,000 miles for trade-in of straight trucks.[18]* Since few owners are likely to go to the expense of a rebuild at 173,000 miles, and then trade in the truck 27,000 miles later, 200,000 miles is a reasonable estimate of useful life for non-rebuilt engines.

Therefore, addition of 57 percent of 173,300 miles (98,781) to 43 percent of 200,000 miles (86,000) yields a weighted average of 184,781 miles, so EPA will establish a period of 185,000 miles as the MHHDE assigned useful life.

Given the change in the HDDE classification approach from gross vehicle weight to what is essentially an application-based approach, there also is a need for a reassessment of the assigned useful-life period for HHDDEs, just as was done for MHDDEs. The heavy heavy-duty diesel engine subclass originally proposed by EPA covered GVW Classes VII and VIII trucks and buses, and these vehicles included some engines that would now be classified as MHDDEs or even LHDDEs under the EMA approach. Caterpillar's comments indicated, for example, that its 3208 engine, which the manufacturer considered an MHDDE, was sold "almost solely" in Class VII or VIII GVW vehicles.[19] International Harvester Corporation, which also manufactures LHDDE and MHDDEs, stated that "every diesel engine" the company offers for sale could be found in Class VII or VIII GVW vehicles.[20] The assigned useful-life period for heavy heavy-duty diesel engines in the proposal reflected this vehicle mix and is therefore understated for HHDDEs under the EMA approach. With the adoption of EMA's subclasses based on application rather than GVW, the HHDDE subclass will now be predominantly premium-engines designed for long-haul, high-mileage service applications, necessitating an adjustment in the assigned useful-life period. The SDR Classes VII and VIII data are not adequately representative of premium HHDDEs to serve as the basis for the analysis since these vehicles would use some MHDDEs, just as EMA asserted that the Class VI SDR figure was overstated because it included some HHDDEs. However the SDR survey determined a rebuild mileage of 303,000 for "long haul" usage engines, which would clearly reflect HHDDEs. Also, the Fleet average rebuild mileage for sleeved engines (281,000 miles) and the ATA mean rebuild mileage for "tractors" (296,862 miles) are clearly representative of the type of engine and operation in question. An average of these three sources plus the A.D. Little engineering estimate (290,000 miles) yields a mileage of 292,716 miles. Based on this average, EPA will assign a useful-life value of 290,000 miles for this subclass.

If the median or modal values in the ATA survey (300,000 miles) were substituted for the mean, the resulting average of the four sources would be 293,500 miles. Using the EMA approach to the HDDE subclasses effectively addresses the comment concerning the grouping together of Class VII and Class VIII trucks in the heavy heavy-duty diesel subclass proposed by EPA.

The final area to be considered is the number of years, as opposed to miles, in the assigned useful-life values. EMA stated that EPA's position appeared to be that a truly representative years-to-rebuild value was not necessary "if an accurate mileage value is prescribed."[21] EMA did not agree with this position, saying that an accurate figure for equivalent years to rebuild was necessary due to the fact that many HDDEs accumulate a great many hours of running time without accumulating many miles. Actually, EPA has never maintained the position claimed by EMA. In most cases, the period of years was roughly equivalent to miles of use as described above. The Michigan Technological University (MTU) vehicle mileage tables used in the EPA Emission Factors Program, the National Highway Traffic Safety Administration (NHTSA) mileage tables, and the Department of Energy "Highway Fuel Consumption Model" (DOE) annual vehicle mileage tables were consulted in determining years to the end of useful life for all categories except Classes VII and VIII.[22] In the latter case EPA found that while most applications were very high mileage (i.e., the useful-life mileage would be accumulated in 3-5 years), enough relatively low-mileage applications would be included so that a considerably longer period of years was necessary to be representative of their full useful lives. Examples of these low-mileage applications include concrete mixers, fire trucks, and garbage packers. Although some of these applications will now likely be included in the MHDD service class, EPA believes that some HHDDEs will continue to be sold for this kind of use. An extended period of years should not affect long-haul intercity vehicles for which the useful-life mileage total will become the limiting factor, but will allow a more representative useful-life period for the lower mileage applications. Therefore, EPA will adjust the useful-life year values for approximate equivalency with the revised useful-life mileages, except for HHDDEs, which will be assigned the same useful-life years as MHDDEs (i.e., 8 years).

Conclusions

Based on the above analysis, and the HDDE classification system suggested by EMA, EPA finds it appropriate to revise the useful-life values as follows:

	Mileage		Years	
	Proposed	Final	Proposed	Final
LDT	130,000 mi.	120,000 mi.	12 years	11 years
HDGE/LHDDE	120,000 mi.	110,000 mi.	10 years	8 years
MHDDE	200,000 mi.	185,000 mi.	10 years	8 years
HHDDE	275,000 mi.	290,000 mi.	10 years	8 years

EPA concludes that scrappage data should not be excluded from the assigned useful-life calculations, as EMA suggested, but has no objection to inclusion of other data as desired by EMA. The assigned useful-life period will be the same for all LDTs, rather than setting a shorter period for the lighter 4-cylinder vehicles as desired by VW and others. Finally, it should be repeated that a manufacturer has the option to request an alternative useful-life period for an individual engine family if there is reason to believe that the assigned useful-life value is unrepresentative.

Minor Issues

Summary of Comments

Manufacturers have raised a number of minor issues under the modified full-life provisions. GM asked whether a manufacturer would be expected to test engines after they were worn out to determine a deterioration factor (DF) for the full assigned useful life and also how a manufacturer would determine the DF if the test engine failed before reaching the assigned useful-life value. Mack Trucks suggested that bench testing would be sufficient for checking the durability of HDDE emission control components and that there would be no need for full-life useful life. Ford presented its opinion that the manufacturer's certification statement, to the effect that a properly maintained engine will conform to the applicable standards for its full useful life, must be qualified to take into consideration engine wearout before the end of the assigned useful-life period. The ATA wanted EPA to publish useful-life values for all HDEs. Lastly, AMC stated that full life would break the link allowing shared technology between light-duty vehicles (LDVs) and LDTs, since LDTs would now require more durable components. AMC predicted increased costs to both manufacturers and consumers as a result of breaking this LDV/LDT link.

Analysis of Comments

In response to GM's concerns, there will be no specific durability testing requirement under modified full life. As long as the manufacturers are satisfied that emissions will not exceed the standard for the useful life of their vehicles/engines, they are free to determine deterioration factors using any method desired, as long as good engineering practices are followed. The bench testing option advanced by Mack Trucks might be a more cost-effective way to assess component durability, for example, if the manufacturer felt confident of the accuracy of that approach. However, EPA disagrees that such bench testing is adequate to eliminate the need for the full-life useful-life requirement. EPA believes that the full-life requirement is still necessary to provide increased assurance of durable component design by holding the manufacturer accountable for lifetime emissions compliance. Bench testing represents one potential approach to durability assessment which the manufacturers may choose.

With regard to Ford's point concerning the certification statement, elimination of the useful-life labeling requirement also removes the current compliance statement required for LDTs and HDEs under 40 CFR 86.084-35. However, for vehicle/engine classes where a single assigned useful-life value is specified, that label is replaced by a general compliance label, as is currently specified for LDTs and HDEs. This label states that the vehicle/engine conforms to the applicable model year EPA regulations. Since HDDEs are not all assigned the same useful-life period, they will also be labeled to indicate the subclass for which they are certified. Any LDT/HDE for which an alternative useful-life value is approved by the Administrator will also be labeled with the alternative useful-life value. To address the Ford concern, EPA will retain the current qualifying statement that "This engine's actual life may vary, depending on its service applications."

Since engine-specific useful-life values are replaced by assigned useful-life periods, there should be no need to publish individual useful-life data as requested by the ATA. The assigned useful-life values for classes/subclasses are published in this rulemaking. In addition, as outlined above, HDDE manufacturers will be required to label their engines with the service classes for which they are certified. As requested by ATA, any vehicle/engine for which an alternative useful-life value was approved would also be labeled with the alternative value. Since ATA's interests seem to be primarily in the area of HDDEs which will all be labeled with the subclass as a matter of course, and since alternative useful-life values will be indicated if applicable, EPA feels ATA's needs will be addressed by the above measures.

Finally, EPA does not believe the impact of full-life useful life will be so great as to inhibit the sharing of technology between LDVs and LDTs, as AMC suggests. It is hardly cost-effective to redesign a component or design a replacement for it and then continue to produce the old one in parallel with production of the new or redesigned component.

The Agency finds it difficult to believe that any manufacturer would choose this course of action, particularly since it provides a much narrower base for amortization of development and tooling costs than would application of the component to the entire product line. Since the applications and technology are basically similar for both LDVs and LDTs, EPA believes that commonality of components will continue to be standard practice. If the durability of some of these components improves as a result of the full-life requirement for LDTs, it will result in an additional benefit to the LDV buyer and improve the emissions of the LDV. There is no reason, however, why separate components need be produced for LDVs and LDTs.

Conclusions

Most of the minor certification issues require no action on EPA's part. The qualifying statement on the label that average useful life will vary according to service application will address Ford's concerns. ATA's request for publication of the assigned useful-life values is addressed by the values published in the rulemaking and by the labeling requirement for HDDE subclasses and for alternative useful-life periods. AMC's fear that full-life useful life will break the traditional technology link between LDVs and LDTs appear overstated and EPA rejects the idea that any duplication of effort or waste of resources will result.

References

1. Summary and Analysis of Comment to the NPRM, 1983 and Later HDEs, pp. 105-110, December 1975.

2. Summary and Analysis of Comment to the NPRM, 1983 and Later LDTs, p. 1-3, May 1980.

3. "Report of the Committee on Public Works, 94-717," Legislative History of the CAA Amendments of 1977, Vol. 3, p. 671, May 10, 1977.

4. "The Clean Air Act as Amended, August 1977," Ser. 95-11, p. 11, November 1977.

5. arley-Davidson Motor Company, Inc. vs. EPA, U.S. Court of Appeals, D.C. Circuit, No. 77-1104, March 9, 1979.

6. See Reference 4, p. 122.

7. "House of Representatives Report 95-564," 75th Congress, 1st Session, p. 164, 1977.

8. EPA Memorandum, "Summary of the February 18, 1983 HDE/LDT Useful-Life Workshop," Terry P. Newell, March 1, 1983.

9. Fleet Maintenance and Specifying, Vol. 7, No. 3, March 1981, pp. 39-43.

10. "Report on Commerical Trucking Diagnostic Needs Survey," American Trucking Associations, Inc., c.1981.

11. Draft Report "HD Vehicle Engine Service Accumulation Cycle, A. D. Little, Inc., EPA Contract 68-03-2712, April 1977.

12. 40 CFR 86.084-4(b)(1).

13. "Calculation of Total Rebuild Percentages for LDTs and HDGEs," EPA Memorandum from Robert J. Johnson, July 25, 1983.

14. "Determination of Useful-Life Values for Light-Duty Trucks and Heavy-Duty Engines," EPA Memorandum from Robert J. Johnson, December 13, 1982.

15. Response to January 12, 1983 NPRM, Public Docket A-81-II, IV-D-86, p. 16, April 18, 1983.

16. Letter from Thomas C. Young to Kathleen M. Bennett, Office of Air, Noise and Radiation, May 3, 1982.

References (cont'd)

17. Fleet Maintenance and Specifying, Vol. 7, No. 7, May 1981.

18. See Reference 9, p. 6.

19. Caterpillar Response to January 12, 1983 NPRM, Public Docket A-81-11, IV-D-77, p. 4, April 13, 1983.

20. International Harvester Response to January 12, 1983 NPRM, Public Docket A-81-11, IV-D-81, p. 23, April 18, 1983.

21. EMA Response to January 12, 1983 NPRM, Public Docket A-81-11, IV-D-83, p. 53.

22. "Conversion of Useful-Life Mileages to Periods of Years," EPA Memorandum, Robert J. Johnson, July 25, 1983.

3. Issue: Alternative Test Cycles

A. The Real Time Cycle for Heavy-Duty Diesel Engines

Summary of the Issue

An alternative heavy-duty diesel test cycle, the Real Time Cycle (RTC), has been developed by the Caterpillar Tractor Company (Caterpillar). It was developed in response to industry-wide concern over the methodology used to generate the EPA cycle and its resulting representativeness.

Summary of Comments

Most manufacturers and the Engine Manufacturers Association (EMA) have made specific recommendations concerning the use of the RTC for certification testing. Some of the recommendations, however, have changed over time as additional data were gathered on the RTC. A brief review of the chronology of events is appropriate for this discussion.

The EMA and member companies recommended in April 1982 that EPA adopt as a test option the use of the RTC. This recommendation was based upon the industry's concern about the representativeness of the EPA cycle.

Shortly thereafter, EPA reviewed the technical basis for the creation of the RTC. (Part of EPA's earlier analysis is reproduced below.) EPA also reviewed the available data base wherein emission results from both cycles were compared. At the time, about 30 comparative data points were available. EPA's draft analysis noted that a net difference in emissions existed between the test cycles, and recommended that the applicable emission standards be adjusted to account for the offset. This was recommended so as to preclude an effective relaxation of the emission requirements promulgated on January 21, 1980. EPA's original analysis (see Appendix, Chapter 5 of the Transient Test Study) was distributed for public comment in early summer 1982.

The EMA and member companies reviewed EPA's draft analysis, and over time, in both informal and formal communications, took issue with two of EPA's conclusions. First, EMA disputed the need for an emission standard adjustment. The argument was made that the heavy-duty diesel cycle was never used in the standards development process, and the use of a specific diesel cycle is decoupled from the level of the standards. (The heavy-duty gasoline engine cycle was used to derive the statutory emission standards.) Secondly, if an adjustment were to be made, EMA disagreed with the methodology EPA used to derive the equivalently stringent standard. EMA proposed a methodology which yielded an RTC-based hydrocarbon (HC) emission standard of 1.20 grams per brake horsepower-hour (g/BHP-hr), using the latest available data. EMA and its member companies formalized their position in a May 13, 1983 submission to EPA. They also recommended, contrary to earlier recommendations, that only a single test cycle be used for certification. If the RTC cycle was not made available with a HC standard of 1.2 g/BHP-hr, the industry preferred the use of the EPA cycle at the 1.3 g/BHP-hr HC standard.

Analysis of Comments

In this analysis, we address the construction, representativeness, and relative stringency of the RTC. Methodologies for emission standard adjustments are also evaluated, as is the justification for such an adjustment. Finally, the selection of a certification test cycle is made.

Cycle Development[3]

Caterpillar developed the RTC because of concern over the accuracy of simulation of in-use truck operation represented by the EPA cycles. This concern stemmed from alleged instrumentation problems in the CAPE-21 project which they argued resulted in a significant amount of questionable data being accepted into the data base, and from the methodology EPA used to generate the cycle. Caterpillar's objectives in developing the RTC were to generate a cycle from the portion of the CAPE-21 data base which it considered valid, and to construct the cycle so it better represented its judgment of real-world truck operation.

The entire data base was first edited to remove what Caterpillar believed to be questionable data. This editing left 23 truck-days of data, or about 25 percent of the original data base. Statistical parameters were then chosen to characterize the edited data base. These were mean values and cumulative distributions of percentage rpm, percentage power, and positive percentage rpm. The percentage idle time and distribution in length of idle were also used. These statistical parameters then became the target values for the construction of the new test cycle.

To construct the new test cycle, the data were broken down into the smallest elements which did not interrupt the normal driving sequence. These elements were defined as the vehicle operational events which occurred between vehicle stops. The elements were then assembled into trial test segments which matched, as closely as possible, the desired statistics of the categories they represented. The categories were: New York

Freeway (NYF), New York Non-Freeway (NYNF), Los Angeles Freeway (LAF), and Los Angeles Non-Freeway (LANF). The idle time and category weighting were adjusted to match the original CAPE-21 data base, since it was judged unlikely that instrument error would change these parameters. The trial test segments were then tested against the data base for maximum deviation of cumulative distributions and then were compared visually. The best cycles were selected and assembled into an entire driving cycle.

The result was a heavy-duty diesel engine (HDDE) driving cycle, the "Real Time Cycle," which matched very closely the statistics of the edited CAPE-21 data base, and which the diesel engine manufacturers believed was more representative of in-use truck operation than the EPA cycle.

Statistical Analysis

A comparison of the target statistics from the edited data base, the RTC statistics, and the EPA cycle statistics is shown in Table 3-1. Additional statistics from the RTC, EPA cycle, and the original CAPE-21 data base are listed in Table 3-2. The most important statistical differences between the RTC and the EPA cycle are:

1. The RTC includes a NYF segment, while the EPA cycle does not.* (The NYF segment is higher in mean percentage rpm and higher in mean percentage power than the NYNF segment.)

2. The RTC is 5.2 percent higher in mean percentage power, overall, than the EPA cycle.

3. The RTC is 4.8 percent lower in percentage idle time, overall, than the EPA cycle.

4. The sequential ordering of the cycle segments on the RTC is LANF, LAF, NYF, and NYNF. The ordering on the EPA cycle is NYNF, LANF, LAF, NYNF.

The statistical differences cited here may or may not affect engine emission levels. A potentially significant factor is that the observed engine work done over the test cycle (BHP-hr) is higher by 16-18 percent on the RTC. Furthermore, the reordering of the segments in the RTC permits the engine to operate in the high power LAF mode earlier in the cycle, which may lead to an earlier engine warm-up (although

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* EPA omitted the NYF segment because invalid data had been included in the data base and the weighting for this segment was small compared to the other segments.[4]

Table 3-1

Target, RTC, and EPA Cycle Statistics [3]

	Los Angeles Non-Freeway			Los Angeles Freeway		
	Target	Real Time	EPA	Target	Real Time	EPA
Average rpm (%)	40.7	41.8	43	80.0	83.5	83
Average Power (%)	24.1	25.9	26	58.9	56.4	56
Average Positive Acceleration	4.6	5.7	6.1	1.9	1.2	2.4
Idle Time (%)	35.0	32.7	34	2.0	1.4	2.3
Category Weighting	23.7	27.3	25.0	26.3	25.1	25.0

	Los Angeles Non-Freeway			Los Angeles Freeway		
	Target	Real Time	EPA	Target	Real Time	EPA
Average rpm (%)	41.5	47.1	--	17.7	19.8	20
Average Power (%)	41.0	54.4	--	19.4	22.3	16
Average Positive Acceleration	2.8	4.6	--	3.8	3.6	5.6
Idle Time (%)	19	21	--	51.0	51.0	55
Category Weighting	9.0	5.9	0	41.0	41.7	50.0

	Overall		
	Target	Real Time	EPA
Average rpm (%)	41.7	43.4	41.5
Average Power (%)	32.8	33.7	28.5
Average Positive Acceleration	3.9	4.2	4.6
Idle Time (%)	31.4	31.8	36.6

Table 3-2

RTC, EPA Cycle, CAPE-21 Data Base Statistics

Parameter	RTC	EPA	CAPE-21
Torque			
Mean (%)	30.57	28.32	27.00
Percent of Cycle Time			
Acceleration (%)	18.21	15.68	15.10
Deceleration (%)	18.37	16.85	15.25
Cruise (%)	22.48	20.43	18.75
Motor (%)	7.98	11.43	15.00
Idle (%)	32.96	35.61	35.00
RPM			
Mean (%)	42.78	41.52	41.75
Percent of Cycle Time			
Acceleration (%)	23.45	21.77	21.50
Deceleration (%)	22.48	21.93	19.50
Cruise (%)	19.74	16.10	19.50
Idle (%)	34.33	40.20	39.00

operation in the LAF segment of the RTC is initially cooler than on the EPA cycle). Inclusion of the NYF segment in lieu of another NYNF segment is one obvious reason why the RTC BHP-hr is higher than that of the EPA cycle.

Test Cycle Correlation

Heavy-duty diesel engine manufacturers and EPA have now tested many engines on both the RTC and the EPA cycle for the purpose of comparing emissions results. All of the available data have been collected and are summarized in Table 3-3. Results are also plotted in Figures 3-1, 3-2, and 3-3. Since typical diesel carbon monoxide (CO) emissions are much lower than statutory levels, this pollutant comparison was not included. Immediately obvious is the fact that emission levels are different between the candidate test cycles.

The HC emissions difference between the test cycles is explainable and expected. A decrease in brake specific HC emission rates at higher engine loads is typically observed on diesel engines. Consider the following mechanism for such an observation: in diesel engines, HC emissions are in large part attributable to residual fuel in the injector sac. The sac volume is constant regardless of the amount of fuel injected; as the load is increased (i.e., more fuel is injected), the mass rate of HC emissions from the sac remains constant. However, the brake specific rate of HC emissions (g/BHP-hr) decreases at higher loads since the denominator (power-hour) increases while the numerator (mass HC) remains the same. This could explain most of the difference in HC emissions, given that the RTC is a higher power test cycle and that both cycles exercise the engine in fundamentally the same way.

The constant residual sac volume is likely not the only mechanism by which emissions from each cycle are different. However, further discussion of exact mechanisms at this point is not important. What is important is the fact that the RTC cycle correlates very well with the EPA cycle (and vice versa) for many different engines. This indicates that emissions from one cycle can be accurately predicted from those of the other. The excellent correlation also indicates that both cycles should be comparable in the ability to predict in-use emission reductions, and that there is no inherent advantage in using one cycle over the other. Given the difference in cycle generation methodologies and the correlatable emission results, and the reasonable presumption that the HC emissions offset is primarily attributable to the difference in load factor between the cycles, EPA concludes that both cycles are comparably representative. Each by itself would be technically acceptable for certification testing.

Table 3-3

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
Mack ETSX-676[c]	EPA	EPA		4		--	--	--	1,8,10	.65	8.40	.752
		RTC		4		--	--	--		.55	8.56	.777
Cummins VTB-903[c]	EPA	EPA		4		--	--	--	1,8,10	1.60	5.07	.544
		RTC		4		--	--	--		1.27	5.01	.504
IHC DT-210	IHC[e]	EPA	1-3	2-7	1,2,3,4,	.89	7.20	--		--	--	--
		RTC	1-3	2-7	8,9,10,11	.78	6.80	--		--	--	--
IHC DTI-210	IHC	EPA	1-3	2-7	1,2,3,4,	1.07	4.15	--		--	--	--
		RTC	1-3	2-7	8,9,10,11	.95[1]	4.16	--		--	--	--
IHC DTI-180	IHC	EPA	1-3	2-7	1,2,3,	1.18	4.94	--	5,6,7	1.14	--	--
		RTC	1-3	2-7	4,5,6,7, 8,9,10,11	1.06	4.73	--		1.05	--	--
IHC 9.0L	IHC	EPA	1-3	2-7	1,2,3,4,5,	2.03	7.18	--	5,6,7	2.04	--	--
		RTC	1-3	2-7	6,7,8,9, 10,11	1.90	7.52	--		1.90	--	--
Cummins #1[f]	Cummins	EPA		2		--	--	--	1,8,9,10	.55	7.50	.46
		RTC		2		--	--	--		.48	7.46	.43
Cummins #2	Cummins	EPA		2		--	--	--	1,8,9,10	1.19	8.10	.66
		RTC		2		--	--	--		.91	7.92	.66
Cummins #3	Cummins	EPA		2		--	--	--	1,8,9,10	.87	7.37	.70
		RTC		2		--	--	--		.63	7.29	.56
Cummins #4	Cummins	EPA		2		--	--	--	1,8,9,10	.94	4.63	.94
		RTC		2		--	--	--		.67	5.42	.94
Cat 3208	IHC	EPA	5	12		--	--	--	1	1.30	7.68	.70
		RTC	4	6		--	--	--		.84	8.57	.60

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start: Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
Mack #1[g]	Mack	EPA			1,2[d],8,	.46	5.6	.51		--	--	--
		RTC			9,10,11	.41	5.9	.46		--	--	--
Mack #2	Mack	EPA			1,2[d],8,	.55	7.8	.79		--	--	--
		RTC			9,10,11	.46	8.4	.69		--	--	--
Mack #3	Mack	EPA			1,2[d],8,	1.10	10.3	.85		--	--	--
		RTC			9,10	.87	9.0	.69		--	--	--
Cat 3208[c]	IHC	EPA	5	11	1,2,5,	1.30	7.59	.70	5	1.24	--	--
		RTC	4	6	8,10,11	.85	8.59	.60		.81	--	--
Mack ETSX-676[c]	Cat	EPA	2	12	1,2,3,	.73	6.82	.53	5,6	.74	--	--
		RTC	1	7	4,5,6,8,10	.65	7.62	.63		.64	--	--
IHC DTI-466B[c]	Cat	EPA	2	15	1,2,3,	1.00	4.44	.69	5	.95	--	--
		RTC	1	6	4,5,8,10	.90	4.30	.70		.90	--	--
Cat 3208	Cat	EPA	5	11	1[h],2,3,	.97	8.40	.86	5,6,7	.92	--	--
		RTC	1	7	4[h],5,6,7, 8,9,10,11	.88	8.79	.88		.85	--	--
Cat 3406	Cat	EPA	3	14	1,2,3,	.49	4.82	.83	5,6,7	.48	--	--
		RTC	1	6	4,5,6,7, 8,9,10,11	.40	5.00	.73		.39	--	--
Cat 3208	Cat	EPA	2	6	1,2,3,	1.07	9.11	.854	5,6,7	1.07	--	--
		RTC	3	8	4,5,6,7,8, 9,10,11	.98	9.24	.712		.97	--	--
Cat 3208 Model 1	Cat	EPA	2	3	1,2,3,4,5,	1.04	14.13	1.04	5,6,7	1.02	--	--
		RTC	5	5	6,7,8,9,10,11	.88	13.96	.820		.88	--	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
Cat 3208	Cat	EPA	2	8	1,2,3,4,5,	2.70	6.38	1.24	5,6,7	2.73	--	--
Model 2		RTC	3	6	6,7,8,9,10, 11	2.40	6.42	.974		2.38	--	--
Cat 3406	Cat	EPA	3	4	1,2,3,4,	.48	7.62	.782	5,6,7	.45	--	--
		RTC	3	4	5,6,7,8,9, 10,11	.37	7.26	.653		.35	--	--
IHC DT-466	IHC	EPA			2,5,6,7,	1.02	--	--	5,6,7	.98	--	--
(210)		RTC			8,9,10,11	.95	--	--		.94	--	--
Cat 3406,	Cat	EPA	2	5	1,2,3,4,	.60	11.82	.726	5,6,7	.52	--	--
Model 1		RTC	3		5,6,7,8,9 10,11	.47	11.56	.601		.43	--	--
Cat 3406,	Cat	EPA	2	5	1,2,3,4,	.57	4.03	1.79	5,6,7	.53	--	--
Model 2		RTC	2	4	5,6,7, 8,9,10,11	.50	3.78	1.33		.49	--	--
Cat 3406,	Cat	EPA	3	4	1,2,3,4,	.89	4.12	2.20	5,6,7	.82	--	--
Model 3		RTC	2	6	5,6,7,8, 9,10,11	.77	3.64	2.27		.74	--	--
Cummins	DDA	EPA		1		--	--	--	1,8,10	1.98	5.07	--
VTB-903[c]		RTC		1		--	--	--		1.73	4.80	--
DDA 8V-92,	DDA	EPA		2		--	--	--	1,8,9,10	.81	4.60	--
Model 1		RTC		2		--	--	--		.72	4.26	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	Number and Type of Tests (HS)	Combined Cold/Hot Start: Regressions	Combined Cold/Hot Start: HC (g/BHP-hr)	Combined Cold/Hot Start: NOx (g/BHP-hr)	Combined Cold/Hot Start: Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	Hot Start Only: HC (g/BHP-hr)	Hot Start Only: NOx (g/BHP-hr)	Hot Start Only: Part. (g/BHP-hr)
DDA 8V-92,	DDA	EPA		3		--	--	--	1,8,9,10	.68	8.38	--
Model 2		RTC		3		--	--	--		.73	7.69	--
DDA 8V-71TA[c]	Cat	EPA			2,3,4,5,6,	.63	--	--	5,6	.63	--	--
		RTC			8,10	.61	--	--		.62	--	--
IHC 466B[c]	Cummins	EPA				--	--	--	8,10	.66	4.01	.76
		RTC				--	--	--		.62	4.09	.77
DDA 8.2L	DDA	EPA		3		--	--	--	1,8,9,10	1.14	5.78	--
		RTC		3		--	--	--		.92	5.44	--
Cummins	Cummins	EPA			2,8,9,10,11	1.66	4.97	.91		--	--	--
VTB-903		RTC				1.37	5.14	.76		--	--	--
IHC DT-466[c]	EPA	EPA				--	--	--	8,10	.64	3.53	.65
		RTC				--	--	--		.62	3.53	.66
DDA 8V-71TA	DDA	EPA			2,8,9,10,11	.55	6.75	.35		--	--	--
		RTC				.59	6.96	.33		--	--	--
Mack ETSX-676	Mack	EPA				--	--	--	8,9,10	.78	7.86	.56
		RTC				--	--	--		.71	7.4	.53
IHC DT-466	IHC	EPA			2,5,6,7,	.75	--	--	5,6,7	.68	--	--
		RTC			8,9,10,11	.63	--	--		.62	--	--
3241	Cummins	EPA		1		--	--	--	8,9,10	.88	5.45	--
3242		RTC		1		--	--	--		.69	5.57	--
3261	Cummins	EPA		1		--	--	--	8,9,10	1.3	5.90	--
3263		RTC		1		--	--	--		2.51[j]	5.80	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start: Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
3301	Cummins	EPA		1		--	--	--	8,9,10	.89	5.80	--
3302		RTC		1		--	--	--		.68	5.84	--
3321	Cummins	EPA		1		--	--	--	8,9,10	.84	6.56	--
3322		RTC		1		--	--	--		.64	6.53	--
3341	Cummins	EPA		1		--	--	--	8,9,10	.91	6.53	--
3342		RTC		1		--	--	--		.73	6.42	--
3391	Cummins	EPA		1		--	--	--	8,9,10	1.08	6.96	--
3393		RTC		1		--	--	--		.60	6.63	--
3413	Cummins	EPA		1		--	--	--	8,9,10	.84	7.16	--
3414		RTC		1		--	--	--		.64	6.98	--
3461	Cummins	EPA		1		--	--	--	8,9,10	.82	6.68	--
3463		RTC		1		--	--	--		.58	6.77	--
3501	Cummins	EPA		1		--	--	--	8,9,10	.80	5.37	--
3502		RTC		1		--	--	--		.65	5.66	--
3531	Cummins	EPA		1		--	--	--	8,9,10	.83	4.42	--
3532		RTC		1		--	--	--		.72	4.53	--
3612	Cummins	EPA		1		--	--	--	8,9,10	.77	7.40	--
3613		RTC		1		--	--	--		.61	7.38	--
3641	Cummins	EPA		1		--	--	--	8,9,10	.72	7.32	--
3642		RTC		1		--	--	--		.57	7.28	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start: Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
3761	Cummins	EPA		1		--	--	--	8,9,10	2.07	6.13	--
3762		RTC		1		--	--	--		1.58	6.27	--
3742	Cummins	EPA		1		--	--	--	8,9,10	.93	6.77	--
3743		RTC		1		--	--	--		.72	7.01	--
3761	Cummins	EPA		1		--	--	--	8,9,10	.89	6.24	--
3762		RTC		1		--	--	--		.65	6.11	--
3781	Cummins	EPA		1		--	--	--	8,9,10	1.58	6.72	--
3782		RTC		1		--	--	--		.98	6.80	--
3791	Cummins	EPA		1		--	--	--	8,9,10	.26	6.05	--
3792		RTC		1		--	--	--		.17	6.10	--
3841	Cummins	EPA		1		--	--	--	8,9,10	.88	7.86	--
3842		RTC		1		--	--	--		.54	8.11	--
3852	Cummins	EPA		1		--	--	--	8,9,10	.85	7.19	--
3853		RTC		1		--	--	--		.67	7.52	--
3861	Cummins	EPA		1		--	--	--	8,9,10	.60	7.22	--
3862		RTC		1		--	--	--		.47	7.54	--
3871	Cummins	EPA		1		--	--	--	8,9,10	.56	7.49	--
3872		RTC		1		--	--	--		.43	7.54	--
3881	Cummins	EPA		1		--	--	--	8,9,10	.65	7.35	--
3882		RTC		1		--	--	--		.53	7.27	--
3961	Cummins	EPA		1		--	--	--	8,9,10	.74	6.55	--
3962		RTC		1		--	--	--		.59	6.58	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	Number and Type of Tests (HS)	Combined Cold/Hot Start: Regressions	Combined Cold/Hot Start: HC (g/BHP-hr)	Combined Cold/Hot Start: NOx (g/BHP-hr)	Combined Cold/Hot Start: Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	Hot Start Only: HC (g/BHP-hr)	Hot Start Only: NOx (g/BHP-hr)	Hot Start Only: Part. (g/BHP-hr)
4011	Cummins	EPA		1		--	--	--	8,9,10	.69	6.36	--
4012		RTC		1		--	--	--		.50	6.38	--
4031	Cummins	EPA		1		--	--	--	8,9,10	.65	7.67	--
4032		RTC		1		--	--	--		.53	7.92	--
4042	Cummins	EPA		1		--	--	--	8,9,10	1.48	6.82	--
4043		RTC		1		--	--	--		1.18	6.91	--
4051	Cummins	EPA		1		--	--	--	8,9,10	.67	7.43	--
4052		RTC		1		--	--	--		.53	7.55	--
4081	Cummins	EPA		1		--	--	--	8,9,10	.86	6.33	--
4082		RTC		1		--	--	--		.72	6.44	--
4245	Cummins	EPA		1		--	--	--	8,9,10	.83	3.83	--
4246		RTC		1		--	--	--		.66	4.74	--
4261	Cummins	EPA		1		--	--	--	8,9,10	.75	6.57	--
4262		RTC		1		--	--	--		.63	6.90	--
4331	Cummins	EPA		1		--	--	--	8,9,10	.77	6.05	--
4332		RTC		1		--	--	--		.68	6.26	--
4351	Cummins	EPA		1		--	--	--	8,9,10	.88	5.91	--
4352		RTC		1		--	--	--		.74	5.62	--
4381	Cummins	EPA		1		--	--	--	8,9,10	1.02	6.43	--
4382		RTC		1		--	--	--		.77	6.59	--
4401	Cummins	EPA		1		--	--	--	8,9,10	.76	6.39	--
4102		RTC		1		--	--	--		.53	6.29	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
4451	Cummins	EPA		1		--	--	--	8,9,10	.61	6.30	--
4452		RTC		1		--	--	--		.58	6.23	--
4521	Cummins	EPA		1		--	--	--	8,9,10	.75	6.47	--
4522		RTC		1		--	--	--		.56	6.48	--
4561	Cummins	EPA		1		--	--	--	8,9,10	.72	4.09	--
4562		RTC		1		--	--	--		.63	4.14	--
4581	Cummins	EPA		1		--	--	--	8,9,10	.66	4.36	--
4582		RTC		1		--	--	--		.56	4.35	--
4611	Cummins	EPA		1		--	--	--	8,9,10	.80	3.93	--
4612		RTC		1		--	--	--		.65	3.99	--
3661	Cummins	EPA		1		--	--	--	8,9,10	.87	6.13	--
3663		RTC		1		--	--	--		.65	6.32	--
4661	Cummins	EPA		1		--	--	--	8,9,10	.79	6.94	--
4662		RTC		1		--	--	--		.56	6.01	--
4801	Cummins	EPA		1		--	--	--	8,9,10	.86	8.88	--
4802	Cummins	RTC		1		--	--	--		.69	9.06	--
4721	Cummins	EPA		1		--	--	--	8,9,10	.91	6.19	--
4722	Cummins	RTC		1		--	--	--		.68	6.24	--
4773	Cummins	EPA		1		--	--	--	8,9,10	.72	7.91	--
4774	Cummins	RTC		1		--	--	--		.59	7.70	--
4713	Cummins	EPA		1		--	--	--	8,9,10	.98	6.20	--
4714	Cummins	RTC		1		--	--	--		.76	5.73	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	Number and Type of Tests (HS)	Combined Cold/Hot Start: Regressions	Combined Cold/Hot Start: HC (g/BHP-hr)	Combined Cold/Hot Start: NOx (g/BHP-hr)	Combined Cold/Hot Start: Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	Hot Start Only: HC (g/BHP-hr)	Hot Start Only: NOx (g/BHP-hr)	Hot Start Only: Part. (g/BHP-hr)
4831	Cummins	EPA		1		--	--	--	8,9,10	.71	8.04	--
4832	Cummins	RTC		1		--	--	--		.53	8.03	--
3361	Cummins	EPA		1		--	--	--	8,9,10	.60	4.96	--
3364	Cummins	RTC		1		--	--	--		.68	5.16	--
3491	Cummins	EPA		1		--	--	--	8,9,10	.92	3.90	--
3492	Cummins	RTC		1		--	--	--		.75	3.88	--
3981	Cummins	EPA		1		--	--	--	8,9,10	.87	4.33	--
3982	Cummins	RTC		1		--	--	--		.78	4.47	--
4021	Cummins	EPA		1		--	--	--	8,9,10	.87	4.81	--
4022	Cummins	RTC		1		--	--	--		.78	4.91	--
4101	Cummins	EPA		1		--	--	--	8,9,10	.91	4.55	--
4102	Cummins	RTC		1		--	--	--		.82	4.60	--
4123	Cummins	EPA		1		--	--	--	8,9,10	.62	4.81	--
4125	Cummins	RTC		1		--	--	--		.50	5.11	--
4201	Cummins	EPA		1		--	--	--	8,9,10	.46	4.84	--
4202	Cummins	RTC		1		--	--	--		.44	4.62	--
4251	Cummins	EPA		1		--	--	--	8,9,10	.66	3.93	--
4252	Cummins	RTC		1		--	--	--		.56	3.87	--
4271	Cummins	EPA		1		--	--	--	8,9,10	.65	4.23	--
4272	Cummins	RTC		1		--	--	--		.60	4.13	--
4391	Cummins	EPA		1		--	--	--	8,9,10	.69	5.64	--
4392	Cumins	RTC		1		--	--	--		.72	5.61	--

Table 3-3 (cont'd)

Summary of Emissions Data EPA Cycle vs. Real Time Cycle

Engine/ Test Number[a]	Test Lab	Cycle	Number and Type of Tests (CS)	(HS)	Combined Cold/Hot Start: Regressions	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)	Hot Start Only: Regressions[b]	HC (g/BHP-hr)	NOx (g/BHP-hr)	Part. (g/BHP-hr)
4461	Cummins	EPA		1		--	--	--	8,9,10	.52	4.99	--
4685	Cummins	RTC		1		--	--	--		.37	5.08	--
4694	Cummins	EPA		1		--	--	--	8,9,10	.42	4.40	--
4695	Cummins	RTC		1		--	--	--		.37	4.42	--
4697	Cummins	EPA		1		--	--	--	8,9,10	.46	4.73	--
4696	Cummins	RTC		1		--	--	--		.35	4.82	--
4861	Cummins	EPA		1		--	--	--	8,9,10	.53	4.70	--
4864	Cummins	RTC		1		--	--	--		.52	5.06	--
DDA-"A"	DDA	EPA			8,9,11	.57	--	--		.57	--	--
	DDA	RTC				.52	--	--		.52	--	--
DDA-"B"	DDA	EPA			8,9,11	.49	--	--		.48	--	--
	DDA	RTC				.43	--	--		.42	--	--
Mercedes	MB	EPA			8,9,11	1.16	--	--		1.12	--	--
OM362LA	MB	RTC				1.11	--	--		1.09	--	--

[a] Engines are listed per original EPA analysis; more recent data are included at the end of the list.
[b] An explanation of the regressions appears in Table 3-4.
[c] Duplicate engine.
[d] Data changed from hot only to combined per EMA docket submittal, May 13, 1983.
[e] Particulate data not included.
[f] Engine models not specified.
[g] Emissions data derived from plots. Engine models and number and type of tests not specified.
[h] Regression analysis calculated with wrong data (EPA = 1.08, RTC = 1.18).
[i] Changed from .85 to .95 per telephone conversation with IHC on May 16, 1983. The value of .95 was used in Methodologies 4, 5, 8, and 9.
[j] Spurious point; not used in HC regressions.

FIGURE 3-1

EPA Cycle vs. RTC BSHC Emissions

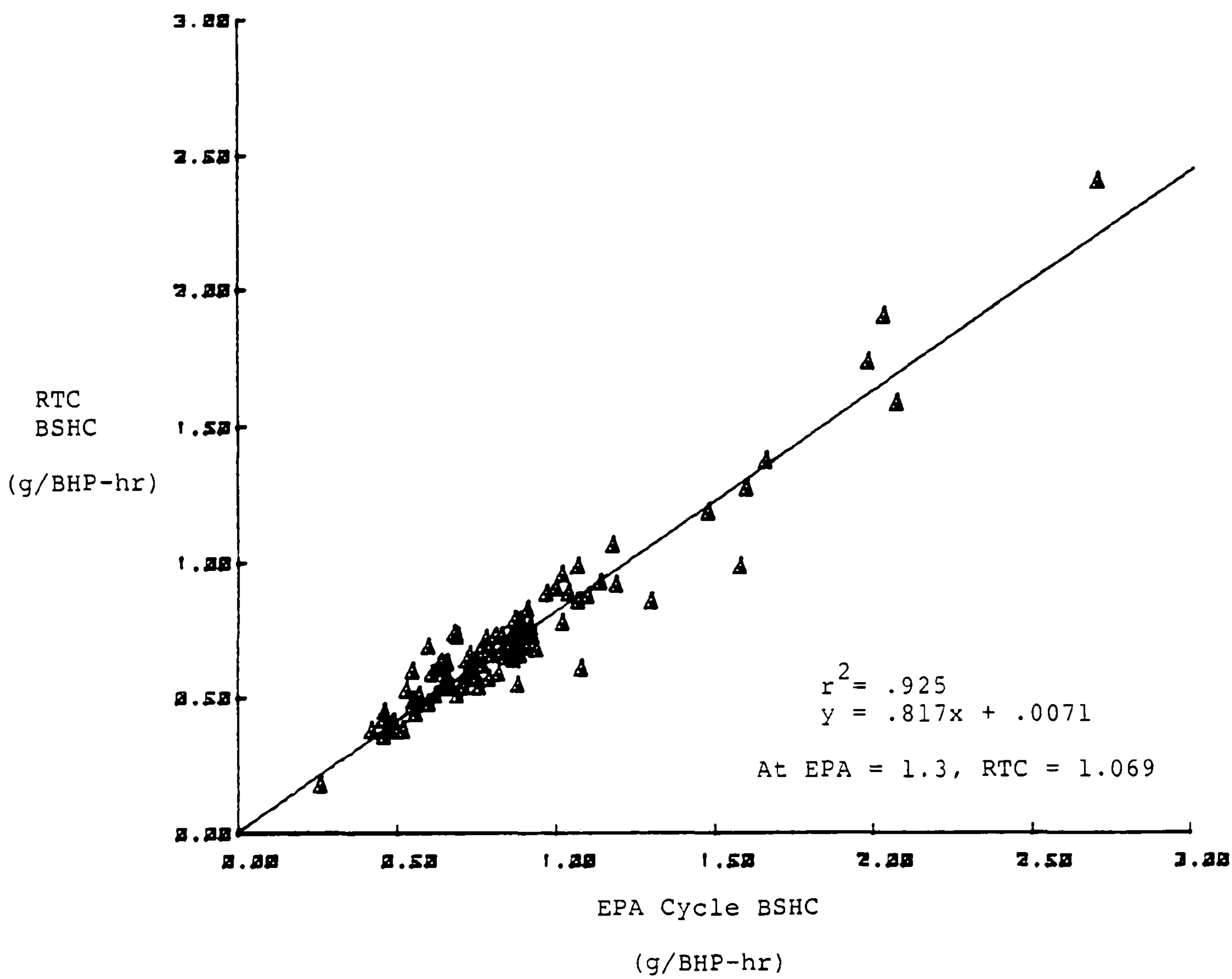


FIGURE 3-2

RTC vs. EPA Cycle BSNOx Emissions

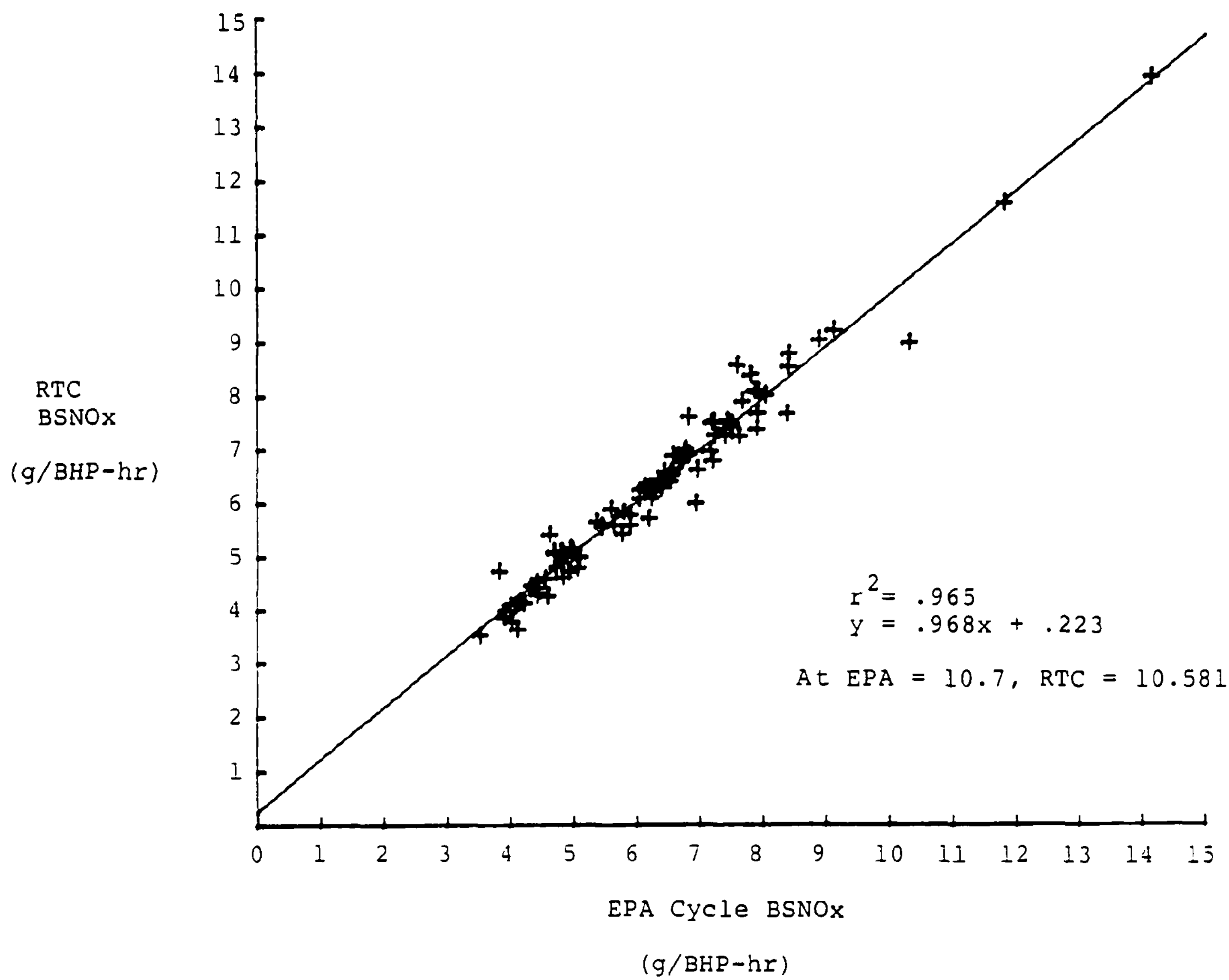
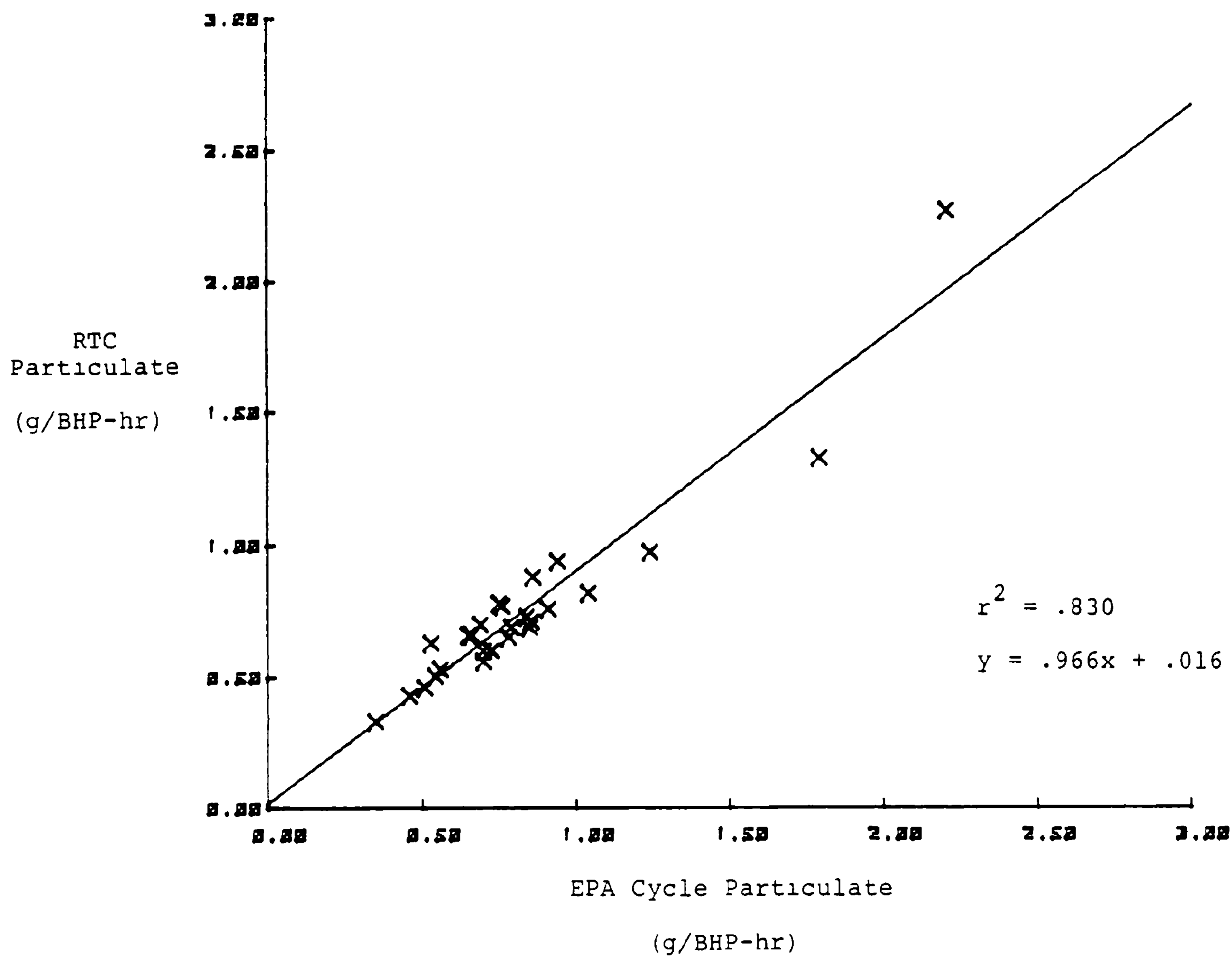


FIGURE 3-3

RTC vs. EPA Cycle Particulate Emissions



Justification for a Standard Adjustment

Given the consistent HC offset between the cycles, EPA believes that there are compelling reasons to adjust the emission standard. EPA cannot agree with EMA's argument that the diesel test cycle should not be linked to the level of emission standards.

First of all, emission standards promulgated on January 21, 1980 were derived using the EPA test cycle. That final rulemaking established the "baseline" against which all subsequent actions must be judged. Test procedures and emission standards are fundamentally related; any significant change to one without the appropriate change to the other represents a net change in the stringency of compliance requirements.

Secondly, the construction of the diesel cycle is not entirely independent from the standard setting process. The gasoline test cycle was used to establish the uncontrolled emission baseline, from which 90 percent reductions were taken to derive the statutory standards. The absolute emission level of the baseline was fundamentally determined by the construction of the gasoline test cycle. Both the EPA gasoline and diesel cycles were composed of the same subcycles in the same sequence (NYNF-LANF-LAF-NYNF). They were both intended to represent characteristic operation of gasoline and diesel trucks over comparable road conditions. This comparability gave EPA confidence that the level of emissions representing the full 90 percent reductions would be achieved by both classes of engines. As noted above, however, the RTC cycle incorporates a NYF segment in lieu of the second NYNF, and some of the operational comparability between the RTC cycle and the gasoline engine baseline is lost. Indeed, had such an operational change been made to the gasoline cycle, EPA is convinced that both the HC baseline and the statutory HC standard would be lower. (Gasoline engine brake specific HC emission rates are substantially lower on the LAF segment than on the LANF segment.) For this reason, the construction of the diesel cycle is not independent of the standard-setting process; comparability in represented road type between gasoline and diesel cycles assures that subsequent emission test results are also comparable.

For the two reasons cited above, EPA does not believe that the specific diesel engine test cycle is independent of either the standard-setting process or the level of the standards. A change in test cycle, therefore, requires an adjustment in emission standards to maintain equivalent stringency.

Standard Adjustment Methodology

To determine equivalently stringent standards for the RTC cycle, EPA evaluated several different methodologies, the results of which are shown in Table 3-4. EPA's first evaluation, distributed for public comment in the summer of 1982, used data from 30 engines/configurations. Twenty-one pairs of the data were combined (cold/hot) results; the remainder were hot-only results. Nine of the engines/configurations are "duplicates," (i.e., they represent the same engines included elsewhere in the data base, but the additional data come from tests performed at different laboratories). This analysis yielded an equivalently stringent HC standard of 1.1 g/BHP-hr (see Table 3-4, Methodology 1).

In early March 1983, Caterpillar recommended another methodology based upon its evaluation of the original data base. Caterpillar concluded that only 16 of the 30 data points used in the EPA evaluation were valid. Caterpillar's evaluation excluded: 1) the hot-only data, and 2) the duplicate engines which were not tested in the laboratory of the engines' manufacturer. Caterpillar excluded the hot-only data claiming that they were "incomplete" tests. (The Federal Test Procedure requires the use of combined cold and hot data.) Caterpillar also excluded duplicate engines from their analysis, claiming that lab-to-lab sensitivity as well as cycle-to-cycle sensitivity would be reflected. After omitting these data points, Caterpillar recommended an RTC equivalent HC standard of 1.2 g/BHP-hr (see Methodology 3, Table 3-4).

EPA then reviewed Caterpillar's analysis to determine if the inclusion of hot-only data and duplicate engines had indeed biased EPA's analysis. (Caterpillar's methodology was accepted and recommended by EMA on May 13, 1983.) EPA staff first contacted the manufacturers and requested all additional data which had been generated since the initial analysis. These data were incorporated into the data base and Caterpillar's (and EMA's) two main concerns were evaluated.

The assertion that the inclusion of hot-only data unduly influenced EPA's analysis was evaluated by directly comparing hot-only data and combined (cold/hot) data in three linear regression analyses (see Methodologies 5, 6, and 7, Table 3-4). The comparisons were done only on engines which had both combined (cold/hot) and hot-only data available. Duplicates were both included and excluded in separate methodologies.

Use of either methodology on identical engines produced insignificant differences in the adjusted emission standards (see Table 3-4). Far more error is induced in the adjusted standard by excluding the hot-only data than including them, primarily because their exclusion reduces the size of the data

Table 3-4

Comparative Methodologies and Results

Methodology	Sample Size	Correlation Coefficient (r^2)	Regression Slope, m	Regression Intercept, b	At EPA = 1.3, EMA =
1. EPA's original analysis using data available in March 1982:	30	.943	.873	-.0302	1.105
2. All available combined data as of March 1982 (duplicates included):	21	.970	.884	-.013	1.134
3. Caterpillar's methodology of early 1983, using EPA's original data (excluding one erroneous point):	16	.993	.920	-.039	1.156
4. Caterpillar's exact methodology of early 1983 (EPA's original data with one erroneous point):	16	.983	.922	-.029	1.170

Table 3-4 (cont'd)

Cold/Hot Versus Hot-Only Comparison

Methodology	Sample Size	Correlation Coefficient (r^2)	Regression Slope, m	Regression Intercept, b	At EPA = 1.3, EMA =
5. Direct comparison of combined cold/hot data vs. hot-only data (duplicates included):					
a. Combined data	17	.974	.905	-.035	1.142
b. Hot-only data	17	.974	.883	+.000	1.148
6. Same as 5, but all duplicate engines excluded if "home" lab has both combined and hot-only data:					
a. Combined data	15	.995	.922	-.034	1.164
b. Hot-only data	15	.994	.897	+.002	1.167
7. Same as 5, but only "home" lab data used (all duplicates excluded):					
a. Combined data	13	.996	.928	-.047	1.160
b. Hot-only data	13	.995	.899	-.003	1.166

Table 3-4 (cont'd)

Comparative Methodologies and Results

Methodology	Sample Size	Correlation Coefficient (r^2)	Regression Slope, m	Regression Intercept, b	At EPA = 1.3, EMA =
8. All combined data, plus hot-only data for engines where combined data is not available (duplicates included). For all data available by June 1, 1983. (EPA's recommended methodology):	99	.925	.817	.007	1.069
9. Same as Methodology 8 (EPA's recommended methodology), but duplicates excluded (home lab data only):	90	.923	.826	-.0018	1.072
10. EPA's recommended methodology, but "sales-weighted," using each manufacturer's percentage of total sales, as shown in Table 3-5:	162	.920	.810	.037	1.09
11. EMA's proposed methodology (May, 1983), excluding hot-only data and duplicates:	23	.988	.901	-.018	1.153

base by almost 70 percent, including the exclusion of all but one engine of the major manufacturer (Cummins Engine Company). The importance of the additional data can be seen in Figure 3-4, in which RTC HC equivalent emissions are plotted as a function of sample size. As the data base increases, the adjusted standard converges on 1.1 g/BHP-hr. Again, this may not so much be an effect of sample size, but more an effect of the inclusion of Cummins's engines in a more representative number. In short, the most accurate representation of the difference between the test cycles is derived from the larger data base; the starting condition of the engine has been demonstrated to be unimportant.

The resulting equivalently stringent HC standard using all available data (Methodology 8) is 1.1 g/BHP-hr. Note that Methodology 9 excluded duplicate engines but included hot-only data; the impact of the duplicate engines on the magnitude of the adjustment is insignificant once hot-only data is included.

As a final evaluation of the sensitivity of the standard adjustment to methodology, and to ensure that one manufacturer's data didn't bias the adjustment, EPA also performed a "sales-weighted" analysis (see Methodology 10). Table 3-5 shows each manufacturer's percentage of total sales and the "weight," (i.e., the number of times added to the regression) of each manufacturer's engines used in the analysis. Again, the equivalent HC emission standard was found to be 1.1 g/BHP-hr.

Based upon the insensitivity of the standard adjustment to engine starting condition, the best and most representative data base is that which includes all of the available data. The emission standards for the RTC are derived by substituting the EPA standards in linear regression equations derived from the most representative data base. Using the regression equations from Figures 3-1 and 3-2 (derived using Methodology 8), and EPA standards of 1.3 g/BHP-hr HC and 10.7 g/BHP-hr nitrogen oxides (NOx), the respective standards for the RTC would be:

HC: 1.1 g/BHP-hr NOx: 10.6 g/BHP-hr

Cycle Selection

In their final comments, the EMA recommended that either the RTC cycle be adopted with a HC standard of 1.2 g/BHP-hr, or the EPA cycle be retained with the existing 1.3 g/BHP-hr standard. In any case, EMA argued, only a single cycle should be set in place.

Table 3-5

"Sales Weighted" Regression Analysis

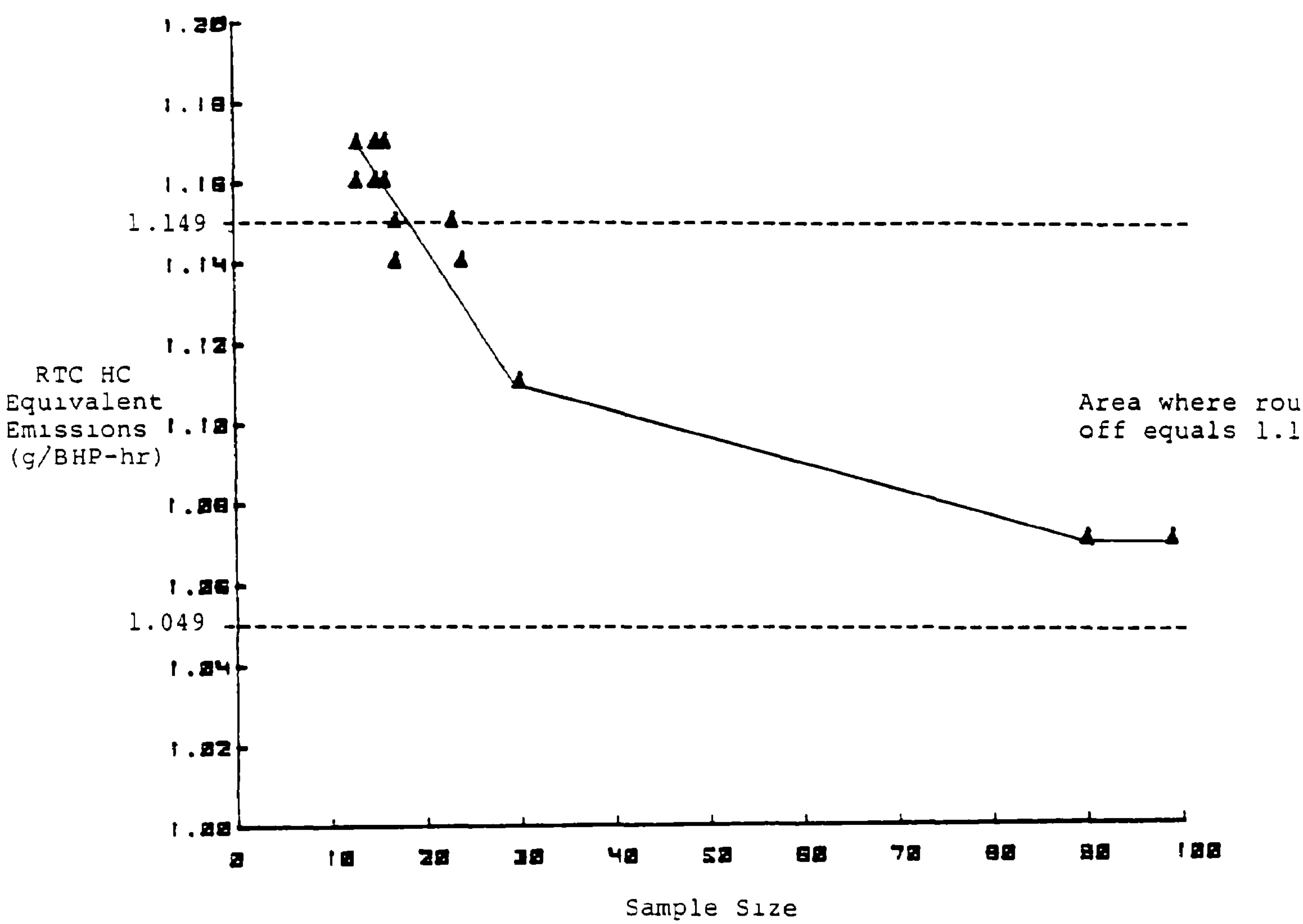
Existing Data:

Number of Engines		Factor	New Data Base	Percent of Total
10 Caterpillar	X	2	20	12.4
66 Cummins	X	1	66	40.7
5 DDA	X	8	40	24.7
9 IHC	X	2	18	11.1
6 Mack	X	3	18	11.1
		Total:	162	100%

* These percentages correspond roughly to 1979 market shares, based upon actual production volumes.

Figure 3-4

Sample Size vs. RTC HC Equivalent Emissions



With respect to the number of test cycles, EPA concurs with EMA's rationale for a single cycle. The use of more than one cycle should be avoided when possible, since it can create unnecessary testing and can add unwarranted complexity to the certification process. With respect to the representativeness of the RTC cycle, EPA considers the development work done by Caterpillar to be technically sound and to have produced a thoroughly valid and representative test cycle. On the other hand, the strong correlation between both cycles increases EPA's already strong confidence in the ability of its own test cycle to predict in-use emission reductions (see Appendix, Chapter 4 of the Transient Test Study).

The issue then boils down to the adjustment of emission standards. Given the observed difference in emissions between test cycles, and given that statutory standards with the existing cycle have already been promulgated, there is no alternative but to adjust the standards for a change in test procedure. If the new test cycle represented an increase in stringency at the same numerical standard, instead of the decrease in stringency seen with the RTC, a standard adjustment would likewise be appropriate. With respect to the magnitude of the adjustment, EPA has been consistently open in presenting its methodologies and results, and has been open to industry's comments. EPA's analysis yields a greater HC adjustment than EMA's recommended methodology, but in EPA's judgment represents a more accurate characterization of the average cycle-to-cycle relationship for the average engine.

EPA has attempted, over time, to reach a consensus with the EMA on the technical issue of the test cycle. EMA's final recommendation to EPA is to promulgate a single cycle, either the EPA cycle at 1.3 g/BHP-hr HC or the RTC cycle at 1.20 g/BHP-hr. For the reasons cited above, EPA can promulgate the RTC cycle with an HC standard of 1.1 g/BHP-hr.

Conclusion

The EPA cycle will be retained as the single driving cycle for the certification of 1984 and later model year HDDEs, in conjunction with the 1.3 g/BHP-hr HC and the 10.7 g/BHP-hr NOx standards.

B. The MVMA Cycle for Heavy-Duty Gasoline Engines

Summary of the Issue

The Motor Vehicle Manufacturers Association (MVMA) has developed an alternative heavy-duty gasoline engine (HDGE) driving cycle. The MVMA cycle was developed because of its concern about the representativeness of the EPA cycle.

Summary of Comments

MVMA and member manufacturers have on several occasions submitted specific recommendations for the MVMA cycle. A brief synopsis of events is again appropriate.

In earlier submissions to EPA, Ford Motor Company (Ford), General Motors Corporation (GM), and the MVMA recommended that EPA replace its own test cycle with the MVMA cycle. This position was reiterated in comments made to the Agency in April of 1982.

EPA's original evaluation (see Appendix, Chapter 6 of the Transient Test Study) of the MVMA test cycle was distributed for public comment in the early summer of 1982. That analysis drew several conclusions about the MVMA cycle. First of all, the MVMA cycle was shown to correlate well with the EPA cycle. Secondly, both HC and CO emissions measured over the MVMA cycle were less than those measured on the EPA cycle, and an adjustment of emissions standards was recommended. Finally, the available data base comparing both cycles was small, and given the undocumented nature of the MVMA cycle's generation, EPA was cautious in its recommendations. More comparative testing between cycles was recommended; EPA judged on the basis of available evidence that the MVMA cycle might perhaps be acceptable as a test option.

Industry's reaction to EPA's analysis initially disputed the need for an adjustment of emission standards, but also agreed with the need for more testing between cycles. The need for more testing was especially clear at the level of the statutory HC and CO standards. No comparative data existed at these low emission levels, creating substantial uncertainty as to the proper adjustments to the statutory standards.

Since then, EPA and the manufacturers have cooperated in generating more test data. The original data base of 14 engines/engine configurations has been expanded to 35. The new data base includes engines of all technologies, ranging from uncontrolled 1969 baseline engines to catalyst-equipped 1985 prototypes. (The analysis of this data base is presented below.)

Both EPA and the industry evaluated the new emission data. In letters to EPA dated on June 10 and June 16, 1983, the MVMA recommended provision of the MVMA cycle as a test option (contrary to earlier recommendations). The industry agreed that a standard adjustment was appropriate, and a specific standard adjustment methodology was recommended, whereby the data base would be split into catalyst and non-catalyst groupings, and emission standards would be adjusted from analysis of the appropriate data base.

Analysis of Comments

In this analysis, we address the construction, representativeness, and relative stringency of the MVMA cycle. Methodologies for emission standards adjustment are discussed, as is the selection of a test cycle for certification testing.

Cycle Development

The MVMA HDGE driving cycle was developed because of industry concerns that the EPA cycle was inadequate in the following two areas:

1. It was not representative of real world truck operation.

2. The irregular nature of the cycle could create interlaboratory correlation problems.

In an attempt to alleviate some of these concerns, MVMA modified the EPA cycle to obtain a driving cycle which they felt was more representative and more acceptable. MVMA established four basic objectives for constructing the modified test cycle. The modified cycle had to:

1. Maintain the general character of the EPA cycle.

2. Improve the relationship between simultaneous speed, power, and acceleration.

3. Reduce momentary speed excursions.

4. Reduce excessive throttle manipulations.

To accomplish these objectives, the cycle was simply examined on a second-by-second basis; using engineering judgment, the speed and torque specifications were revised where deemed appropriate. The resulting driving cycle was a smoothed version of the EPA cycle with a revised synchronization between speed and torque commands. Technical justification for specific cycle changes were not submitted or documented by MVMA.

Statistical Analysis

A comparison of overall statistical parameters from the MVMA cycle, EPA cycle, and the CAPE-21 data base is listed in Table 3-6. The CAPE-21 statistics are included for comparison purposes, although the MVMA cycle was not directly derived from the CAPE-21 data base.

Table 3-6
Cycle Statistics: MVMA Cycle, EPA Cycle, CAPE-21 Data Base

Parameter	MVMA	EPA	CAPE-21
Torque			
Mean (%)	37	36	34
Percent of Cycle Time			
Acceleration (%)	15	17	15
Deceleration (%)	19	20	16
Cruise (%)	28	26	28
Motor (%)	9	10	13
Idle (%)	28	27	28
RPM			
Mean (%)	31	30	31
Percent of Cycle Time			
Acceleration (%)	20	24	20
Deceleration (%)	26	21	26
Cruise (%)	26	23	26
Idle (%)	28	31	28

As can be seen from the table, the EPA cycle and MVMA cycle are very similar statistically. There are no major discrepancies, which is to be expected since the MVMA driving cycle is directly derived from the EPA cycle. However, data from engine tests indicate total engine work (BHP-hr) over the MVMA cycle is about 10 percent higher than on the EPA cycle. This increase in cycle work is attributable to the resynchronization of the speed and torque commands. The MVMA cycle is also less transient than the EPA cycle. The speed and torque sequences are smoother, and numbers of torque accelerations have been completely eliminated, thereby reducing the number of throttle position changes. (This reduces accelerator pump operation and transient fuel enrichment.)

The MVMA cycle is statistically similar to the EPA cycle, but not operationally identical.

Test Cycle Correlation Analysis

EPA, Ford, and GM have now tested 35 gasoline engine configurations to compare the MVMA and the EPA cycle. Both catalyst and non-catalyst configurations have been tested, as have engines at all levels of emission control. (The emission data from these tests are summarized in Table 3-7.)

Excellent statistical correlations were observed between the MVMA cycle and the EPA cycle. The data were split into non-catalyst and catalyst sets, on which linear regression analyses were performed. For non-catalyst emissions of HC and CO, coefficients of determination (r^2) values were found to be .972 and .987, respectively. The r^2 values for catalyst emissions of HC and CO were .915 and .975, respectively. For the entire data base, the r^2 value for NOx emissions was .974. The above data indicates that in all cases, the correlation between the test cycles is strong.

In both sets of data, however, MVMA cycle emissions are consistently less than those measured on the EPA cycle. These differences are explainable by the operational differences between the cycles, (i.e., the MVMA cycle is smoother, and that the speed and torque commands follow each other more closely on the MVMA cycle resulting in an increase in integrated power-hour). These changes are illustrated graphically in Figure 3-5 where the same characteristic sections from both test cycles have been overlaid. The decrease in the transience of the MVMA cycle results in less movement of the engine accelerator pump, which would be expected to result in lower HC and CO emissions. The rephasing of the speed and torque commands results in different modes of engine operation on the two test cycles, with fewer events at both lower speed and load on the MVMA cycle. The observed increase in power-hour over the MVMA cycle may also explain the decrease in the brake

Table 3-7

MVMA Transient Test Cycle Adjustment Analysis
Emissions Data: g/BHP-hr

No.	Test Facility	EPA Cycle Tests	EPA Cycle HC	EPA Cycle CO	EPA Cycle NOx	MVMA Cycle Tests	MVMA Cycle HC	MVMA Cycle CO	MVMA Cycle NOx	Comments
1	EPA	3C/5H	6.12	118.4	6.54	2C/5H	4.72	109.4	6.38	1969 GM 4.8L (292 CID) - original data base
2	EPA	2C/4H	7.64	126.6	7.74	2C/4H	6.49	125.0	7.50	1969 Ford 4.9L (300 CID) - original data base
3	EPA	2C/5H	8.14	135.5	4.43	2C/5H	7.71	143.2	4.22	1969 GM 5.8L (350 CID) - orignial data base
4	Ford	2C/2H	2.86	28.4	8.04	1C/1H	2.40	21.7	8.75	1985 prototype Ford 4.9L (300 CID) - original data base
5	Ford	1C/1H	2.36	28.9	7.42	1C/1H	1.50	27.8	6.67	1985 prototype Ford 6.1L (370 CID) - original data base
6	Ford	2C/4H	2.46	30.5	8.29	2C/6H	1.59	25.7	8.01	1985 prototype Ford 6.1L (370 CID) - original data base
7	Ford	1C/3H	3.28	31.3	8.55	1C/3H	1.81	27.7	8.77	1985 portotype Ford 6.1L (370 CID) - original data base
8	Ford	1C/1H	2.34	30.6	8.17	1C/1H	1.48	25.5	8.04	1985 prototype Ford 6.1L (380 CID) - original data base
9	GM	1C/1H	1.28	47.9	5.06	1C/1H	1.44	52.4	4.91	1981 GM 7.5L (454 CID) - original data base
10	GM	1C/1H	3.12	98.7	5.48	1C/1H	2.89	100.4	4.25	Ibid: less controls - original data base

Table 3-7 (cont'd)

MVMA Transient Test Cycle Adjustment Analysis
Emissions Data: g/BHP-hr

No.	Test Facility	EPA Cycle Tests	EPA Cycle HC	EPA Cycle CO	EPA Cycle NOx	MVMA Cycle Tests	MVMA Cycle HC	MVMA Cycle CO	MVMA Cycle NOx	Comments
11	GM	1C/1H	7.45	63.4	6.22	1C/1H	5.85	52.9	6.47	1981 GM 7.0L (427 CID) - original data base
12	GM	1C/1H	10.06	129.6	5.67	1C/1H	8.51	116.0	5.93	Ibid: less controls - original data base
13	GM	1C/1H	3.33	26.7	8.13	1C/1H	2.70	26.3	8.11	1981 GM 4.8 (292 CID) - original data base
14	GM	1H	1.66	12.3	8.93	1H	1.08	10.8	8.89	Ibid: less controls - original data base
15	Ford	4C/4H	3.21	34.6	8.09	4C/4H	2.02	27.1	8.11	1983 modified Ford 6.1L (370 CID) - correlation program
16	EPA	4C/4H	4.05	30.8	7.04	4C/4H	3.30	30.0	7.14	Ibid
17	Ford	2C/2H	1.75	36.9	7.32	2C/2H	1.46	34.1	7.48	1983 modified GM 5.8L (350 CID) - correlation program
18	GM	4C/4H	2.23	33.3	7.90	3C/3H	1.79	34.1	7.99	Ibid
19	Ford	2C/2H	1.84	35.3	5.56	3C/3H	1.28	29.8	5.09	1985 prototype Ford 7.5L (454 CID)
20	Ford	2C/2H	1.70	19.7	5.44	1C/1H	1.20	18.2	4.77	Ibid
21	Ford	4C/4H	0.47	18.2	5.43	3C/3H	0.37	16.3	4.86	1985 prototype Ford 7.5L (454 CID): 2 150 in^3 COC LDT new catalysts
22	GM	2H	0.41	55.5	1.70	2H	0.41	60.3	1.76	1983 LDT GM 5.8L (350 CID): 260 in^3 COC new pelletized catalyst

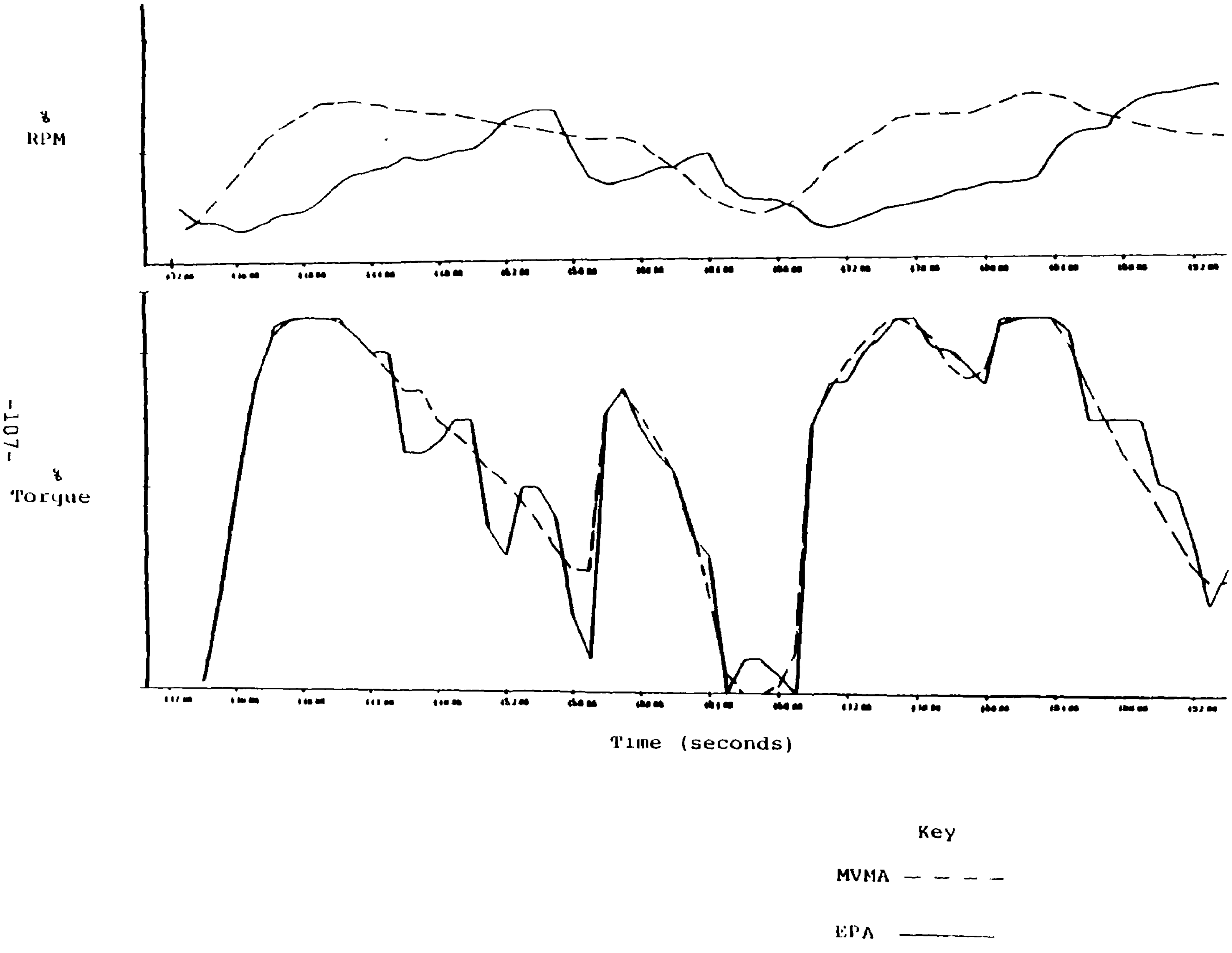
Table 3-7 (cont'd)

MVMA Transient Test Cycle Adjustment Analysis
Emissions Data: g/BHP-hr

No.	Test Facility	EPA Cycle Tests	EPA Cycle HC	EPA Cycle CO	EPA Cycle NOx	MVMA Cycle Tests	MVMA Cycle HC	MVMA Cycle CO	MVMA Cycle NOx	Comments
23	EPA	3C/3H	0.52	40.8	2.97	3C/3H	0.48	45.0	2.63	1982 LDV-S/W GM 5.0L (305 CID): 260 in^3 COC pelletized catalyst
24	SwRI	2C/2H	0.39	5.6	2.50	2C/2H	0.34	7.3	2.30	1975 5.7L (350 CID): COC/TWC pelletized catalyst
25	EPA	2C/2H	0.78	72.6	.19	2C/2H	.79	75.3	1.07	1982 LDT Ford 5.0L (302 CID): 128 in^3 COC/TWC system
26	EPA	1C/1H	4.15	105.5	3.84	1C/1H	2.59	106.0	3.90	Ibid: without catalysts
27	EPA	2C/2H	2.42	94.5	1.80	2C/2H	1.88	83.8	1.90	Ibid: catalyst system moved to location behind muffler
28	EPA	5H	4.04	153.6	5.51	2H	3.57	164.7	4.60	1981 LDV GM 5.8L (350 CID) TWC system: tested without catalyst
29	GM	1C/1H	.53	5.6	4.44	1C/1H	.41	4.7	4.54	Chevy 350 HD prototype: 2 260 in^3 COC pellet catalysts
30	EPA	2C/2H	.89	20.0	9.54	2C/2H	.61	18.7	9.18	1985 prototype Ford 7.5L (454 CID): 2 150 in^3 COC LDT new catalysts
31	EPA	1C/2H	2.49	33.3	8.88	1C/2H	1.95	30.9	9.21	Ibid: without catalysts
32	EPA	2C/2H	1.68	59.4	2.62	2C/2H	1.43	55.7	2.72	1982 LDT Ford 5.0L (454 CID): 128 in^3 COC catalyst
33	EPA	1C/2H	4.74	89.7	4.18	1C/2H	3.84	87.7	3.97	Ibid: without catalyst

Figure 3-5

MVMA Cycle and EPA Cycle Comparison



specific emissions (i.e., more emissions divided by increased output work). Changing the engine speed at which motoring (defined as -10 percent maximum engine torque) occurs would certainly create HC emission differences between the cycles. Smoothing of the MVMA's cold start cycle may also yield lower HC emissions, especially for catalyst-equipped engines.

In summary, the MVMA cycle does not yield emissions equivalent to the EPA driving cycle; it is not equivalently stringent at the same numerical emission standards for HC and CO. The MVMA cycle does, however, correlate well with the EPA cycle for a wide variety of engines. This strong correlation implies that there is no advantage in using one cycle over the other to predict in-use emission reductions.

Standard Adjustment Methodology

EPA's review of the available data indicates that different correlations exist between the test cycles, depending upon the technology applied to the engine. Specifically, the relationship between the test cycles is affected by the presence of a catalyst, especially for HC. Given this fact, we also note the fact that the standards to be adjusted, 1.3/15.5 and 2.5/40.0, represent 100 percent catalyst and 100 percent non-catalyst technologies, respectively. The most rigorous technical approach for adjusting the emission standards would therefore be to split the data base into catalyst and non-catalyst groupings. The MVMA cycle-based non-catalyst standards would be obtained from an analysis of only non-catalyst data. Similarly, the MVMA cycle-based catalyst standards would be obtained from only the catalyst data.

The non-catalyst data and the resulting linear regression equations for HC and CO are presented in Figures 3-6 and 3-7. The non-catalyst analysis is straightforward, and uses all available non-catalyst data. However, the derivation of appropriate linear regressions for the catalyst data base cannot be made without first exercising some engineering judgment. Emissions observed on these catalyst-equipped engines lay over a very wide range. (Several of the engines were light-duty truck engines, with catalysts and air injection systems ill-designed to control CO emissions over the heavy-duty test.) Some data lay far enough outside of the range expected for HDGEs that they should be judged unrepresentative and excluded from analysis. In addition, excluding all unrepresentatively high CO data for catalyst-equipped engines leaves only six representative data pairs. This is a data base whose small size may raise concern as to the accuracy of the derived MVMA cycle-based standard.

All in all, five data pairs should be discarded from the CO analysis as unrepresentative. (Each of the five lies above

Figure 3-6

EPA Cycle vs. MVMA Cycle
BSHC Non-Catalyst Emissions

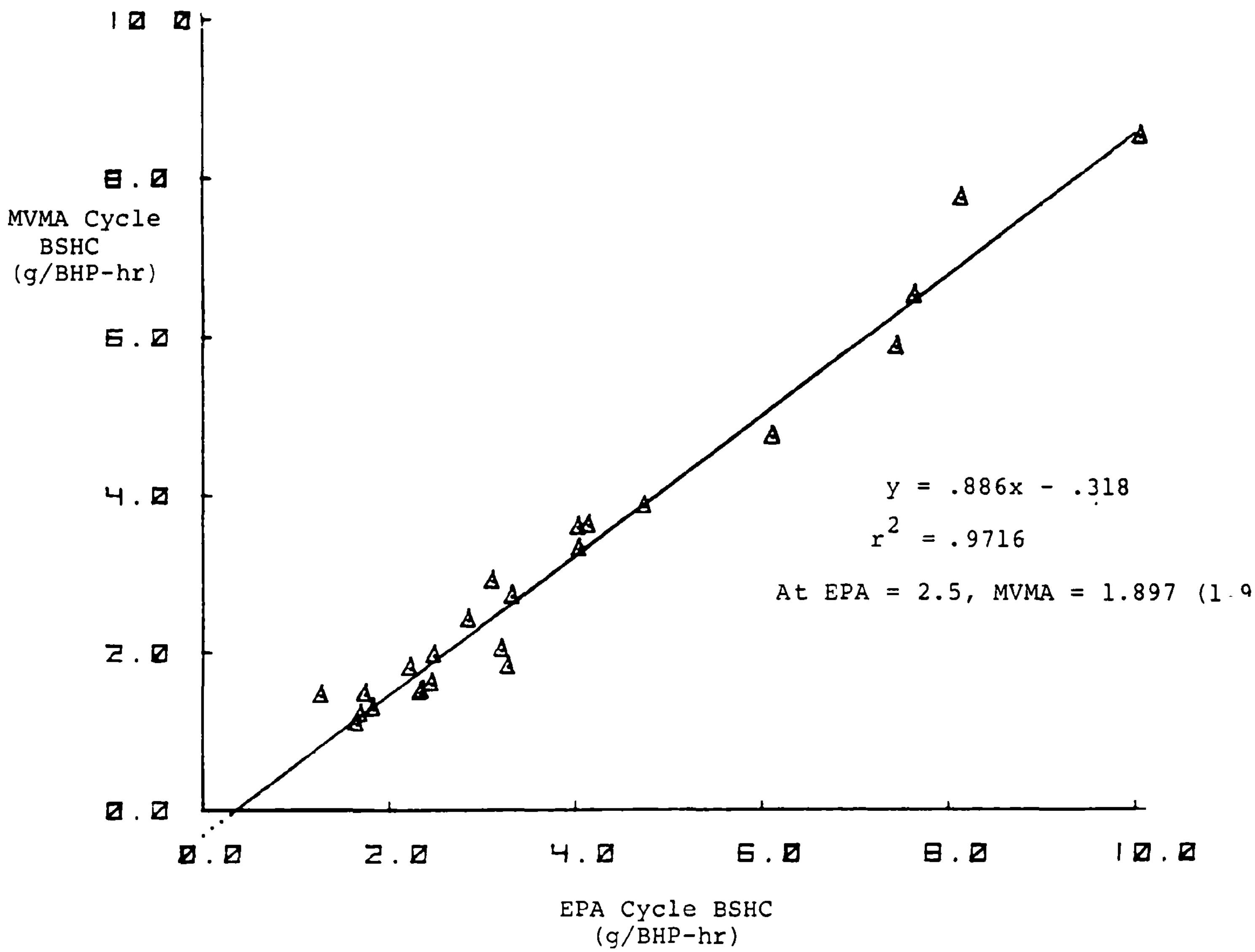
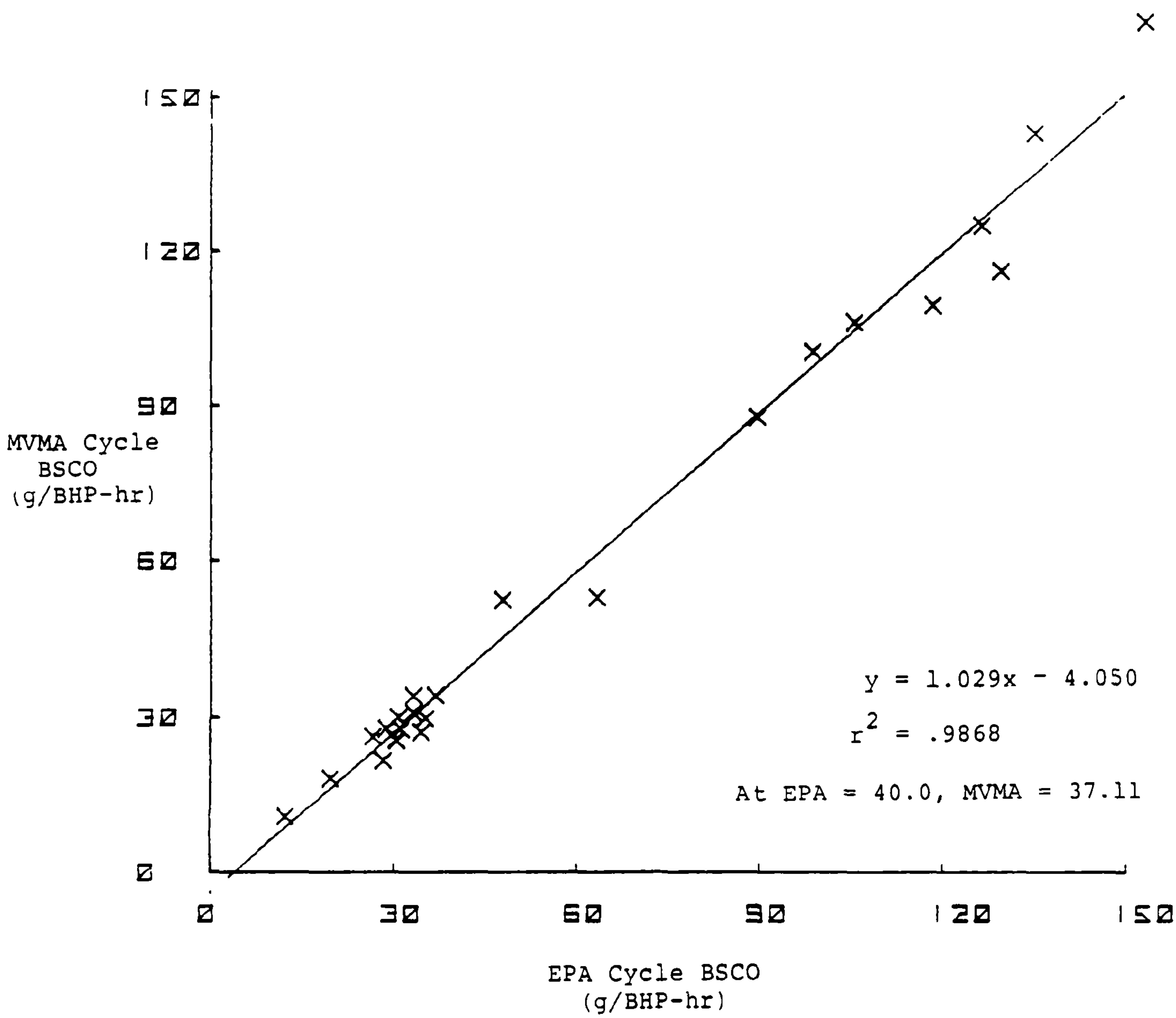


Figure 3-7

EPA Cycle vs. MVMA Cycle
BSCO Non-Catalyst Emissions



40.0 g/BHP-hr, well beyond the range of the 15.5 g/BHP-hr standard.) Similarly, one data pair should be discarded from the HC analysis. (This data was taken by EPA with the catalyst relocated behind the muffler in an attempt to characterize the effects of catalyst location. The HC emissions were well above the 1.3 g/BHP-hr level, and the engine is not representative of a typical catalyst-equipped engine.) Using the remaining data, the catalyst regression equations for HC and CO are presented in Figures 3-8 and 3-9.

Finally, for the adjustment of the NOx standard of 10.7 g/BHP-hr, all 35 data pairs were used. NOx emissions are not significantly affected by the presence of a catalyst, and it is not necessary to segregate the data base. This analysis and its accompanying regression equation are presented in Figure 3-10.

Based upon the 1985 non-catalyst EPA cycle-based standards of 2.5 g/BHP-hr HC, 40.0 g/BHP-hr CO, 10.7 g/BHP-hr NOx, the 1987 EPA cycle-based standards of 1.3/15.5/10.7, and the derived regression equations, equivalently stringent standards for the MVMA cycle are as follows:

	HC (g/BHP-hr)	CO (g/BHP-hr)	NOX (g/BHP-hr)
1985 MVMA Standards (non-catalyst)	1.9	37.1	10.6
1987 MVMA Standards (catalyst)	1.1	14.4	10.6

EPA is confident in the accuracy of the derived adjustments for both HC standards (catalyst and non-catalyst), both NOx standards, and the non-catalyst CO standard. EPA was initially concerned, however, about the accuracy of the adjustment for the 1987 CO standard because of the small sample. Upon reviewing all data, however, EPA is reasonably confident in its accuracy. For six data pairs included in this analysis, the offset between cycles is fairly consistent; the ratios of MVMA cycle CO to EPA cycle CO exhibit a coefficient of variation of 17.3 percent, but only 4.4 percent if the single outlier is excluded. In other words, the offset is repeatable. More significantly, the ratio of the adjusted MVMA cycle-based standard to the EPA cycle-based standard for catalyst engines is virtually identical to that observed in the adjustment of the non-catalyst standard (14.4/15.5 equals .929, whereas 37.1/40.0 equals .928.) Assuming substantially similar test cycles, and assuming that the catalyst operates at a constant oxidation efficiency over the test cycles, this observation is to be expected. Note that the same observation

Figure 3-8

EPA Cycle vs. MVMA Cycle
BSHC Catalyst Emissions

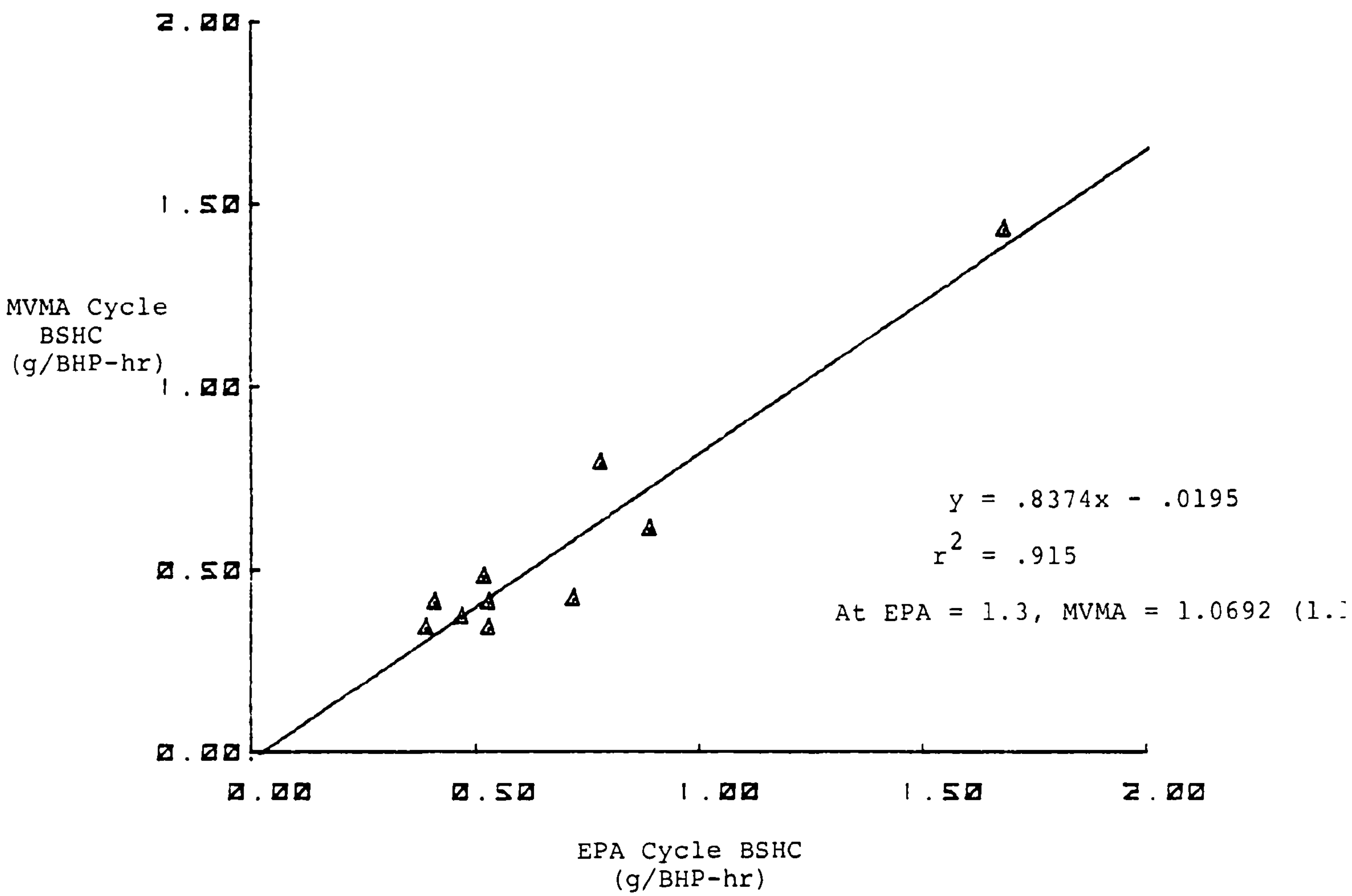


Figure 3-9

EPA Cycle vs. MVMA Cycle
BSCO Catalyst Emissions

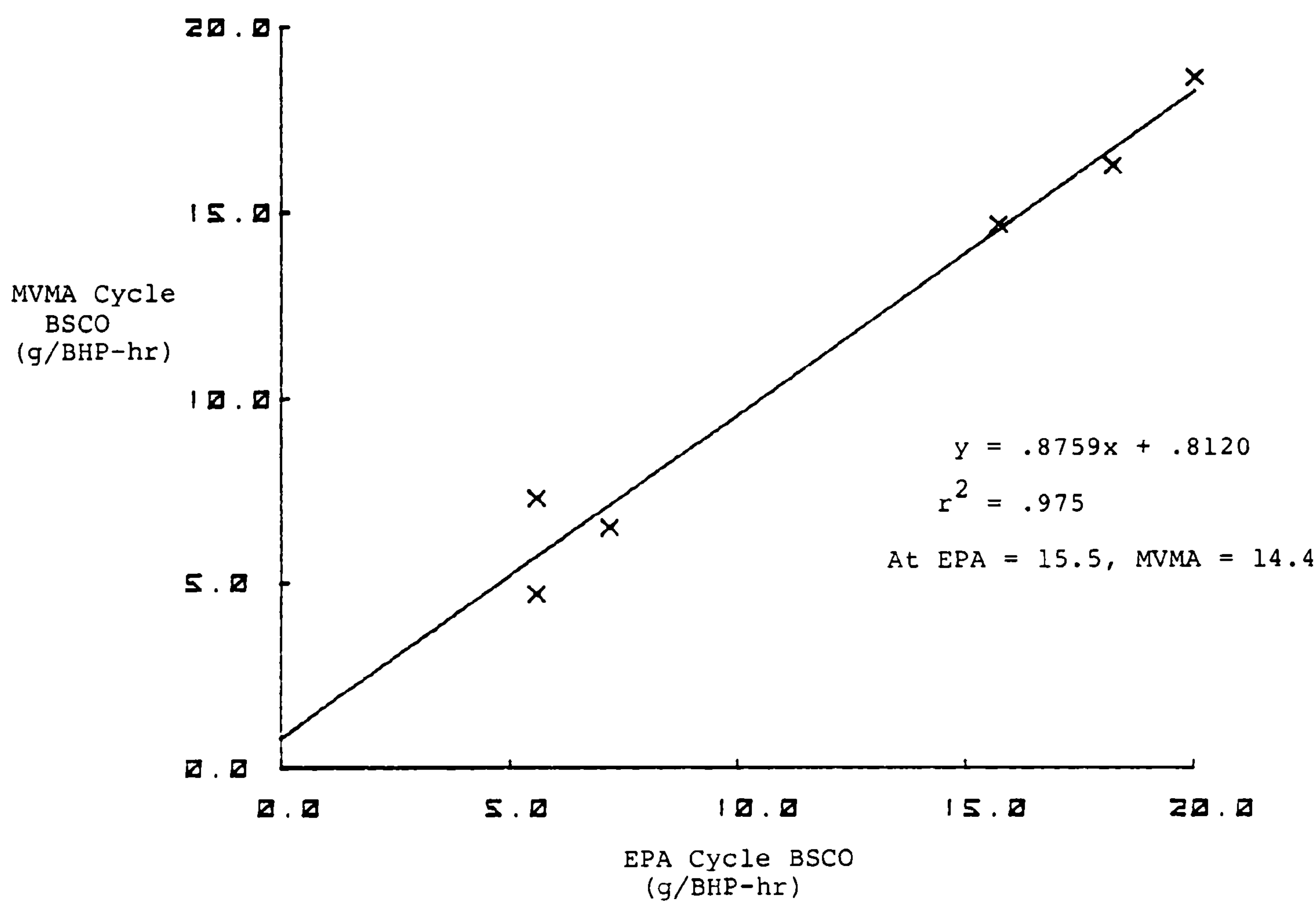
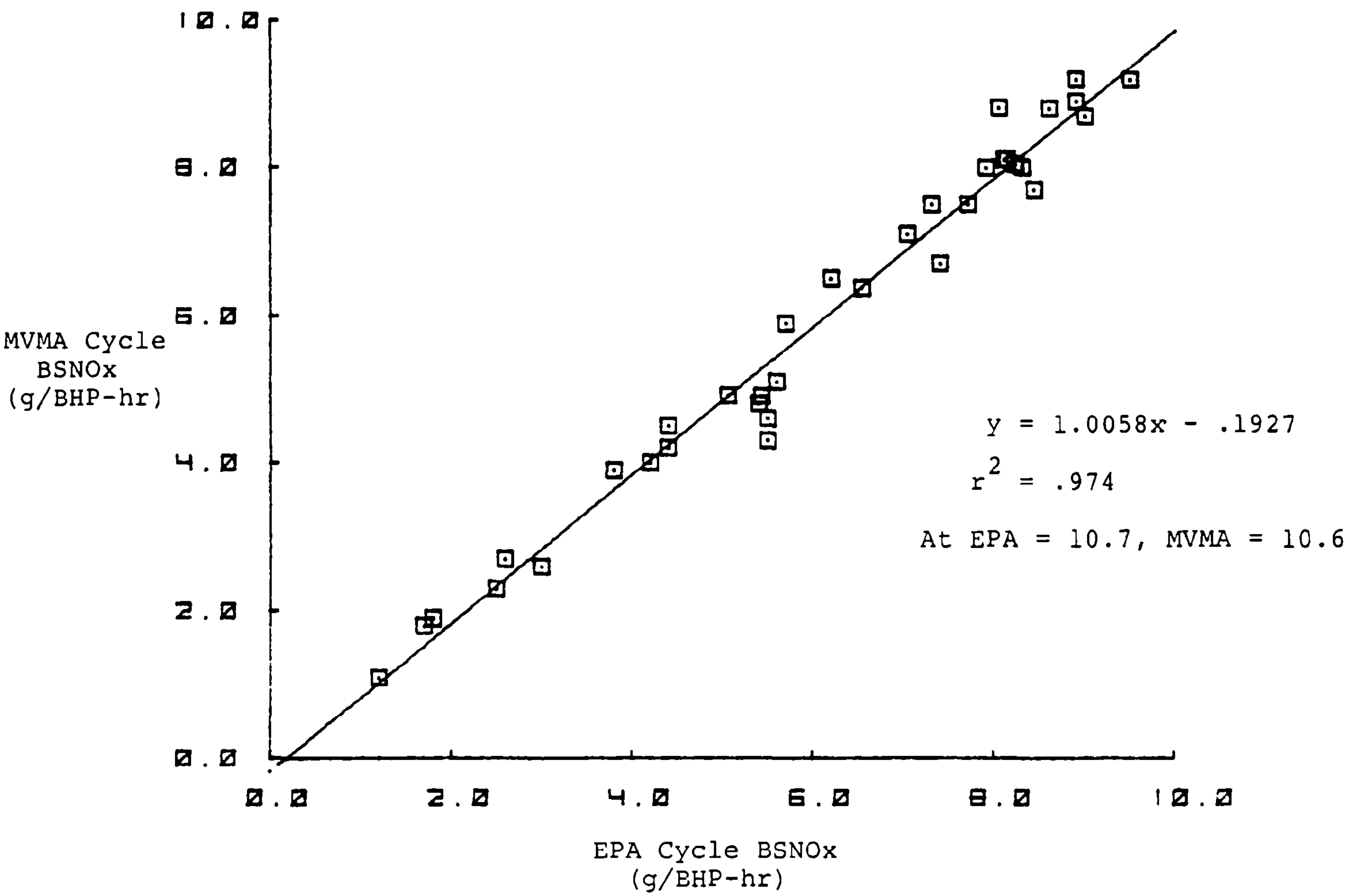


Figure 3-10

EPA Cycle vs. MVMA Cycle
BSNOx (Catalyst and Non-Catalyst)



is not true for HC: 1.1/1.3 equals .846, whereas 1.9/2.5 equals .760. This is also to be expected, however, because the catalyst does not maintain a constant efficiency over the test cycle for HC oxidation. The cold start produces the majority of HC emissions on catalyst-equipped engines; the HC offset between the MVMA and EPA cycles on catalyst-equipped engines is primarily attributable to the offset in HC emissions before catalyst light-off. (HC emissions on either cycle after light-off are virtually eliminated by the catalyst.) Primarily for this reason, the degree of HC adjustment between cycles differs between catalyst and non-catalyst engines. Most of the CO emissions, however, for both catalyst and non-catalyst engines come from high-power, warmed-up operating modes. For this reason, EPA believes that its assumption of constant catalyst efficiency in evaluating the CO adjustment is valid, and that the derived MVMA cycle-based statutory CO standard is correct. Any error in the adjustment of the statutory CO standard is likely to be small.

Test Cycle Selection

For the reasons discussed in the RTC analysis, EPA prefers the use of a single cycle for certification. MVMA, however, recommended that its cycle be adopted as an option for 1985, primarily because different member manufacturers have conducted development work on different cycles. Selection of a single cycle for 1985 may penalize a manufacturer who has used the rejected cycle for all development work. In a letter to EPA dated June 16, 1983, MVMA was unable to identify conditions under which it would accept a single cycle (unlike EMA's final recommendation on the EPA/RTC cycle selection). MVMA also did not specifically recommend which cycle should eventually be chosen as the single certification cycle beyond 1985, although it agreed with EPA that a single cycle should eventually be selected.

EPA can appreciate the position a manufacturer would find itself in if the test cycle on which all its development work was based was suddenly eliminated. For this reason, EPA can accept the use of an optional test cycle in 1985, and the Agency will conduct all its confirmatory testing, SEA testing, etc., with the specific cycle on which a manufacturer certifies, provided that the manufacturer certifies its entire product line on the same cycle. (Required use of a single cycle by a manufacturer for all its engines will eliminate the potential for gamesmanship by selecting the "best" cycle for a specific engine family.) Under these conditions, EPA finds the use of the MVMA cycle as an optional procedure for 1985 to be acceptable.

On the other hand, EPA cannot accept the indefinite provision of two test cycles. Our analyses indicate that either cycle would be acceptable, provided that the emission standards were appropriately adjusted. For this reason, and in the interest of reaching a technical accommodation with the industry, EPA has no objection to adopting the MVMA cycle as the official EPA certification test cycle. It is EPA's judgment that the MVMA cycle is preferred by the industry. This adoption is most reasonably made in the 1987 model year, when the next major recertification of HDGEs occurs.

Conclusions

1. Both the EPA and MVMA test cycles will be permitted for certification in 1985 and 1986; optional use of either cycle will be permitted, provided that any single manufacturer certifies all its engines on the same test. Similarly, all confirmatory and other regulatory testing will be conducted on the same cycle on which the manufacturer originally certified.

2. After 1986, all certification and running change testing (except carryover for non-catalyst engines previously certified on the EPA cycle) will be conducted on the MVMA cycle.

3. The following emission standards, as derived by this analysis, will be used:

		BSHC (g/BHP-hr)	BSCO (g/BHP-hr)	BSNOX (g/BHP-hr)
1985:	EPA Cycle	2.5	40.0	10.7
	MVMA Cycle	1.9	37.1	10.6
1987:	MVMA Cycle	1.1	14.4	10.6

References

1. Derived from Comments Submitted to EPA Public Docket No. A-81-20.

2. Derived from Comments Submitted to EPA Public Docket No. A-81-11.

3. "Evaluation of the Federal Test Procedure for Heavy-Duty Diesel Engines for 1984 and the Development of the Real Time Test Cycle," W. L. Brown, Jr., Research Report 88-29, File 18967, Caterpillar Tractor Company, June 22, 1981.

4. "Transient Cycle Arrangement for Heavy-Duty Engine and Chassis Emission Testing," Chester J. France, EPA Report HDV 78-04, August 1978.

5. MVMA-Modified Heavy-Duty Gasoline Engine Transient Emission Test Cycle, Attachment, Letter to EPA Administrator, Motor Vehicle Manufacturers Association, February 15, 1982 (see EPA Public Docket No. A-81-11, IV-D-2 and IV-D-2a).

4. Issue: Environmental Impact

Summary of the Issue

The impact of this rulemaking on the nation's air quality was a topic of substantial comment. Many commenters were critical of the revised rule on the grounds that it would not lead to the maximum possible air quality improvements, while others criticized it as being more stringent than is necessary.

Summary of the Comments

Comments arguing that this rule fails to force the maximum achievable air quality benefits were received from the following individuals and organizations: Senator Gary Hart of Colorado; Frances J. Scherer of New York, a private citizen; the National League of Women Voters (LWV); the Manufacturers of Emission Controls Association (MECA), an industry trade group; the Natural Resources Defense Council (NRDC); the Regional Air Pollution Control Association (RAPCA) of Dayton, Ohio; and the Western New York Allergy and Ecology Association (WNYAEA). These state and local LWV affiliates also submitted comments: Michigan; Carson City, Nevada; New York City; and Doylestown, Pennsylvania.

Those maintaining that the revised rule is still unnecessarily stringent from the standpoint of achieving the desired improvements in air quality were all manufacturers. The comments of Ford Motor Company (Ford), General Motors Corporation (GM), International Harvester (IH), and Mack Truck (Mack) are summarized after those of the commenters listed above.

All of the commenters in the former group (opposing relaxation) maintained that these revisions to the light-duty truck (LDT) and heavy-duty engine (HDE) emission rules pose a threat to the public health and welfare. Citing figures from the December 1979 EPA Regulatory Analysis projecting average improvement of 7 percent in 1995 for carbon monoxide (CO), Senator Hart noted that for cities with very high CO levels such as Denver and Los Angeles, this difference could "...determine whether or when the ambient air quality standards will be achieved." The LWV, MECA, NRDC, and RAPCA all cited this figure, and the 2 percent average improvement for ozone in 1995 projected in the same document, to argue that air quality improvements of that magnitude are necessary if areas currently in nonattainment status for either pollutant are to be brought into compliance.

The NRDC, MECA, and LWV all noted that control of hydrocarbon (HC) and CO emissions from HDEs has previously been found to be cost effective, and that the control technology necessary to meet the statutory standards is available. Emissions from HDEs have not been reduced to nearly the extent that light-duty vehicle (LDV) emissions have, NRDC and LWV stated; thus, HDEs have not borne their proportionate share of mobile source emissions reductions and associated costs to date.

MECA listed some of the air quality problems foreseen by the Association of State and Territorial Air Pollution Administrators (ASTAPA) "...if auto and truck emission standards are relaxed." Citing To Breathe Clean Air, the 1981 final report of the National Commission on Air Quality (NCAQ), and EPA-supplied data, MECA noted that violations of the National Ambient Air Quality Standard (NAAQS) for ozone are projected to occur through at least 1995 and stated that "...it is generally agreed that if the ozone air quality standard is ever to be achieved all feasible and reasonable hydrocarbon controls will be needed."

MECA indicated that even if it were concluded, contrary to "clear and compelling evidence," that adequate control of HDE emissions of HC and CO could be achieved without the use of catalysts, catalyst technology should still be implemented. Catalysts offer "an attractive answer to [future] gasoline-truck NOx control," MECA stated, and rejection of catalysts for HC and CO control at this time will make it more difficult to implement such technology in the future.

RAPCA was critical of the lack of detailed air quality analysis data included in the Federal Register publication of this rulemaking, stating that the information provided "...is so sparse as to make it virtually impossible to determine the impact of the anticipated emission increases on the Dayton Region." Since the Dayton area is currently operating under a nonattainment State Implementation Plan (SIP) for ozone, RAPCA finds it difficult to accept EPA's "...conclusory assertion of no impact." RAPCA also called it unseemly for EPA to propose "a large increase in truck emissions" and assert that the impact on air quality will be small, while simultaneously "restricting access" to the detailed information (air quality modelings) necessary for independent evaluation of EPA's conclusions.

In addition to their concerns over the ozone and CO air quality impacts of this rule, LWV expressed reservations about anticipated increases in lead emissions from HDEs as compared to the original 1984 rulemaking. They contended that the relaxation of the HDE emission standards to non-catalyst levels will increase lead emissions both directly, through continued

HDE lead emissions which would have been eliminated under the originally promulgated standards, and indirectly, through extension of a legitimate source of demand for leaded gasoline at the retail level, thereby extending the opportunity for misfueling of catalyst-equipped LDVs and LDTs.

NRDC documented its opposition to this rule using many quotes and figures taken from EPA's December 1979 Regulatory Analysis. In addition, pertinent quotes were taken from House Report No. 95-294 (95th Congress, 1st Session, 1977), the NCAQ final report, other reports by the National Academy of Science, the Library of Congress, and the New York City Department of Air Resources, a study conducted by the Jet Propulsion Laboratory, and former Senator Edmund Muskie, floor manager for the 1977 Clean Air Act (the Act) amendments. All of these stressed the need for further control of HDE emissions.

Finally, NRDC also claimed that the air quality impacts calculated by EPA and included in the September 1981 Draft Regulatory Support Document are significantly understated when the deterioration factors (DFs) contained in EPA's January 15, 1982 response to questions from Senator Robert Stafford of Vermont on motor vehicle emission standards are used. NRDC claimed that EPA used different (and lower) DFs in the Regulatory Support Document. On this basis, NRDC urged "...that EPA reanalyze the air quality impacts, impacts on nonattainment status, and impacts on the number of exceedances using the more recent deterioration factors submitted to Congress."

The remaining comments concerning the air quality impacts of this rule are those of the manufacturers. All felt that the rule, even as revised, is unnecessarily stringent for attainment of the air quality benefits sought. Several different bases for this position were advanced.

Ford and Mack both questioned the need to control HC emissions from HDEs to the extent required in the rule, on the grounds that all areas exceeding the NAAQS for ozone are urban, while much of the HC from heavy-duty trucks (HDTs) is emitted in rural areas. Ford stated that approximately half of all HDT vehicle miles travelled (VMT) are in rural areas, and that the air quality impacts for ozone and CO projected by EPA are therefore approximately twice the magnitude of the actual impacts. Mack quoted the Department of Commerce 1977 Truck Inventory and Use Survey, which showed that only 22 percent of the VMT of Class VIII heavy-duty diesels (HDDs) are accumulated in urban areas. On this basis Mack, which manufactures only heavy-duty diesel engines (HDDEs) for Class VIII applications, stated that EPA must consider the fraction of all HDT VMT that are accumulated in urban areas when performing air quality analyses.

Mack also accused EPA of failing to use the findings of the August 1980 pollutant-specific study (PSS) for HC when setting the standards for HDDEs. Its argument can be summarized as follows: The 57 areas in violation of the NAAQS for ozone are all urban areas. According to the PSS, in 1999 HDDEs will be contributing only 4.7 percent of total HC emissions in those 57 areas. (Mack added that a report by Southwest Research Institute (SwRI) shows that this HDDE fraction of total HC will be only 3.6 percent in 1999.) The SwRI report also said that $377 million would be spent during the 1990s on control of HC from HDEs, in order to bring "only one or two AQCRs" into compliance. Since further control of HC from HDDEs is "obviously" not cost effective based on this information, Mack concluded, EPA did not use the findings of the PSS in setting the standards. In failing to do so, Mack claimed that EPA has "...overlooked a very important and significant issue."

IH recommended that EPA perform a complete reanalysis of all air quality and cost/benefit questions, taking into account two factors that they maintained were not considered. The first of these dealt with the multiplier that EPA used to convert 1979 certification HC emission rates to equivalent 1984 transient cycle HC emission rates for HDDEs. In the December 1979 Regulatory Analysis, EPA used a multiplying factor of 2.4 to make this conversion. IH states that their testing and that of other manufacturers indicates that the value of this multiplier should have been 1.3; therefore, EPA overestimated pre-1984 HDDE HC emissions by a factor of 1.8 (2.4/1.3).

According to IH, EPA also used "unrealistic estimates of the trend to diesels in the heavy-duty market" in the Regulatory Support Document. By underestimating the magnitude of the shift to diesels in the 1980s and overestimating the level of HC emissions from 1979-83 HDDEs, IH argued, EPA has based its ambient air quality arguments for the transient test and emission standards on faulty assumptions. IH maintains that the air quality benefits intended to result from this rule will "by and large" be accomplished through continued diesel penetration of the HDE market in the 1980s.

In arguing for their proposed HDE emission standards, Ford also made reference to the latest projections for diesel penetration of the heavy-duty market in the 1980s. Ford then described the results of their own air quality analyses in which the impact of the standards being set at 3.3 HC/42 CO, rather than 2.5 HC/35 CO as specified in the proposal, is seen to be quite small. These impacts are given as "considerably less than one percent" foregone improvement for ozone as of the year 2000 and "one percent or less" foregone improvement for CO as of 1995.

General Motors criticized the estimates of HDE fuel economy (FE) that EPA used, arguing that they may have been too low by as much as a factor of two and, that as a result, HDE emissions and their contribution to overall air quality may be overstated by a factor of two. General Motors noted that EPA used FE estimates of 5.0 miles per gallon (mpg) for heavy-duty gasoline engines (HDGEs) and 5.8 mpg for HDDEs, derived from the EPA transient HDE test cycles, which in turn were based on CAPE-21 survey data. They argued that the survey did not include any heavy-duty gasoline vehicles (HDGVs) from Class IIB (8,501-10,000 lbs. gross vehicle weight (GVW)), which are the largest subset of all HDGVs and have average fuel economy of considerably more than 5.0 mpg. In addition, EPA assumed that these FE values would be constant throughout the projection period; actually these values are expected to rise significantly during the 1980s, GM said, partly due to increasing diesel penetration of the lower-GVW heavy-duty classes.

Most of the comments made by GM sought to minimize the significance of this rule to national air quality. GM argued, for example, that "...*clearly, any HC standard more stringent* than the 1979-83 HDE standard would be adequate to avoid significant effect on urban air quality." On the basis of the "negligible" and "insignificant" air quality improvements projected, GM maintained: 1) that a Selective Enforcement Audit program for HDEs cannot be justified; 2) that extended useful-life requirements are unnecessary; and 3) that the 1984 LDT requirements will have no significant impact on air quality violations. GM concluded that HDE standards of 3.5 HC/70 CO will "allow early attainment of the NAAQS in even the worst areas of the country," while having minimal cost impact, eliminating the need for overtemperature protection controls, and not imposing any fuel penalty.

Analysis of the Comments

The subissues raised by the commenters are discussed in this section in roughly the same order as they were presented in the summary section.

At the outset, it is important to keep in mind the statutory authority and Congressional guidelines for this rulemaking. The emission standards are being revised principally under the authority of Sections 202(a)(3)(B) and (C). Although EPA has evaluated the air quality effects of this rulemaking, the revised standards are based on findings concerning cost, technology and leadtime, as explained in the preamble and elsewhere in this document. Congress has specified that revised standards provide for "the maximum degree of emission reduction which can be achieved by means reasonably expected to be available" for the duration of the revised standards, set against an ultimate Congressional goal of 90 percent emission reductions, also established in these rules for lighter HDEs.

Thus, the comments on both sides of the issue of the appropriate degree of air quality protection are somewhat misplaced. Although the air quality effects of these rules are important, air quality considerations are not the driving force behind the amendments.*

In the December 1979 Regulatory Analysis, EPA projected average air quality improvements in 1995 of 7 percent (CO) and 2 percent (ozone). Commenters noted that improvements of this magnitude are very important for areas that exceed or just meet the NAAQS for either pollutant, and could be the deciding factor in whether and when cities with very high CO levels reach attainment of the standard. EPA concurs with the importance of HDE emission reductions to such areas, and notes that air quality improvements of 5 percent (CO) and 1 percent (ozone) are still projected in 2000 as a result of this rule. EPA considers the HDE emission standards being promulgated in this action to be the most stringent reasonably available at this time, taking into consideration such issues as leadtime, cost effectiveness, technological feasibility, and fuel economy effects. These factors are dealt with in more detail in other sections of this document.

Commenters indicated that further emission controls for HDEs have been shown to be cost effective and technologically feasible, and that the statutory standards mandated in the 1977 amendments to the Act can be achieved. It was stated that the 1979-83 HDE emission standards are too lenient; the sharp

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* As described elsewhere, air quality effects do bear on related portions of these rules. For example, EPA selected a modified full-life useful-life requirement over a half-life approach based in part on the Agency's determination that the former approach helps assure that the full air quality benefits of these rules will be realized. So, too, EPA in allowing the use of manufacturers' test cycles has adjusted standards to assure that the air quality benefits of the previously promulgated standards will not be compromised.

contrast in the degrees of emission control required of light-duty vehicles (LDVs) and LDTs, and of HDEs in the same time period, was cited. EPA agrees that the current discrepancy in HDE and LDV/LDT emission control requirements is inequitable in the long run, and that significant reductions in HDE emissions may be achieved at reasonable cost. This rule substantially reduces the inequality in the stringency of light-duty and heavy-duty emission control requirements, and results in lifetime per-vehicle emission reductions for HDGEs of 0.25 tons HC and 16.42 tons CO (representing reductions of 39.5 and 73.6 percent, respectively, from model years 1979-83 lifetime emission levels).

According to MECA the use of catalytic converters on HDGEs should be required, even if the HC and CO emission standards are set at levels that would not require the use of catalysts, because substantial fuel economy gains could be realized and catalysts provide an attractive method for future NOx control from HDGEs. The LWV said that requiring catalysts on HDGEs would decrease future misfueling, while MECA said it would allow more stringent future NOx control and increase fuel economy. These points are acknowledged, but it should be noted that EPA does not specify what emission control technology should be used to meet any emission standards. In addition, the revisions in the HC and CO standards for HDGEs contained in this rulemaking for 1985-86 are only temporary. Catalysts will be used on the majority of HDGEs beginning in 1987 to meet the statutory standards.

The concerns of ASTAPA as outlined in the MECA comments are understandable; especially if, as stated in the comments, both auto and truck emission standards were being relaxed. This rule has no bearing on LDV emission standards or test procedures; and while the HDE standards are being temporarily revised, the standards contained in this rule are still considerably more stringent than those in effect for model years 1979-83. The air quality analyses, which are discussed in detail in Chapter 2 of the Regulatory Support Document, show that the "worst-case" fears of ASTAPA are unfounded.

After receiving the RAPCA comments, which criticized the lack of detailed air quality data included in the Federal Register Notice of this rulemaking, EPA immediately provided them with copies of all air quality analyses. Since the period for public comment on this rule was subsequently extended for 21 days, RAPCA had the opportunity to comment further after receipt of those analyses.

The National Resources Defense Council's claim that EPA used two different sets of deterioration factors, one shown in the September 1981 Draft Regulatory Support Document and the other submitted in response to Senator Stafford's questions, is erroneous. NRDC apparently took deterioration factor (DF) and deterioration rate (DR) to be synonymous. They are not. Senator Stafford asked for HDG vehicle DRs, while the calculation of lifetime per-vehicle emissions in the Draft Regulatory Support Document used DFs.

Deterioration rates are based on testing of vehicles in the field, while DFs are derived from manufacturers' certification data. Both quantities attempt to describe the deterioration in the emissions of a vehicle or engine. However, the DR accounts for many in-use causes of deterioration not accounted for in the DF, including causes that might not be directly within a manufacturer's control. In-use deterioration (i.e., the DR) includes the effects of climatic extremes, inadequate maintenance, and tampering and abuse, as well as the normal wear and tear which the DF is supposed to represent. Thus, as the comment by NRDC reflected, the DR and the DF can be and usually are very different numbers.

The Agency's air quality model uses DRs, not DFs, to model the deterioration of emission levels with increasing mileage. The DFs are used in the calculation of the zero-mile emission levels (ZMs), and thus are only used indirectly by the model. The air quality analyses used in the September 1981 Draft Regulatory Support Document, and in the final Regulatory Support Document which accompanies this Final Rule, used the DRs submitted to Senator Stafford. The model's outputs (including the number of urban areas in violation, the number of exceedances, the average percent reduction, and the inventory in tons of pollutant) therefore result from the use of DRs, not DFs. The only instance where DFs were used was in the calculation of the per-vehicle lifetime emissions for the Draft Regulatory Support Document. DRs can also be used to calculate the per-vehicle lifetime emissions, and are more accurate if absolute numbers are desired. However, the calculation in the Draft Regulatory Support Document used DFs because the focus was on relative numbers, that is, on the differences between the scenarios rather than the absolute number of tons under each scenario. These relative numbers using either a DR or a DF calculation are about the same. The final Regulatory Support Document uses the DR calculation, since the focus is on the absolute, as well as the relative numbers.

The remainder of this section is devoted to discussion of the comments submitted by the manufacturers. Several of these comments raised issues that, while valid points of concern, are beyond the immediate issue (the air quality impact of this rulemaking) and are not subject to quick or simple resolution. Neither are they considered by EPA to be of sufficient magnitude as to affect the rulemaking decision process. Such issues include the urban/rural VMT split cited by Mack and Ford, and the criticism by GM of the heavy-duty fuel economy estimates and the representativeness of the CAPE-21 data base. EPA allows that improvements in the accuracy of the air quality projections are possible. However, dealing thoroughly and appropriately with questions such as those mentioned above is not a trivial exercise. EPA is concerned with improving the accuracy of the air quality model and the assumptions that go into it, and efforts to do so will continue in the future. However, at this time EPA notes that there is no reason to consider rural HC emissions to be unimportant. Ozone is a regional pollutant, and in the time that HC emissions are reacting to form ozone, they could travel a considerable distance from their original emission points.

Mack cited the August 1980 pollutant-specific HC study to argue that further HDE HC emission controls are not cost effective. While cost effectiveness may to some extent be relative, EPA feels that the cost effectiveness of further HDE emission control has been demonstrated to be good, as described in a recent EPA staff paper.[1] The staff paper analysis considers EPA's best estimates of both costs of this action and its associated air quality benefits in arriving at that conclusion. The point raised by Mack about the relatively small contribution from HDDEs could be equally applied to many other HC emission source categories and lead to the erroneous conclusion that none of these sources need be controlled according to Mack's logic. Since HC emissions include a large number of relatively small sources, it is important if progress is to be made to control HC emissions wherever that can be done in a cost-effective manner.

EPA rejects IH's contention that the multiplying factor used to convert 1979 certification HDDE HC emission data to equivalent 1984 transient test emission data should have been 1.3, and not 2.4 as used by EPA. The value of 2.4 used by EPA was based on the results of tests of HDDEs manufactured by Caterpillar, Cummins, and Detroit Diesel Allison (GM). While EPA acknowledges that these tests were conducted several years ago and that considerable additional testing has since been conducted, it is also noted that IH did not submit any new data to support their claim. The value of 2.4 is intended to be representative of the heavy-duty industry as a whole; thus it is entirely possible that the 1.3 value may be more accurate for IH engines alone, for example. Basically, this comment is unrelated to the air quality impact of this rule.

In response to claims by the manufacturers that EPA used unrealistically low projections of diesel penetration of the heavy-duty market in the 1980's, thereby overestimating the contribution of the heavy-duty fleet to overall air quality, EPA notes several things. First, a major premise of this argument is invalid. Stating that HDDEs will always have lower lifetime HC emissions than HDGEs, given the same standard and useful life for both engine types, is simply not true. The zero-mile emission rate is higher for HDDEs than for HDGEs under the same standard. Our calculations show that, under the same standard, HDDEs will emit more HC than will HDGEs over the lifetime of the engine. It is only the fact that the HDDE HC standard will be lower than the HDGE HC standard for 1985-87 that makes HDDEs "cleaner." Second, EPA acknowledges that the nature of the heavy-duty market has changed somewhat since the original Regulatory Analysis was published. However, as was noted by IH in their discussion of this point, there are factors (such as sudden changes in fuel costs) that can cause the rate of diesel penetration of the heavy-duty market to change dramatically in a short time; thus, any projections, whether by EPA or the manufacturers, are at best educated guesses and subject to quickly being overtaken by events.

Finally, in terms of air quality the crucial estimate is the relative change in HDDE and HDGE VMT, not the changes in vehicle registrations or HDE market shares. EPA assumed that HDDE VMT would increase by 5 percent annually, while HDGE VMT would decrease by 2 percent annually during the same time period. These estimates still appear reasonable.

Ford's air quality projections, showing almost no decrease in air quality if the standards of 3.3 HC/42 CO advocated by Ford are implemented rather than the 2.5 HC/35 CO specified in this rule, appear to be valid. EPA simply notes that small, incremental relaxations in emission standards will, by definition, result in relatively small air quality impacts. Extending Ford's line of reasoning, any and all emission standards could be discarded incrementally, since each incremental air quality impact would be minimal. Given both the current and projected future need for improvements in ozone ambient air quality, EPA must reject Ford's approach. All reasonably attainable HC control is important in terms of air quality. The proposal by GM that interim standards be set at 3.5 HC/70 CO must also be dismissed on the same grounds, since this proposal represents virtually no reduction from the 1979-83 emission levels. Finally, EPA also notes that §202(a)(3)(B) of the Act requires that when interim emission standards less stringent than those mandated are implemented, those interim standards represent "...the maximum degree of emission reduction which can be achieved by means reasonably expected to be available for production." Both the Ford and GM proposals are inconsistent with this requirement of the Act.

Conclusions

Although EPA recognizes the concerns of those opposed to any revisions to the HDE gaseous emission standards, and also recognizes that some of the points raised by the manufacturers merit further study, EPA concludes that the Agency is acting within its legislative authority in promulgating both the interim non-catalyst emission standards and the long-term reductions in these rules. Further changes to this rule are not justified on the basis of these comments.

References

1. "Issue Analysis - Final Heavy-Duty Engine HC and CO Standards," Staff Paper, U.S. EPA, OMS, OANR, ECTD, SDSB, March 1983.

B. Secondary Issues

1. Issue: Deterioration Factors

Summary of the Issue

In the original FRM, EPA finalized provisions for the application of multiplicative deterioration factors to HDE exhaust emissions. Commenters opposed this change from the previously used additive deterioration factors. Comments were also received indicating that negative deterioration factors should be accepted by EPA. One comment concerned the methods used to determine deterioration factors.

Summary of the Comments

Most of the comments criticized the application of multiplicative deterioration factors to HDEs. These comments argued that no justification exists for the use of multiplicative deterioration factors with non-catalyst emission control systems. It was also noted that, in the opinion of the commenters, multiplicative deterioration factors effectively increase the stringency of the applicable emission standards, particularly those at low numerical values, thereby increasing the control system development costs to the manufacturers.

Comments requesting that EPA recognize the validity of negative deterioration factors were received from EMA, with supporting data on HDEs being provided by several manufacturers. These data show that some HDE exhaust emissions, particularly NOx, may actually decrease over the useful life of the engine. One engine manufacturer also submitted data which it claimed demonstrated that properly maintained HDEs have no significant deterioration in emissions during useful life, and that emissions have been observed to decrease in some cases.

One comment was made concerning the method used to determine deterioration factors. The commenter maintained that deterioration factors should be determined through 1,000-hour durability runs per §86.082-28(c)(4), and not by fleet tests with uncontrolled parameters.

Each of the comments concerning the application of multiplicative deterioration factors to HDEs cited the lack of justification for extending the use of multiplicative deterioration factors to vehicles and engines using non-catalyst emission control systems. A few also noted that the use of multiplicative deterioration factors cannot be justified now on the basis of possible regulations implementing trap-oxidizer technology for HDDEs in the future.

Analysis of the Comments

EPA's analysis in support of the original FRM[1] did not provide conclusive evidence that one type of deterioration factor was more appropriate than the other for engines without aftertreatment devices. That analysis did conclude that multiplicative deterioration factors are more representative of actual emission deterioration when aftertreatment technology is used, however, since such technology reduces emissions on a proportional basis. Therefore the use of multiplicative deterioration factors should still be required for vehicles or engines utilizing aftertreatment technology.

The possibility that durability testing of a vehicle or engine may result in an additive deterioration factor less than zero, or a multiplicative deterioration factor less than one, is recognized. However, at least for HC and CO, EPA views such results as anomalous and clearly not indicative of actual in-use deterioration. At best, a well-maintained engine could be expected to exhibit stable emission levels; there is no mechanical reason for in-use HC or CO emissions to decrease with accumulated time or mileage. In addition, accepting such deterioration factors would allow relaxation of low-mileage target levels to values above those otherwise required for compliance at low mileages. This would be incompatible with the purpose behind the use of deterioration factors in certification, which is to estimate the highest emission level a vehicle is expected to exhibit over its life so that compliance is assured on that basis. If emissions were expected to decline with mileage or time, then the level of concern for certification purposes would be the unadjusted new-vehicle level. Thus, EPA feels that the current rule, under which an additive deterioration factor of less than zero is considered to be zero and a multiplicative deterioration factor of less than one is considered to be one, is justified.

The comment concerning methods of determining deterioration factors can be addressed quite briefly. The determination of deterioration factors is entirely the responsibility of the manufacturer; within certain constraints, so are the methods and procedures used in the determination. Section 86.082-28(c)(4) does not specify that 1,000-hr durability runs or fleet tests by used to determine deterioration factors, but refers only to "...deterioration factors, determined from tests of engines, subsystems, or components conducted by the manufacturer."

Conclusions

While studies[1] have been inconclusive regarding the appropriateness of multiplicative deterioration factors for non-aftertreatment vehicles and engines, they are clearly more accurate in describing deterioration in the performance of proportional-reduction devices. Thus, EPA has decided to delay the required use of multiplicative deterioration factors for HDEs until such time as more stringent emission standards requiring the use of catalysts (for HDGEs) or particulate traps (for HDDEs) are established and implemented. The first use of multiplicative deterioration factors will then be for lighter HDGEs certifying to the statutory standards in 1987. For reasons cited in the analysis, EPA also has decided that additive deterioration factors of less than zero and multiplicative deterioration factors of less than one will continue to be taken as equal to zero and one, respectively.

References

1. "Summary and Analysis of Comments to the NPRM: 1983 and Later Model Year Heavy-Duty Engines, Proposed Gaseous Emission Regulations," U.S. EPA, OANR, OMS, ECTD, SDSB, December 1979.

2. Issue: Idle CO Test and Standards

Summary of the Issue

In the original FRM, EPA finalized a separate standard and test procedure for idle CO emissions from gasoline-powered LDTs and HDEs. The commenters on this issue were unanimous in their opposition to these requirements. Much of the criticism stressed the allegedly redundant nature of the test and the planned use of the test by EPA to detect failed catalysts and set lower I/M cutpoints. One manufacturer claimed that the idle test requirements will force it to include additional hardware on its LDTs. Several procedural and technical questions were also raised.

Summary of the Comments

The manufacturers commenting on this issue all criticized the idle CO test as redundant, unnecessary, and unjustified. Several claimed that the 26.8 percent of the transient certification test spent idling guarantees that idle CO emissions must be closely controlled in order to pass the entire test. The comments indicated that the added cost and complexity of certification including the idle test would thus be an unnecessary burden on the manufacturers.

EPA was also criticized for planning to use data from idle CO tests in the detection of failed catalysts and the establishment of lower I/M cutpoints. One comment specifically cautioned EPA to "avoid the belief that idle CO measurements would be a viable method of in-service compliance checking."

Several commenters indicated that EPA cannot promulgate the idle CO test without demonstrating that a reasonable correlation exists between the idle test and the other required CO measurements (transient cycle and performance-warranty short test). According to the commenters, this correlation is required under Sections 206 and 207(b) of the Clean Air Act and has not been demonstrated.

The numerical level of the standard was criticized in several of the comments. One manufacturer criticized the standard as infeasible and said that it should be revised upward to reflect non-catalyst technology, while another indicated that the dry volumetric measurements used make the same numerical standard more stringent for smaller-engine vehicles. Volkswagen questioned the authority of EPA under Section 202(a)(1) of the Clean Air Act to implement the same numerical standard across the entire LDT class, noting that it would be forced to install "new systems" on its LDTs less than 6,000 lb. GVWR simply because of the idle CO standard.

Volkswagen submitted data on idle emission characteristics relative to FTP results from two of its light-duty pick-up trucks. While these vehicles met the current FTP standards for HC, CO, and NOx emissions, the volumetric tailpipe idle CO measurements were between 1.3 and 1.4 percent. VW claimed that these data show that it would be forced to install new systems on these trucks solely because of the idle requirements. VW also noted that these vehicles would otherwise be able to meet the emission standards promulgated for 1984 and later LDTs with minor calibration changes.

In a follow-up conversation between EPA and VW staff, the possibility of adjusting the idle A/F mixture to a leaner setting in order to reduce idle CO was discussed. VW expressed concern that leaning the idle A/F ratio, combined with the possibility of in-use drift of this setting, could result in engine stalling problems. Should leaning of the idle A/F mix either fail to bring idle CO under the standard, or result in unacceptable driveability problems, VW stated it would be forced either to install a "new system" (air pump) in its LDTs or to go to a closed-loop system. VW indicated that it would prefer the closed-loop solution.

Finally, several minor issues were addressed in the comments: the inclusion of the idle CO test in SEA testing, the applicability of DFs to idle emission data, and the scarcity of data on idle CO deterioration throughout the useful life of a vehicle or engine.

<u>Analysis of the Comments</u>

Each of the comments criticizing the HDGE idle CO standard and test as redundant pointed to the 26.8 percent of total time spent idling in the transient test cycle. It was argued that since the transient cycle is deemed representative of in-use operation, idle mode emissions are adequately represented. (One manufacturer made the same argument for LDTs, noting that 18 percent of the time in the FTP cycle is spent idling.) Strict control of idle emissions was claimed to be necessary in order to certify under the transient cycle test procedure.

EPA rejects the manufacturers' contention that strict control of idle emissions is prerequisite for certification under the transient cycle test procedure. This contention is based on the large portion of the <u>time</u> in the transient cycle (26.8 percent) that is spent at idle. In calculating CO emissions for certification, the total mass CO emissions generated during the test are divided by the total work performed by the engine during the test, yielding a result in g/BHP-hr that is measured against the applicable standard.

Since the volumetric exhaust flow is much lower at idle than at higher engine speeds, the mass contribution of CO during the idle portions of the transient cycle is not proportional to the time spent at idle. As a result, the 26.8 percent of the cycle time spent idling contributes much less than 26.8 percent of the total mass CO emissions. Thus, the statement that strict idle mode emission control is required in order to be certified using the transient cycle test procedure is not true.

In fact, one manufacturer's comments supported the EPA position on this issue. Data submitted on two HDGEs (4.9L and 6.1L) showed that of the total CO emissions during the transient test, only 14 percent and 3 percent respectively were contributed by the idle mode segments of the transient cycle. The manufacturer states that "...the idle test in no way reflects the ability of an engine to comply with the transient test." EPA notes that the converse of this statement, that the transient test does not reflect the ability of an engine to comply with the idle CO test, logically follows; this undercuts the assertion that the idle test is redundant.

The cost-per-vehicle of the idle test requirements is minimal. Since compliance with the standard is virtually automatic with the use of catalysts, there are no associated development or hardware costs. Even in the case of non-catalyst systems, only small development and calibration costs are likely. The only other cost is that of conducting the idle tests during certification and SEA, which is very small on a per-vehicle or per-engine basis. With the benefits discussed herein, EPA cannot agree that these requirements constitute an unnecessary or unreasonable burden on the manufacturers.

The detection of failed in-use catalytic emission control systems will have a positive impact on air quality. These benefits will be achieved through reduction of the number of gross-emitting in-use vehicles. While several commenters stated that the idle standard cannot be used as a practical I/M cutpoint, no data were provided supporting this assertion. The only substantive comment received in this respect noted that idle CO levels are largely a function of previous operating conditions, including pre-test idle time, evaporative content, over-temperature conditions, and fuel volatility. EPA remains convinced that the idle CO requirements are appropriate for catalyst-equipped vehicles and engines, and will be a useful tool in the detection of failed catalysts. Since this is the most important application of the idle test requirements, however, EPA agrees that these requirements should be deferred for HDGEs until more stringent HC/CO emission standards requiring the use of catalytic control technology take effect in 1987.

MVMA and several of the manufacturers challenged the idle standard and test procedure on the basis that EPA has not yet established a "reasonable correlation" between the idle test and the other standards and procedures applicable to the control of CO emissions, as required by Sections 206 and 207(b) of the amended Clean Air Act. The issue is premature. EPA has not proposed to use the idle CO test as a "short test" for enforcing the performance warranty under Section 207(b). If EPA takes that step, the issue of "reasonable correlation" will then be ripe.

Comments regarding the numerical level of this standard contained no information to justify a relaxation. One manufacturer suggested that the proposed standard be revised upward to reflect non-catalyst technology. Since the EPA recommendation (above) is to limit the applicability of the idle CO test to vehicles and engines utilizing aftertreatment technology, and since all HDGEs will be capable of meeting the revised HC/CO emission standards without utilizing such technology, this comment need not be addressed further.

The question of the appropriateness of the dry volumetric method of measurement used in the idle test and whether the standard is thereby effectively made more stringent for vehicles using smaller engines was raised. The method of measurement to be used in the idle test procedure was taken into account in the setting of the standard, and so the stringency of the standard is not greater than was intended. Smaller engines must have a slightly richer A/F mixture at idle to avoid problems with stalling, which implies that the idle CO emissions of a smaller engine could be somewhat greater than those of similar but larger engines. However, the use of catalysts should make compliance with the idle standard easily attainable by engines of all sizes that are affected by these requirements. In addition, EPA notes that data submitted by one manufacturer, on idle CO emissions from 15 LDTs with engine displacements ranging from 1.9L to 5.7L, showed that the average idle CO emissions of well-maintained vehicles with properly functioning catalytic systems were markedly below the standard. These data do not support the contention by the manufacturers that vehicles using relatively smaller engines will have an effectively more stringent idle CO standard to meet.

Several commenters discussed the applicability of the idle CO standard and test procedure to LDTs, although this issue was not officially open for comment. The issues and analyses surrounding LDTs are the same as those discussed above for HDEs. In particular, EPA notes these relevant facts: The inclusion of the idle test requirements in the certification procedure serves a valid purpose. Section 206(a)(1) of the Act allows such test requirements to be implemented. The earlier discussion, indicating that the mass CO contribution of the idle portions of the transient test is proportionally much lower than the percent of cycle time spent at idle, is equally applicable to the idle portions of the FTP.

In reference to VW's assertion that these regulations will require the use of additional emission control hardware on its LDTs, EPA notes that data submitted by other manufacturers showed idle CO levels for LDTs to be well within the standard. The idle CO standard went through an extensive proposal and comment period as part of the original LDT rulemaking, and the record indicates that neither VW nor any other LDT manufacturer raised any issue over the feasibility of the standard. Since that time, VW has certainly had an adequate period of leadtime to meet the new requirements. VW should investigate the possibility of meeting the idle standard through adjustment of idle A/F settings. If this approach results in driveability problems unacceptable to VW or fails to bring idle CO levels under the standard, then one of the other two options (closed-loop system or air pumps) should be exercised.

Turning now to the lesser issues raised, the first concerns the use of the idle test in future SEAs. The idle test procedure, as an integral part of the certification procedure for vehicles and engines utilizing aftertreatment technology, will be included in SEA testing.

The use of DFs with idle emission data was questioned by one manufacturer, who noted the lack of data on idle CO deterioration during useful life and the fact that negative DFs are not allowed. In response, EPA notes that the application of DFs is required for <u>all</u> emission standards, and therefore will be required for this standard. Although negative DFs are not allowed, manufacturers having data showing that no deterioration occurs for a given regulated emission during the useful life, can use a multiplicative DF of 1.0 or an additive DF of zero, thereby demonstrating useful-life compliance with that standard at the time of certification.

The lack of idle CO deterioration data for non-catalyst vehicles/engines, which was addressed by another manufacturer, is not an issue. As noted earlier in this section, vehicles and engines not utilizing aftertreatment control technology will not be subject to the idle CO standard and test requirements.

Conclusions

The primary benefit of the idle CO standard and associated test procedure will be in the detection of failed in-use catalytic emission control systems. With this in mind, EPA has decided to delete the idle test requirement for all vehicles and engines that do not utilize aftertreatment control technology, but to retain it for catalyst-equipped vehicles and engines. Hence for HDGEs, the idle test requirements will be delayed until more stringent HC/CO standards requiring the use of catalysts take effect. To make the standard and the test more practically useful, in terms of the degree of accuracy needed for both certification and in-use testing, the original standard of 0.47 percent will be rounded to 0.50 percent.

The comments submitted on this issue contained no information justifying additional changes in these requirements.

3. Issue: Fuel Economy

Summary of the Issue

This analysis addresses the fuel economy impact of emission standards for heavy-duty gasoline engines (HDGEs) for 1985 and later model years. Two separate issues are included: 1) the fuel economy effect of 1985 HC and CO emission standards that are achievable without catalysts, and 2) the fuel economy effect of catalyst-based HC and CO standards for 1987 and later model years.

Summary of the Comments

The consensus of the gasoline engine industry is that a substantial fuel economy penalty would result from the use of stringent non-catalyst standards, such as those originally proposed.

General Motors (GM) asserted in July 1981 that with full life and 40 percent AQL requirements, the fuel economy penalty will be around 2 percent for gasoline engines meeting standards of 3.7 g/BHP-hr HC and 45 g/BHP-hr CO, when compared to the 1979 baseline mpg. Its reasoning for the penalty was that the larger air pumps required to meet the standards will require more energy than that gained by having a leaner full power calibration.[1]

On March 16, 1983, EPA released for public comment a staff paper[2] which, among other things, discussed the expected fuel economy impact of the non-catalyst standards. For standards of 2.5 g/BHP-hr HC and 35 g/BHP-hr CO, EPA expected HDGEs to experience as much as a 10 percent improvement in fuel economy relative to 1979 engines. This estimate was based upon a review of data submitted by Ford in April 1982.

In its most recent comments,[3] GM criticized EPA for basing its estimate of a 10 percent fuel economy benefit on only two prototype Ford engines. GM presented confidential data to show that wide open throttle (WOT) power and fuel economy losses would occur on engines calibrated to meet standards of 1.3/35. (GM's WOT calibration was leaner than stoichiometry, and required substantial timing retard to preclude knock.) General Motors did not comment on the fuel economy impact of catalyst standards, nor has it commented on the fuel economy impact of non-catalyst standards of 2.5/35.

Ford's most recent comments of May 1983 also disputed the conclusions of EPA's staff paper. Based upon the current position of its product line, as submitted in its "best effort" data of May 1983, Ford claimed that those emission levels result in no significant change in power, fuel economy, or durability relative to 1979 requirements.[4]

Ford did not comment on the fuel economy impact of catalyst standards.

Analysis of the Comments

Non-Catalyst HDGEs

This section will review available fuel economy data, identify the likely emission control techniques to be used, and discuss the fuel economy effects as these techniques are applied to allow compliance with emission standards of 2.5 g/BHP-hr HC and 40 g/BHP-hr CO.

The data that are available for non-catalyst HDGEs are presented in Tables 3-1 and 3-2. Table 3-1 addresses GM's concern that only Ford data were used to assess the fuel economy impact of the standards. The GM data in Table 3-1[5] show that decreases in fuel consumption for their development engines range from approximately zero to 19 percent. None of the prototype engines had increased fuel consumption relative to their 1979 counterparts. The engine with the lowest emissions in both HC and CO had both the lowest fuel consumption, and the largest decrease in fuel consumption (19 percent) relative to 1979.

Examination of Ford's 1984 prototype engine data in Table 3-2[6] also shows that fuel consumption has decreased relative to 1979 HDGEs. (More recent data submitted by Ford[4] did not include BSFC.) Fuel consumption decreased by more than 7 percent when the average of all the April 1982 prototype tests are compared to all of the corresponding 1979 baseline engine tests. (Ford's concern that lab-to-lab correlation problems could lead to EPA drawing erroneous conclusions from available data is unfounded. Tentative results from the EPA/MVMA correlation project show superb agreement between laboratories for CO_2 emissions, the emission with the most direct bearing on fuel consumption calculations, and between BSFC results themselves.)

Aside from the actual data, there are theoretical reasons why fuel economy should improve as technology is applied to engines to meet non-catalyst standards of 2.5 HC and 40 CO. These theoretical reasons are based upon the combined fuel economy effects of the technologies which will likely be

Table 3-1

GM Development Data from August 1982[5]***

Engine	BSFC* 1979 Baseline	BSFC* Prototype	% Decrease in Fuel Consumption	Prototype Emissions** HC	Prototype Emissions** CO
292-L6	.655	.640	-2.29	2.41	21.82
	.655	.639	-2.44	2.17	24.93
350-2V8	.717	.604	-15.76	1.57	28.20
350-4V8	.727	.656	-9.77	2.08	29.02
	.727	.649	-10.73	1.99	27.22
366-V8	.719	.582	-19.05	.75	17.88
454-V8	.668	.666	-.30	1.01	22.18

Average (by engine family): -9.6 percent

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* lbs/BHP-hr, EPA cycle based.

** g/BHP-hr, EPA cycle based.

*** GM stated in August 1982 that these data "are representative of HDGE emission control systems and calibrations which are currently believed to be at least plausible for production... [although]...[n]one of these arrangements have been durability tested..."[5]

Table 3-2

Ford Development Data from April 1982[6]

Engine Family	BSFC[1] 1979 Baseline	BSFC[1] Prototype	% Decrease in Fuel Consumption	Prototype Emissions[2] HC	Prototype Emissions[2] CO
4.9L	.696	.560	-19.54	1.66	23.2
6.1L	.681	.654	-3.96	2.33	28.8
7.5L	.633	.633	0.00	2.21	24.3

Average (by engine family): -7.8 percent

[1] lbs/BHP-hr, EPA cycle based.
[2] g/BHP-hr, EPA cycle based.

applied to comply with the non-catalyst emission standards: primarily leaner A/F ratios, retarded spark timing, and increased air injection.

A/F ratios for current technology (1979 requirements) HDGEs are generally quite rich, and it is expected that the new emission standards will require leaner carburetor calibrations. For example, GM stated that it has leaned out its A/F ratios on its 1985 prototypes at wide-open throttle, but that its calibrations are still on the rich side of stoichiometric. As a case in point, Table 3-3 shows the relationship between the A/F ratio, fuel consumption, and power for a Chevrolet 350-CID V-8 HDGE operating at wide-open throttle (WOT). As the A/F ratio was changed from 12:1 to 14.6:1, the fuel consumption dropped by 14 percent while the power declined by 6 percent.[7] The HDGE engine data presented in Table 3-3 represent performance only at WOT, and EPA concedes that WOT constitutes a small percentage of total cycle operating time. Logic suggests, however, that leaning A/F ratios to reduce HC and CO emissions over all combinations of operating modes on the transient test will also significantly improve HDGE fuel economy. Generally, leaner A/F mixtures decrease fuel consumption (BSFC) and therefore improve fuel economy (mpg).

Retarding spark timing also reduces HC emissions by raising post-combustion cylinder gas and exhaust gas temperatures, thus promoting oxidation of the HC emissions. This technique was widely used in pre-catalyst light-duty vehicles to control HC. However, retarding spark timing typically causes an increase in fuel consumption. For example, Ford data showed that by retarding initial spark timing by 4° (from 12° to 8° BTDC) on a 4.9L development engine, there was a 15 percent decrease in HC emissions, but a 5 percent increase in fuel consumption.[6,8] A similar analysis of a GM 350-V8 engine in a light-duty vehicle showed that retarding timing 20° from MBT resulted in a 10 percent fuel consumption increase at a 14:1 A/F ratio.[9] However, because of the relaxation of the non-catalyst HC standard from 1.3 to 2.5 g/BHP-hr, very little timing retard should be necessary to allow compliance, as suggested by the actual fuel economy data presented in Tables 3-1 and 3-2.

Increased air injection will also be used to reduce HC and CO emissions. For example, for its development engines, Ford replaced the standard two 19 in^3 pumps with two 23 in^3 pumps and added multiple injection points. These pumps had a 37 percent higher flow capacity.[6] There is, however, a practical limit to the amount of air injection; too much air can actually quench the oxidation reactions and preclude further emission reductions. (Ford experimented with a 50

Table 3-3

Chevrolet 350-CID V-8 Engine Data[8]

Air/Fuel Ratio	Fuel Consumption[1]	% Change in Fuel Consumption[2]	% Change in Power[2]
12.0:1	.575	--	--
12.8:1	.542	-5.7	-2.1
13.2:1	.525	-8.7	-2.9
13.8:1	.493	-14.3	-3.5
14.6:1	.493	-14.3	-5.9
15.0:1	.493	-14.3	-9.4

[1] lbs/HP-hr.
[2] Relative to 12:1 A/F ratio.

in^3 air pump, and observed no significant incremental emission reductions.) As with retarded spark timing, increased air injection reduces fuel economy. (Air pumps require energy to be driven.) EPA's own test data[10] indicate that there may be a 2.5 to 4 percent increase in fuel consumption if air injection rates are increased to the extent necessary for catalysts. (EPA expects the air injection rates for 1985 non-catalyst and 1987 catalyst engines to be similar.).

Other emission control techniques EPA expects to be used in 1985 should affect overall fuel economy very little. These techniques include early fuel evaporation systems, heated air intake, temperature-actuated timing retard, and automatic chokes. Early fuel evaporation systems use exhaust gases to heat the A/F mixture, resulting in reduced emissions and shorter warm-up periods. Shorter warm-up periods would promote better efficiency and therefore better fuel economy. Heated air intake also reduces engine warm-up time and allows leaner carburetor calibrations, thus better fuel economy. Cold temperature-actuated timing retard reduces cold start emissions at the expense of a slight increase in fuel consumption. These technologies are not anticipated to have any noticeable effect on overall fuel economy, however, because of the small percentage of operating time that engines in the field spend cold.

The theoretical picture painted for fuel economy is one of trade-offs. Fuel economy would be predicted to improve significantly with leaner A/F mixtures but would be predicted to decrease marginally with larger air injection systems. (EPA does not expect significant timing retard to be required to meet the 2.5 g/BHP-hr HC standard.) All of the actual emission data available to EPA show that there is a greater probability for an overall fuel economy benefit rather than a fuel economy penalty, and that the gains from leaner A/F calibrations will more than offset the losses attributable to increased air injection. The fuel economy data for Ford's and GM's prototype engines (Tables 3-1 and 3-2) show that these engines are actually more fuel efficient - with increased emission control - than they were in 1979. On the average basis, these engines are running 7-10 percent more efficient than their 1979 counterparts. Based upon this prototype fuel economy data, a modest fuel economy increase for 1985 HDGEs is anticipated relative to the 1979 baseline engines. Certainly, no aggregate fuel economy penalty is likely.

Catalyst-Equipped HDGEs

Little has changed with respect to the availability of information on the fuel economy effect of catalyst standards since the December 1979 Final Rulemaking. The fuel economy analysis associated with that rulemaking[10] concluded that a 4 to 9 percent improvement in fuel economy would be achieved, relative to 1979 engines, when catalysts were applied to HDGEs. This conclusion was based to a large extent on the performance of light-duty vehicles when catalysts were applied for increased emission control.

Much of the emission control required for catalyst-equipped 1987 HDGEs is being accomplished for 1985 (i.e., the first step in applying catalysts to heavy-duty engines was to reduce engine-out emission levels). As discussed above, the techniques used to reduce HDGE engine-out emissions have also yielded a fuel economy benefit. This is much of the same benefit which would have been observed had catalysts been immediately applied to HDGEs in 1985. The remaining question is how much of an incremental change in fuel economy is to be expected relative to 1985 when catalysts are applied in 1987?

Application of catalysts has traditionally removed much of the need for engine calibrations which tended to reduce fuel economy (e.g., spark retard). However, EPA does not expect the significant use of timing retard, or other engine-out emission control calibration strategies which would degrade fuel economy, to be used for 1985. Therefore, EPA does not expect the addition of catalysts in 1987 to provide much additional flexibility relative to 1985. Catalysts also create modest increases in exhaust backpressure which may somewhat decrease fuel economy; these backpressure increases, however, can be easily offset by larger diameter exhaust systems. Finally, EPA anticipates no increase in air injection rates relative to 1985 significant enough to affect fuel economy. Given the absence of major potential calibration optimizations, and given modest but correctable increases in backpressure as catalysts are applied, EPA judges that little change in vehicle fuel economy will be seen between 1985 and 1987 on account of the change in emission standards. Much of the fuel economy benefit predicted in 1979 as attributable to catalysts will already have been achieved in 1985.

Conclusions

1985 HDGEs are expected to incur a fuel economy benefit as a result of the non-catalyst standards. Prototype engine data indicates that this benefit, on average, could be as large as 7-10 percent. No net change in fuel economy relative to 1985 is expected, however, when catalysts are applied in 1987.

References

1. "Cost Effectiveness Analysis of Alternatives to 1984 Heavy-Duty Engine Emissions Regulations," General Motors Corporation, July 31, 1981.

2. "Issue Analysis - Final Heavy-Duty Engine HC and CO Standards," EPA Staff Report, EPA Public Docket No. A-81-11, March 1983.

3. "General Motors Comments on the March, 1983 EPA Staff Report Issue Analysis - Final Heavy-Duty Engine HC and CO Standards," May 6,1983.

4. "Ford Motor Company Response to the Environmental Protection Agency on Gaseous Emission Regulations for 1985 and Later Model Year Heavy-Duty Engines," May 6, 1983.

5. Letter from T. M. Fisher of General Motors, to Charles L. Gray, Jr., U.S. EPA, dated August 9, 1982.

6. "Response to Revised Gaseous Emission Regulations for 1984 and Later Model Year Light-Duty Trucks and Heavy-Duty Engines," Ford Motor Company, April 1982.

7. "Heavy-Duty Fuel Economy Program: Evaluation of Emissions Control Technology Approaches," EPA Paper No. 460/3-77-010, July 1977.

8. Letter from R. E. Bisaro of Ford Motor Company, to W. M. Pidgeon, U.S. EPA, June 25, 1982.

9. "Optimizing Engine Parameters with Exhaust Gas Recirculation," SAE Paper No. 740104, 1974.

10. "Summary and Analysis of Comments to the NPRM: 1983 and Later Model Year Heavy-Duty Engines Proposed Gaseous Emission Regulations," U.S. EPA, December 1979.

4. Issue: Allowable Maintenance

Summary of the Issue

In 1980, EPA published revised allowable-maintenance intervals for LDTs and HDEs. The primary purpose for these intervals was to encourage the design of long-life emission-related components and to limit maintenance to that which was considered technologically necessary. In the NPRM, EPA proposed to add an HDGE spark plug maintenance interval for leaded fuel, but no other specific changes were proposed. Even though the general area of allowable maintenance was not formally reopened, both LDT and HDE manufacturers submitted comments criticizing the intervals and the HDE manufacturers requested relaxation of several specific intervals.

Summary of the Comments

Light-Duty Trucks

General Motors commented that the LDT requirements were not cost effective, had no air quality benefit, and were inappropriate. It recommended that EPA drop its current requirements and adopt the LDV requirements, thus allowing GM to recommend the maintenance it believes is appropriate.

Heavy-Duty Gasoline-Fueled Engines

Heavy-duty gasoline engine manufacturers generally accepted EPA's leaded-fuel spark plug maintenance interval of 12,000 miles. However, Chrysler asked that the unleaded-fuel spark plug maintenance interval be revised from 25,000 miles to 18,000 miles, primarily because it had no data beyond that point. Ford also requested that the intervals for the EGR valve, PCV valve, heat-control valve, and checking the choke system be revised because they are also subject to lead fouling. As before with LDTs, GM stated that the allowable-maintenance intervals for HDGEs were inappropriate and should be dropped.

Heavy-Duty Diesel Engines

Several commenters stated that the allowable-maintenance intervals for HDDEs were too long. Further, the commenters contended that setting allowable-maintenance intervals for HDDEs was not necessary because heavy-duty diesel truck owners maintain their vehicles due to business reasons, and the very competitive nature of the HDDE business drives the development of more durable components. Specifically, several commenters stated that the current intervals were too long for the newly emerging medium-duty diesel engines, and in some cases were longer than the anticipated engine lifetime.

General

One general comment was received which stated that the allowable-maintenance intervals do not allow the manufacturers to recommend more frequent maintenance than that specified by the interval.

Analysis of the Comments

Light-Duty Trucks

Even though these requirements were not formally reopened for comment, EPA has carefully reviewed the comments received on the LDT allowable-maintenance requirements. Although there is clearly some disagreement between the manufacturers' and EPA's assessments of the cost effectiveness and air quality impact of these provisions, EPA finds no compelling evidence for revising these requirements.

EPA believes it is important to encourage the design and use of more durable, low-maintenance emission-related components, and believes the 1984 LDT allowable-maintenance intervals effectively accomplish this task. Adopting the current LDV requirements would be a step backwards and would do nothing toward meeting that objective. Unfortunately, there are no strong market forces acting to encourage the manufacturers to develop and use more durable, low-maintenance components.

No real data was submitted to question the technological feasibility of these requirements, and EPA continues to believe, based on its original analysis,[1] that these requirements are technologically feasible and are an appropriate and cost-effective means of improving air quality.

It is also important to note that while the new allowable-maintenance requirements are more restrictive than existing provisions in some areas, they at the same time reclassify a great deal of maintenance items as non-emission related. For these items, the manufacturers are free to recommend whatever maintenance provisions they believe are reasonable and necessary, without other regulatory requirements.

Heavy-Duty Gasoline-Fueled Engines

As with LDTs, EPA believes that allowable-maintenance intervals are necessary to encourage the use of more durable, low-maintenance emission-related components. It does not appear that market forces and business competition can be relied upon to meet the stated goal. For example, for the four HDGE manufacturers, there is a range of 6,000 miles in the manufacturers' current recommended maintenance intervals for spark plugs. This discrepancy has existed for several years, and yet there appears to be no effort on the part of the manufacturers at the lower end of the range to lengthen these intervals. It was to deal with this type of situation that the allowable-maintenance provisions were first adopted.

Turning first to Chrysler's request for a relaxation in the unleaded-fuel spark plug maintenance interval (25,000 miles to 18,000 miles), EPA notes that the sole basis for Chrysler's request is that it does not have data beyond its present interval of 18,000 miles, and thus Chrysler is uncertain about the feasibility of the 25,000-mile interval. (Two of Chrysler's three HDGE families are currently certified using unleaded fuel.)

Chrysler's request for a relaxation appears to be based primarily on a desire not to conduct any further testing, which, given EPA's goals in establishing these provisions, is insufficient reason to delete the requirement. If Chrysler decides to remain in the HDGE market after 1984, new testing will be required for development and certification. At this time, Chrysler will then have the opportunity to demonstrate compliance with the longer interval, assuming that Chrysler continues to choose emission-control technology which requires unleaded fuel.

EPA believes that the 25,000-mile spark plug maintenance interval is achievable with Chrysler's present technology. Chrysler's present LDT recommended maintenance interval is 30,000 miles. Chrysler's present heavy-duty gasoline vehicles/engines are so similar to their light-duty trucks/truck engines that compliance could be projected based almost purely on extrapolation. Chrysler's comments even indicate that it has tested some of its heavy-duty gasoline vehicles/engines on the LDT chassis-roll procedure. EPA is confident that Chrysler can meet the 25,000-mile unleaded-fuel spark plug maintenance interval with minimal effort.

EPA concurs with Ford's request that the EGR maintenance interval for leaded fuel be revised to allow one scheduled maintenance prior to 50,000 miles. Past performance of EGR systems on engines using leaded fuel leaves some doubt about the feasibility of the 50,000-mile interval before 1985 with the current level of lead used in leaded fuel. It is the judgment of both EPA and the manufacturers that the proper function of the EGR valve/system could be affected by lead deposition.

However, EPA does not agree with Ford's request for a relaxation of the 50,000-mile PCV valve interval. EPA believes that any plugging or hang-up which may occur in the valve is caused by contaminated blowby oil and not lead deposition. Ford submitted no data to support its request or its position that lead deposition is a major contributor to problems with the PCV valve. EPA believes that the 50,000-mile interval is technologically feasible and will encourage the use of durable, low-maintenance PCV valves.

Ford also requested that HDGE manufacturers be allowed to service (lubricate) their heat-control valve system once during the first 50,000 miles. (Similar systems used by other manufacturers are called early fuel evaporation (EFE).) This request was based on the tight clearances within such systems and the concern that lead buildup might hinder the free operation of the valves.

The current allowable-maintenance provisions (§86.084-25) do not specify maintenance of this type to be emission related. Therefore, the manufacturer is free to perform the maintenance as deemed necessary, provided that such maintenance is recommended to the consumer.

In a follow-up conversation on this issue Ford withdrew its request for additional choke-system maintenance.

Heavy-Duty Diesel Engines

Even though the HDDE allowable-maintenance intervals were not formally opened for comment, the EMA submitted the results of a substantial survey of fleet and owner/operator maintenance practices. EPA is always open to substantive input and data on past regulatory decisions and is considering the EMA submittal accordingly.

On its face, it appears that there is some validity to the manufacturers' contention that the business nature of the heavy-duty truck and bus industry leads to more routine maintenance than might otherwise occur, and drives the HDDE manufacturers toward continually lengthening the recommended maintenance intervals. However, the EMA report on maintenance practices tends to cast some doubt on the manufacturers' assertions that routine maintenance is the norm for HDDVs.

Tables 4-1 and 4-2 summarize the maintenance practices for the components which are currently covered by EPA's allowable-maintenance intervals.* In only a few cases was routine

* No data was submitted on diesel EGR or PCV system maintenance, presumably because neither is in widespread use on current HDDEs.

Table 4-1

Maintenance Practices -- Total Fleets
Injector Nozzles -- Function Incidence Rates*

Item	Total Fleets**	GVW 8	GVW 7-6	Fleet Size 3-49	Fleet Size 50+	Usage Long Haul	Usage Other	Owner/ Operator
Clean/Recalibrate/Check:								
Perform Routine Maintenance (%)	46	48	35	46	44	55	41	34
Routine Maintenace Interval (miles) (x 1,000)	88	89	81	85	100	87	89	98
Perform Maintenance Upon Failure (%)	53	52	62	53	54	44	58	66
Replace:								
Perform Routine Maintenance (%)	21	23	15	19	29	24	19	21
Routine Maintenance Interval (miles) (x 1,000)	143	153	93	143	145	178	111	155
Perform Maintenance Upon Failure (%)	78	77	83	80	69	76	80	79

* Routine and failure maintenance do not always sum to 100 percent due to responses which fell in neither category.

** Does not include owner/operator, which is considered as a separate group in this study.

Table 4-2

Maintenance Practices -- Total Fleets
Turborcharger - Function Incidence Rates*

Item	Total Fleets**	GVW 8	GVW 7-6	Fleet Size 3-49	Fleet Size 50+	Usage Long Haul	Usage Other	Owner/ Operator
Rebuild:								
Perform Routine Maintenance (%)	27	30	16	27	29	31	24	44
Routine Maintenance Interval (miles) (x 1,000)	201	207	149	211	169	190	219	124
Perform Maintenance Upon Failure (%)	64	61	75	63	66	56	70	56
Replace:								
Perform Routine Maintenance (%)	11	11	14	11	14	8	13	26
Routine Maintenance Interval (miles) (x 1,000)	154	179	81	121	182	61	183	135
Perform Maintenance Upon Failure (%)	79	79	79	78	82	76	81	74

* Routine and failure maintenance do not always sum to 100 percent due to other responses which fell into neither category.

** Does not include owner/operator, which is considered as a separate group in this study.

maintenance conducted half the time or more, and in virtually no cases could routine maintenance be considered dominant. In short, the data submitted by EMA tend to refute its contention that allowable-maintenance intervals for HDDEs are not necessary due to good maintenance practices by heavy-duty truck owners.

However, the data submitted by EMA provide some useful information on the average-mileage intervals followed by those users who do perform routine maintenance. Even though there are some substantial disparities among the intervals followed by the various HDDE users, the data are useful for comparing the length of the EPA allowable-maintenance intervals against current field practices as represented by the EMA data.

The EMA data show that EPA's allowable-maintenance interval for cleaning of injector tips is generous. EPA's interval is 50,000 miles, and the EMA data indicate a fleet-average value of 88,000 miles, and an owner/operator average value of 98,000 miles.

EPA currently has an allowable-maintenance interval of 200,000 miles for replacement of injectors. Data submitted by EMA indicate a wide range of values in current practices. Intervals tend to be lower for Gross Vehicle Weight Rating (GVWR) Classes VI and VII trucks or non-long haul applications (93,000-111,000 miles), and higher for GVWR Class VIII trucks or fleets involved in long-haul applications (153,000-178,000 miles). For owner/operators the average-mileage interval is 155,000 miles. These data indicate that EPA's interval is too stringent, especially for the HDDE class as a whole. An interval of 200,000 miles might be reasonable for engines designed for long-haul/Class VIII trucks, but is probably too stringent and not as cost effective for less durable engines. A revision of the current EPA interval appears appropriate if one interval is to serve for the entire HDDE class. In this case, setting a revised interval of 150,000 miles seems appropriate based on the EMA data.* This would tend to extend the intervals in the cases where routine maintenance appears least prevalent (and the intervals are shortest), and would extend the intervals on average for the total fleet. EPA believes an interval extended to 150,000 miles is feasible for HDDEs, including those used in Classes VI and VII trucks.

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* Also, in a December 1980 study prepared by a task force of the American Trucking Association, forty respondents to its survey indicated a mean injector replacement interval of 170,125 miles. The range in values was 50,000-375,000 miles, the median was 150,000 miles, and the mode was 100,000 miles.

The EMA data also address the area of turbocharger rebuild/replacement. The EMA data show that rebuilds are far more prevalent than replacement, and that replacements tend to occur as a result of catastrophic failure instead of routine maintenance. As before with injectors, EPA's current interval of 200,000 miles for rebuild of turbochargers appears reasonable for GVWR Class VIII trucks used in fleets in most applications (169,000-219,000 miles), but might be too stringent for GVWR Classes VI and VII trucks and owner/operators (124,000-149,000 miles). EPA's interval of 200,000 miles also covers the replacement of turbochargers. The EMA data are not as useful here because of the heavy dominance of non-scheduled maintenance practices. Even so, it is evident that when replacement does occur, it is at shorter intervals than rebuilds. Considering the EMA data, EPA believes that a revision of the turbocharger rebuild/replacement interval is appropriate. Setting the interval at 150,000 miles would accomplish the goals of the allowable-maintenance program, while at the same time serving as a reasonable compromise value for the rebuild of GVWR Classes VI and VII truck turbochargers and the average fleet interval for replacement. EPA also believes that there is a greater likelihood that the turbocharger maintenance will be performed because of the likely negative performance and fuel economy impacts.

In summary, EPA continues to believe that the allowable-maintenance intervals are necessary for HDDEs, because routine maintenance of emission-related items is not as prevalent as claimed by the HDDE manufacturers. EPA's goal is to certify HDDEs under maintenance intervals that reflect the actual in-use maintenance schedule as closely as possible. However, EPA does see some validity to the manufacturers' contention that the competitive nature of the HDDE business will tend to provide an impetus to lengthen recommended maintenance intervals and to improve general component durability. Relaxing the allowable-maintenance intervals for the two components discussed above is appropriate, because the data submitted tend to indicate that the technologically necessary intervals set by EPA in 1980 are too long for the HDDE class as a whole. The intervals set in 1980 are reasonable for engines used in Classes VII-VIII long-haul trucks, but appear too stringent for less durable medium-duty diesel engines designed for trucks in GVWR Class VI and below. If one interval is to serve for the entire HDDE class then it may by necessity have to be shorter than is technologically necessary for Classes VII-VIII trucks/engines.

General

One commenter claimed that the allowable-maintenance intervals preclude the manufacturers from recommending more frequent maintenance than permitted by EPA. This is not the case. Manufacturers may recommend maintenance at more frequent intervals if they desire, but any maintenance beyond that prescribed by the allowable-maintenance intervals cannot be tied to emission warranty eligibility.

It is also important in this context to remember that, as stated earlier, EPA's allowable-maintenance requirements apply only to emission-related maintenance. Manufacturers are allowed to recommend any maintenance intervals that are reasonable and necessary for non-emission-related maintenance.

Conclusions

1. No changes will be made to the LDT allowable-maintenance provisions.

2. EPA has decided to include an HDGE leaded-fuel spark plug maintenance interval of 12,000 miles, but not to revise the present unleaded-fuel interval.

3. A leaded-fuel EGR valve/system maintenance interval for HDGEs which allows servicing at 24,000 mile intervals will be included.

4. The PCV maintenance interval for HDGEs will not be revised.

5. The injector replacement and turbocharger rebuild/replacement intervals for HDDEs will be reduced, from 200,000 to 150,000 miles.

References

1. "Summary and Analysis of Comments in the Proposed Rulemaking for Gaseous Emission Regulations for 1983 and Later Model Year Light-Duty Trucks," U.S. EPA, OANR, OMS, ECTD, SDSB, May 1980.

5. Issue: Minor Amendments to HDE/LDT SEA

Summary of the Issue

On January 13, 1982, EPA proposed several technical and procedural amendments to the regulations governing Selective Enforcement Auditing (SEA) of HDEs and LDTs contained in Subparts A, K, and N. These regulations were originally promulgated for HDEs at 45 FR 4167 and 4170 (January 21, 1980), and were updated on September 25, 1980 to include LDTs at 45 FR 63767 and 63772.

These amendments were intended to clarify specific aspects of the existing regulations, to improve the efficiency with which the HDE/LDT SEA program will be conducted in the future, and to reduce the compliance burden on the affected manufacturers where practical. Through these amendments, EPA expects the HDE/LDT manufacturers to accrue substantial cash expenditure and cash flow savings.

Summary and Analysis of the Comments

The HDE/LDT manufacturers did not have many major concerns with the amendments to the HDE/LDT SEA procedures. The manufacturers did however, raise numerous minor issues pertaining to various technical points and details of the amended, as well as the original HDE/LDT SEA procedures. The majority of these comments came from General Motors (GM), who stated that its proposal was a resubmittal of its earlier comments (submitted on the HDE NPRM which was promulgated as a final rule on January 21, 1980) on the subject of Subpart K. Therefore, this entire summary and analysis is dedicated to the new comments on the technical and procedural SEA amendments as well as GM's resubmittal of its original comments regarding the HDE/LDT SEA procedures.

The comments received fall into a number of subissues. Each of these subissues will be treated separately.

a. Applicability (§86.1001-84).

GM suggested that this section include a provision to allow a phase-in period for trial test orders for heavy-duty engine (HDE) SEAs. "A minimum period of one year, after the first Heavy-Duty engines are certified on a new test cycle, is recommended."

On January 13, 1982, EPA proposed several regulatory relief initiatives related to the HDE/LDT industry. One of these initiatives was a two-year delay in the start of the HDE SEA program until 1986. The two-year delay in the HDE SEA program already satisfies GM's concern of a phase-in period of one year after the first HDEs are certified on a new test cycle (gas and diesel HDEs are scheduled to be certified on a new transient test cycle in the 1985 model year, with optional transient test standards for the 1984 model year).

In addition, the Agency will make its SEA personnel available, to the extent possible, to monitor trial SEAs prior to the 1986 model year (anytime in the 1985 model year). Any HDE manufacturer that is interested in conducting a trial audit, pursuant to the provisions of Subpart K, may contact EPA in writing to make the appropriate arrangements. Also, the Agency prefers that any manufacturer requesting a trial audit invite other HDE manufacturer representatives to observe the audit in order to maximize its usefulness. These trial audits are designed to provide both the manufacturers and EPA with logistical and procedural experience in running the new SEA program and will be performed on a voluntary basis.

b. Definition of "Configuration" (§86.1002-84(b)).

The present regulations state that a HDE/LDT configuration will be "...described on the basis of...other parameters which may be designated by the Administrator." GM contested this definition as being unreasonably broad and vague and wanted protection against arbitrary selection of parameters by EPA.

This provision about "other parameters" is similar to a provision contained in the present LDV SEA definition of "configuration" (when the present LDV regulations or program are mentioned henceforth, they also include LDTs until the 1984 model year). A LDV configuration has never been defined beyond the specific parameters contained in that definition.

Present HDE/LDT configurations can be described using the specific parameters in the HDE/LDT definition. However, EPA needs some flexibility in specifying configurations, because new emission control technologies developed in response to 1984 and later HDE standards may result in emission control parameters not presently identified. EPA does not intend to use this flexibility in an unreasonable manner but has retained the proposed definition in the final rule.

c. Test Orders - Instructions in test order (§86.1003-84(b)).

GM stated that the phrase "...instructions in the test order.", in the last sentence of paragraph (b), be eliminated as redundant and unnecessary in that the Clean Air Act (the Act) mandates compliance with test orders issued under the regulations. EPA prefers not to delete the phrase because it alerts the manufacturer of their obligations directly in the regulations under Subpart K.

d. Test engine or vehicle selection procedures in the test order (§86.1003-84(c)).

Present regulations state that "The test order will specify... the procedure by which engines or vehicles of the specified configuration must be selected." General Motors believes that this provision is too vague and ambiguous;

it stated that the test sample selection process should be standardized and placed in the regulations. In addition, General Motors recommended revising this provision to ensure engines or vehicles are selected in a quantity not to exceed that required to meet testing schedules while not disrupting normal production activities.

It is not possible to standardize the test sample selection procedure because of the varying production practices and assembly plant operations of the different HDE/LDT manufacturers. This conclusion is based on visits by EPA personnel to domestic HDE/LDT manufacturers and EPA's experience with the LDV SEA program. Also, the sequential sampling plans were designed to prevent severe disruption of a manufacturer's production and customer delivery schedules. The impact on these schedules should be minimized because these sampling plans allow configurations to be tested as expeditiously as possible and the test engines or vehicles may even be selected over several days. It should be emphasized that paragraph §86.1007-84(a) allows for manufacturer input into the determination of the appropriate test sample selection procedure. Therefore, EPA has made no changes in its proposed statement for the final rule.

e. Other standardized test order instructions (§86.1003-84(c)).

The current regulations state that "In addition, the test order may include other directions or information essential to the administration of the required testing." General Motors stated that the latitude allowed EPA by this provision is too broad, and that any instructions which can be standardized should be placed in the regulations and any information which is deemed "essential" should also be included. EPA determined that some of the specific instructions presently incorporated in LDV SEA test orders are applicable to HDE/LDT SEA testing and included them in the January 21, 1980 final rule as new paragraph §86.1003-84(c)(2). However, the provision to include "other directions or information" essential to administer SEA testing has been retained to allow some flexibility in SEA operating procedures. This flexibility can be in both the interest of the manufacturers and EPA, as it will allow audits to be conducted in the most expeditious manner practical, given circumstances unique to a particular manufacturer.

The latitude built into the test order and sample selection sections of the SEA regulations is intended to accommodate procedural variations, especially in the area of test engine selection. Specific instructions may be made to minimize the impact on each manufacturer's normal production activities while still assuring the generation of accurate, representative test results.

f. Selection at non-preferred plants (§86.1003-84(d) and §86.1007-84(a)).

The current regulations assert that, even though a manufacturer has submitted a list of assembly plants preferred for engine or vehicle selection,"...the Administrator may order selection at other than a preferred location." GM stated that this paragraph should be revised to ensure that selection is performed at non-preferred locations only if it will not disrupt normal production activities and only upon making the determination that evidence exists indicating a noncompliance at other than the manufacturer's preferred plant. The sequential sampling plans contained in this regulation were designed to allow flexibility in sample selection to prevent, to the greatest extent possible, disrupting a manufacturer's normal production and delivery schedules. EPA intends to select test engines and vehicles at preferred locations, but requires the flexibility of selecting at non-preferred plants when that would allow the audit to be performed expeditiously or permit the auditing, based upon available evidence, of specific cases of noncompliance. For example, in the LDV SEA program, audits have had to be canceled or significantly delayed due to the preferred plant being down for a couple of weeks, closed indefinitely, or otherwise unavailable for selection. In such cases, the Agency needs to be able to select its test engines or vehicles at non-preferred plants. To retain this flexibility, EPA made no change to the final rule.

q. Additional test orders for noncompliance (§86.1003-84(f)(3)).

EPA provided that after the annual limit has been met, the Administrator may issue additional test orders for which evidence of noncompliance exists. General Motors argues that test orders should not be indiscriminantly and unreasonably issued on the basis of "any evidence." Further GM says, test orders when issued, should count against the annual limit the same as any other test order. Otherwise, the "annual limit" would be open ended and the manufacturer would be subject to an indefinite number of test orders.

EPA has a responsibility to investigate those engine configurations for which it has evidence of noncompliance, and, therefore, has not incorporated this provision into the regulations. Also, this provision is consistent with the present LDV regulations. The Agency is however, sensitive to GM's concern that manufacturers may be subjected to an indefinite number of test orders. Based on evidence of noncompliance, a test order issued within the annual limit will count toward the annual limit, if the configuration passes the audit. If the limit has been reached, additional test orders may be issued only on the basis of evidence of noncompliance. In addition, the provision requiring a statement of the reason for issuance of a test order beyond the annual limit will be retained.

h. Discrepancies between EPA test results and manufacturer test results (§86.1004-84(b) and (c)).

The present regulations state that EPA's test results comprise the official data for a test engine or vehicle when there is a disagreement with a manufacturer's results. GM disagrees with the assumption that the manufacturer's test facility is deficient and that it bears the burden of proving that its own data are correct. It argues that the certificate of conformity should not be suspended with respect to the vehicle or engine configuration in question until the reasons for the lack of correlation are determined. However, the regulations provide two mechanisms for resolving differences between data: (1) paragraph §86.1004-84(c)(2) allows a manufacturer to demonstrate that EPA's data were erroneous and its own data were correct; and (2) if EPA invokes a suspension of the certificate of conformity based on the Administrator's test data, the manufacturer can request a hearing under paragraph §86.1012-84(1) to determine whether the tests were conducted properly. Therefore, this provision is unchanged.

i. Retaining names of involved personnel (§86.1005-84(a)(2)(iii) and (a)(2)(iv)).

Paragraph §86.1005-84(a)(2)(iii) requires the manufacturer to retain the names of all personnel involved in the conduct of an audit and paragraph §86.1005-84(a)(2)(iv) requires the manufacturer to retain the names of all personnel involved in the supervision and performance of a repair. GM proposed that these provisions be deleted because this information is unnecessary and irrelevant for EPA's needs and the information goes beyond that required by the current LDV/LDT regulations.

EPA does agree that these provisions should be consistent with the requirements of the present LDV/LDT regulations which only require the names of supervisory personnel be retained by the manufacturer. Further, EPA believes that the names of manufacturer personnel involved in repairing vehicles or engines and conducting audits can be obtained from supervisory personnel if an investigation of an audit is ever necessary. Therefore, EPA revised paragraphs §86.1005-84(a)(2)(iii) and (a)(2)(iv) to reflect GM's comment of consistency with the LDV/LDT regulations.

j. Requirement for submitting manufacturer's test results (§86.1005-84(c)).

This paragraph requires manufacturers to submit to EPA their own production engine or vehicle test data. GM characterized this requirement as unnecessarily burdensome and unreasonable, wanted a semiannual reporting period (instead of quarterly), wanted to submit only complete Federal Test Procedure (FTP) data from an established quality audit program, proposed to delete the requirement for submitting data on Automatic Data Processing (ADP) equipment, and recommended various revisions and deletions in the required information.

Subpart K does not impose any requirement that a manufacturer conduct an internal quality audit program, but if a manufacturer does conduct such a program, Section 208(a) of the Act authorizes the Administrator to require the submission of these data to EPA. The data may be used to help determine compliance of HDEs or LDTs with applicable emission standards. In addition, Subpart K does not require the manufacturer to submit emission test results on ADP equipment. What the provision says is _if_ emission test results are available on ADP equipment and the manufacturer's storage device is compatible with EPA's ADP equipment, then the manufacturer would submit the information in a form available for automatic processing. EPA will even furnish the necessary ADP storage devices upon a manufacturer's request.

This submission of test data requirement has been proven workable in the current LDV SEA program and does not appear to be unreasonably burdensome to manufacturers. EPA believes that the reporting period (quarterly) and requirements it promulgated for the HDE/LDT manufacturers are reasonable and are similar in scope to those currently being met by LDV/LDT manufacturers. A semiannual reporting period, with closing dates of January 31 and July 31 (as suggested by GM), would not adequately meet EPA's needs. Emission's data received so late in the model year (the first reporting period's data would not be received until late February or early March and the last reporting period's data would not arrive until the end of the model year) would provide the Agency with little help in determining compliance of HDEs and LDTs with applicable emission standards. The manufacturer is required to describe the emission test used to obtain the data submitted (see §86.1005-84(c)(1)) to help EPA evaluate the value of the data when compared to the FTP. EPA, therefore, proposes no changes to §86.1005-84(c).

k. Additional information which the Administrator may require (§86.1005-84(e)).

GM recommended deleting this requirement because it is ambiguous, provides unlimited discretion to the Administrator, and goes beyond the scope of Section 208(a) of the Clean Air Act (GM also recommended that §86.1009-84(d)(5)(vi) be deleted for similar reasons). EPA however, has made no changes to these paragraphs for the final rule because the Agency needs some flexibility in requiring information on a case-by-case basis. Paragraph §86.1005-84(e) states that the Administrator may request information not specifically provided under the other sections of §86.1005-84. However, the Administrator is still bound by Section 208(a) to require only the information that will enable a determination to be made of whether a manufacturer has acted or is acting in compliance with Title II, Part A of the Clean Air Act and the regulations promulgated thereunder.

l. Entry and access (§86.1006-84(b)(4)).

In this paragraph, GM recommended that only "emission related" parts or aspects of an engine or vehicle be investigated, but it did not give a reason for this comment. §86.1006-84(a) states that matters related only to this subpart (Subpart K) will be investigated. Therefore, EPA has not revised §86.1006-84(b)(4) in response to this comment.

m. Entry and access (§86.1006-84(h)(3)).

GM recommended that this paragraph be revised in order to more accurately reflect the current practice of the LDV regulations. Paragraph (h)(3) of §86.1006 deals with the definition of "operating hours" at facilities or areas other than those where engine or vehicle storage is concerned. EPA concurs with GM's comment and has amended §86.1006-84(h)(3) to be consistent with the LDV regulations, for purposes of uniformity and clarity.

n. Authorization for personnel appearance and entry without 24 hours notice (§86.1006-84(h)(4) and (5)).

GM recommended that paragraph §86.1006-84(h)(4) be amended and a new paragraph §86.1006-84(h)(5) be added to require the Assistant Administrator for Air, Noise, and Radiation to approve these authorizations. EPA believes it is unnecessary to require the Assistant Administrator to authorize either appearances of personnel or entry without 24 hours prior notice because these authorizations can be performed by other responsible Agency officials. If a manufacturer refuses to consent to personnel appearance or entry without 24 hours notice, EPA is required to seek a search warrant before attempting to conduct these activities.

Therefore, no changes relating to these issues have been made in the final rule.

o. Selection of incomplete test engines or vehicles (§86.1007-84(b)).

The present regulations state that a test order will specify the manner in which assembly of incomplete test engines or vehicles will be completed. GM recommended that this provision be revised to allow the assembly to be completed according to applicable production and assembly quality control methods and procedures. GM first proposed this revision during the initial comment period on the HDE gaseous emission regulation notice of proposed rulmaking (NPRM). EPA agreed with the request and amended paragraph §86.1007-84(b), in the January 21, 1980 HDE final rule, to allow the use of these methods. However, EPA qualified GM's suggestion by adding that the procedures must be "documented by the manufacturer" and eliminated GM's suggested phrase, "assembled to normal certification dress." These qualifications were necessary to ensure that engines are assembled using only standard assembly line procedures and quality control checks and that these test engines duplicate, as closely as possible, the configuration of the manufacturer's engines being distributed into commerce. EPA continues to believe such documentation is important and will retain paragraph §86.1007-84(b) as is.

p. Exception to sample selection (§86.1007-84(c)).

GM proposed that the last portion of this paragraph be clarified and rewritten to include an exception that the Administrator may approve a modification in the normal assembly procedures. Although GM did not describe a situation in which such an exemption would be needed, the comment has been adopted.

q. Allowance for "dealer preparation" procedures (§86.1008-84(b)(1)).

GM recommended that an additional paragraph be added to the end of this section to reflect the current practice of the LDV regulations. The recommended new paragraph states that a manufacturer may perform "dealer preparation" procedures on the new vehicles or engines, provided that these procedures are documented in written instructions or are approved by the Administrator in advance of their performance. EPA believes that SEA vehicles or test engines that have undergone dealer preparation procedures will represent "real world" conditions to the extent that these procedures are actually and correctly performed by dealers. EPA's experience with LDVs indicates that in several cases, dealer preparation procedures are not performed, or are not performed correctly by the dealers. However, the current regulations do permit dealer preparation procedures to be performed if they are approved in advance by the Administrator. EPA approval will be facilitated if the manufacturer provides sufficient dealer survey data or other information to allow EPA to conclude that the procedures are actually being correctly performed by dealers. Therefore, EPA did not alter this provision.

r. Service accumulation requirements (§86.1008-84(c)(1)).

The current EPA regulations require that service accumulation prior to engine testing be performed at a minimum rate of 16 hours per 24 hour period, unless otherwise approved by the Administrator. GM proposed an 8 hour minimum rate to make this requirement more consistent with the LDV regulations, which does not require the manufacturer to maintain a two shift operation at a test facility. GM did not justify on a technical basis why test engines could not be run for a minimum of 16 hours per day. The Agency would like to conduct the audits in the most expeditious manner possible. We believe that this is still a reasonable requirement because HDE service accumulation does not require a full-time "driver" and can be monitored automatically for emergency shut-down. In addition, there is an existing provision in this paragraph of the regulations that allows the Administrator to approve an alternate service accumulation rate based on a justifiable manufacturer request. Therefore, EPA has not made a revision to this paragraph in the final rule.

s. Test per day requirement (§86.1008-84(g)(1)).

GM recommended that EPA's requirement of a minimum of two SEA tests per 24 hour period be revised to one test per 24 hour period on the average. GM proposed this change to make this regulation consistent with current LDV requirements. GM stated that the LDV regulations require only the use of a single test cell for the expeditious completion of an audit, whereas, for HDEs the manufacturer would have to dedicate two test cells for the purpose of an audit.

In its HDE SEA program, EPA desires to conduct the audits in as expeditious and non-disruptive a manner as possible while still obtaining accurate test results. Based on the time required to perform the transient test procedure, taking into account the "forced cool-down" allowed in the final rule (see Subpart N), EPA has determined that two tests can be performed in a 24 hour period, given two test cells (especially with double-ended dynomometers). EPA used this test cell requirement in its analysis of the cost of these regulations. To require only one test per day would make the SEA last about twice as long, with resultant demands on both the manufacturer's and the Agency's resources. If a manufacturer has a justifiable reason for being unable to perform the minimum number of tests, the regulations allow them (under §86.1008-84(g)(4)) to ask EPA for a reduction. EPA has therefore made no change in the test per day requirement in this paragraph for the final rule.

t. Option to retest (§86.1008-84(i)).

GM wanted EPA's present regulation revised to allow retesting at any time during an audit (as opposed to only after a fail decision has been reached) and to delete the requirement for testing each engine or vehicle the same number of times. It justified these changes on the basis of possible logistic, storage, and economic impacts on manufacturer operations and comparability with the LDV SEA regulations. To permit a manufacturer to retest, before an actual failure has occurred, may unnecessarily delay the audit and may even cause the negative impact on operations that GM wished to avoid. There is nevertheless, an existing provision in this paragraph that allows the Administrator to approve retesting, before a fail decision has been reached, based on a manufacturer's request accompanied by a satisfactory justification. However, the engines or vehicles must still be tested the same number of times. To permit retesting of only failed engines or vehicles or to allow some engines or vehicles to be tested more times than others will bias the test results from a statistical viewpoint because of inherent test-to-test variability. EPA has therefore made no changes to this paragraph for the final rule.

u. Failed engine or vehicle report (§86.1012-84(i)(2)).

GM proposed that this paragraph be changed to delete the requirement that a written report to the Administrator be submitted within five working days after successful completion of testing on a failed vehicle or engine. GM stated that this change will more accurately reflect the current requirement of the LDV regulations.

In the original HDE/LDT NPRMs, EPA proposed regulations that required the written report on corrective testing of engines or vehicles that failed emission testing during an SEA be submitted to EPA within five working days after completion of that testing. While EPA needs to receive reports on the repair of noncomplying engines or vehicles in a timely manner, the Agency acknowledges that corrective action need not be taken immediately after an engine or vehicle failure. To clarify its intent, EPA revised this paragraph (in the January 21, 1980 and September 25, 1980 final rules) so as not to limit the time a manufacturer may take to complete testing of failed engines or vehicles. The Agency also concurs with GM's statement that this paragraph be changed to reflect the current requirements of the LDV regulations, which do not require a five working day time limit for submission of failed vehicle reports. EPA will revise paragraph §86.1012-84(i)(2) to relect GM's comment and the LDV regulations.

v. Applicability (§86.1001-84).

American Motors (AM) commented that the applicability in §86.1001-84 was not changed to reflect the deletion of HDEs for the 1984 model year, and that LDTs are still included in §86.601 applicability (Subpart G). AM goes on to say that EPA could avoid much confusion and simplify the regulation by continuing the requirements of Subpart G for LDTs until such time as EPA requires HDE SEAs (1986 model year). AM opposes grouping LDTs with HDEs for any emission certification or compliance related matters. Therefore, it recommends postponing the applicability of Subpart K until 1986.

On January 21, 1980, EPA promulgated gaseous emission regulations for 1984 and later model year HDEs and a similar rulemaking affecting 1984 and later model year LDTs was promulgated on September 25, 1980. The primary function of these rulemakings was to promulgate the statutory HC and CO standards called for in the 1977 Clean Air Act Amendments (202(a)(3)(A)(ii)). In addition to the statutory standards these rulemakings implemented a number of other provisions to be effective for the 1984 model year, such as: sequential sampling plans for SEA, revised certification requirements, a revised useful life definition, and an idle test and idle emission standard for gasoline-powered LDTs and HDEs.

These new requirements for LDTs and HDEs were promulgated simultaneously to avoid the procedural disruption and waste associated with frequent changes in emission regulations. The Agency chose this comprehensive approach to controlling LDT and HDE emissions because it was the most efficient approach in that it allows the manufacturers to deal with the effects of several regulations at once. This will avoid repeated financial outlays for research, development, recertification, and retooling.

The applicability of §86.1001-84 (Subpart K) was not changed to reflect the deletion of HDE SEAs for 1984 because the regulations still apply for 1984 and later model year HDEs and LDTs (LDTs are still subject to SEAs under Subpart K starting in the 1984 model year - LDTs are currently subject to SEAs under the provisions of Subpart G). The Agency, as part of their regulatory relief initiative, has made a commitment to the HDE manufacturers not to begin the HDE SEA program until the 1986 model year. In addition, Subpart K will be used to implement the nonconformance penalty (NCP) provisions of Section 206(g) of the Act, which, where applicable, may apply to LDTs (greater than 6000 pounds GVW) as well as HDEs. As far as §86.601 (the applicability provision in Subpart G) is concerned, LDTs are still included because this provision for LDTs is effective through the 1983 model year. In another EPA rulemaking, we intend to propose several changes to Subpart G to provide greater consistency with Subpart K. That proposal would make the sampling plans, test procedures, etc. coincide for LDTs and LDVs. Therefore, EPA has not revised paragraphs §86.601 or §86.1001-84 in response to these comments.

6. Issue: Split Standards - Gasoline-Fueled vs. Diesel Engines

Summary of the Issue

Virtually all HDVs are powered by either gasoline- or diesel-fueled engines. In the past, the gaseous exhaust emission standards for each pollutant (i.e., HC, CO, NOx) have been the same for all HDVs regardless of the type of powerplant used in the vehicle. This has been true even though the two types of powerplants have different operating characteristics, which lead to significantly different levels of the various pollutants in the uncontrolled case. Diesel engines are inherently low in HC and CO, while being relatively high in particulates. Gasoline-fueled engines are relatively high in HC and CO but inherently low in particulate. Both types of engines produce similar levels of NOx in the uncontrolled case, but gasoline engine NOx is more easily controlled.

In the past, emission standards were of a level of stringency such that both types of engines could meet them with relative ease. However, as tighter emission standards are considered for the future, the difference in inherent emission levels between the two types of engines may need to be considered. An emission standard which is a practical lower limit for one type of engine may be quite a high level of emissions for the other type of engine. By setting separate standards for the two types of powerplants, the maximum degree of emission reduction might be obtained for all pollutants in a cost-effective manner.

At the February 18, 1982 public hearing, for this rulemaking as well as in its March 23, 1982 notification extending the comment period, the Agency requested comments on this issue of setting separate standards for gasoline- and diesel-fueled engines. The comments received are summarized and analyzed below.

Summary of the Comments

EPA received comments from seven HDV manufacturers and one trade association on this issue. The seven manufacturers were: Caterpillar Tractor Company, International Harvester Company (IHC), Chrysler Corporation (Chrysler), Mack Trucks (Mack), Daimler-Benz A.G., General Motors Corporation (GM), and Ford Motor Company (Ford). The trade association was the Engine Manufacturers Association (EMA). Only one major domestic engine manufacturer, Cummins Engine Company, provided no position on this issue.

Caterpillar recommended "...the complete separation of HD diesel regulations from HD gasoline regulations." Caterpillar stated that it would not be opposed to a less stringent HC standard for gasoline-fueled HDVs as compared to the diesel standard, but it requested that similar consideration be given to future NOx standards.

International Harvester Corporation stated that the standards mandated by the 1977 amendments to the Clean Air Act (CAA) are not feasible when the need to avoid excessive cost and fuel economy losses is considered. Therefore, IHC recommended that the Agency revise all of these standards to utilize the best control technology while minimizing costs. IHC recommended that "...in the future EPA should set standards based upon best and most cost-effective emission control technology taking into consideration the type of basic engine (diesel or gasoline)." IHC did not oppose the concept of split standards.

Chrysler stated that it saw no compelling reason for EPA to consider establishing separate standards that would be applied to comparable vehicles performing similar operations. Chrysler claimed that the CAA made no provisions for separate standards for different types of engines. It quoted from §202(a)(3)(A), which authorizes the Administrator to establish classes based on "gross vehicle weight, horsepower, or other factors as may be appropriate," but Chrysler claimed the legislative history is clear that the use of diesel fuel is not a proper determinant for establishing a separate class of engines.

Mack stated at the public hearing that since gasoline engines are not in competition with its diesels, it has "...no problem with a different standard for gasoline." Mack also expressed a hope that "similar concessions might be in the cards for the diesel should they be needed," with regard to future NOx or particulate standards.

Daimler-Benz agreed with EPA that "...the Clean Air Act permits the establishment of separate standards for diesel and gasoline engines based on the technical capability of each engine class." Furthermore, Daimler-Benz claimed that it is appropriate to establish separate standards for all regulated pollutants.

General Motors stated that it did not believe separate standards should be established for gasoline-fueled vs. diesel-fueled engines, and gave three main reasons to support its position. First, GM commented that the cost of control increases sharply as the lowest achievable levels are approached. As these low level of emissions are approached, setting different standards of approximately equal stringency would become very difficult. Therefore, a competitive advantage would be artificially induced for one or the other engine type.

Second, GM stated that there would be little incentive to develop a less costly, low-emission powerplant of new technology which would be capable of complying with given HDE emission standards if it is likely that after introduction that engine type would be subjected to more stringent standards based on the best available control technology for that engine. The new engine's original cost advantage over other available powerplants would be eroded.

Third, GM claimed that Congress intended one set of standards to cover both engine types. GM quoted the House report which accompanied the 1977 CAA amendments as saying, "In permitting the Administrator to specify separate classes or categories of vehicles or engines, the Committee did not intend to authorize the Administrator to prescribe separate standards for gasoline-powered and diesel-powered engines." Furthermore, GM claimed that the standards which are specified in CAA §202(a)(3)(A)(ii) are to apply to all heavy-duty engines.

General Motors was also concerned that if separate standards were promulgated someone might erroneously conclude that the diesel HC and CO standards should be 90 percent reductions from uncontrolled diesel levels. GM claimed such levels would in some cases be infeasible, thus resulting in unnecessary and expensive regulatory activity to periodically revise the standards as required by the CAA.

Finally, GM noted that EPA discussed the issue in the Advance Notice of Proposed Rulemaking (ANPRM) for LDT/HDE NOx (46 FR 5838). The ANPRM took the position that the same NOx standard should apply to both types of engines within a given class. GM also pointed out EPA's reasoning that it would be inequitable to establish different requirements for competing engines within the same class and that to do so could have the appearance of favoring one powerplant over another. GM stated that EPA's reasoning expressed in the NOx ANPRM is equally applicable to the HDE HC and CO standards.

Ford claimed that "...the public interest is best served by the establishment of uniform standards for competing classes of vehicles." Since Ford did not elaborate on the above statement, we will assume that Ford's comment was concerned with the competitive effects similar to those expressed in GM's comments.

Ford also claimed that EPA does not have statutory authority to set separate standards for gasoline- and diesel-fueled HDEs. Ford quoted from the 1977 report by the

Senate Committee on Environment and Public Works which accompanied Senate Bill 252. The Committee stated, "Diesel vehicles, which inherently emit less hydrocarbons and carbon monoxide, must meet the standards set for gasoline-powered vehicles." Also, Ford submitted the same quote from the House Committee on Interstate and Foreign Commerce that GM submitted.

Ford claimed that Congress' intent to establish uniform standards is further evidenced by the fact that Congress did allow some separate standards, but it did so in a very limited and specific fashion. For example, unique NOx standards for 1981-84 diesel-powered light-duty vehicles (LDVs) that qualify for waivers, and waiver provisions for "small manufacturers" and "innovative technology," are specifically authorized.

Finally, Ford stated that EPA itself has recognized the need for uniformity of standards. Ford, as did GM, pointed out EPA's intention to propose a NOx standard for all HDVs that represents the level that can be achieved by diesel engines. Ford claimed that this same uniformity must apply to all standards.

The Engine Manufacturers Association recommended that the Agency propose a rule in response to which interested parties could comment. EPA should consider how separate standards might correct the problems created by the statutory NOx standard which the Agency "...has already indicated it believes is not technologically feasible." EMA suggested that EPA consider the establishment of future standards based on more representative baselines or control technologies. EMA stated that it would submit additional comments at such time as the Agency articulates a policy which addresses the issues.

Analysis of the Comments

The four commenters who produce only HDDEs stated that EPA could set separate standards for the two engine types. In fact, most of these commenters urged EPA to do so. These commenters felt that split standards were consistent with that requirement in the CAA for EPA to consider the impact of available technology in setting standards.

General Motors, Ford, and Chrysler all produce HDGEs, and all were opposed to split standards. GM also produces HDDEs. Three reasons for opposition were common to both GM and Ford: 1) competitive effects, 2) statutory intent, and 3) EPA precedent. Chrysler's main reason for opposition was statutory intent. Each of these will be discussed in the order given, followed by discussion of the other two concerns of GM (i.e., infeasibility of 90 percent reduction and incentives for new technology).

EPA agrees with the commenters that the possibility of a competitive advantage being established does exist. This situation might occur if the Agency attempted to set standards at the very lowest possible emission limits of the two engine types. Since the cost of control often increases rapidly as such limits are approached, great care would need to be taken to assure that such separate standards would not lead to an unreasonable cost differential for the two engine types. (This clearly would not apply in cases such as evaporative HC or particulate/smoke standards, where only one engine type is regulated.)

However, split standards would not necessarily lead to a competitive advantage for one or the other engine type. For example, the public record for this rulemaking clearly indicates that HDDEs are already achieving the statutory CO standard. HDGEs, on the other hand, could have substantial difficulty meeting that standard by 1985, and in fact would need to utilize an oxidation catalyst-based control system in most cases. Thus, having the <u>same</u> standard for both engine types results in a large initial cost disadvantage for HDGEs. Even when the gasoline standards are relaxed to levels where catalysts would not be necessary, but the diesel standards remain at the statutory level, the average incremental diesel engine cost would be less than the average incremental gasoline engine cost. In this case, the promulgation of split standards would clearly promote equity for the two engine types, while retaining the same standards results in a definite cost advantage for diesels. Therefore, EPA has determined that while the possibility of creating a competitive advantage due to split standards does exist, each individual instance must be carefully analyzed on its own merits to determine if such an advantage would be created.

EPA disagrees with the claim by GM, Ford, and Chrysler that the CAA disallows the setting of separate standards for HDGEs and HDDEs. While GM and Ford raise valid points of legislative history, it is important to realize that no action was ever taken to write these Committees' intents into the CAA, nor is there any indication that such intents were endorsed by the conference committee or the Congress as a whole in establishing the final 1977 amendments. Moreover, although the legislative history cited by both GM and Ford may indicate the House Committee's intent as to how EPA should exercise its discretion, the quotation is more suggestive than mandatory. The actual wording of the CAA, on the other hand, confers broad authority on EPA in this area. According to §202(a)(3)(A)(iv), the Administrator "...may base such classes or categories on gross vehicle weight, horsepower or <u>such other factors as may be appropriate</u>" (emphasis added).

The CAA obviously established the same statutory standard for both engine classes in §202(a)(3)(A)(ii), as GM pointed out. EPA continues to move toward that goal. However, in the provisions for temporary revised standards the CAA calls for technology-based interim standards. The technology, cost, leadtime, and fuel economy considerations involved in establishing such interim standards are all fundamentally engine-type dependent. Thus, it would seem that consideration of basic engine type is clearly an "appropriate factor" under the §202(a)(3)(A)(iv) definition, and that the CAA allows the Agency to establish split standards for HDDEs and HDGEs.

It should also be remembered that distinctive, technology-related standards for HDEs are not foreign to EPA's application of the CAA. Smoke emission standards currently apply to HDDEs, but not HDGEs. EPA has also proposed particulate emission standards to be applicable to diesel engines only, and has recently established evaporative emissions standards for HDGEs only. In none of these cases has any question been raised as to the appropriateness of split standards.

Both GM and Ford claimed that statements made by EPA in the LDT/HDE NOx ANPRM (46 FR 5845), which indicated the Agency's intent to propose a single revised NOx standard for both gasoline and diesel engines, must apply to this rulemaking as well. EPA disagrees with the commenters' claim. Those statements did not reflect a final Agency policy statement, but indicated a preliminary EPA position on the single vs. separate standards issue for HDE NOx, published for public comment in an ANPRM. That position was clearly subject to change as is Agency policy in general. This is especially true when circumstances and conditions change or when new regulatory situations arise. It is in this light that EPA has raised the issue of split standards for HDE HC and CO.

The possible application of split standards for HC and CO likewise should not be taken as precedent setting for HDE NOx. EPA analysis here indicates the Agency's authority to set such standards, and will momentarily discuss further considerations in any decision to use this authority. All of this analysis should make it clear that the approach for NOx standards could be different than the approach for HC and CO standards. For example, in the range of standards now being considered for HDE NOx, gasoline and diesel engine control costs are similar for the same standards. However, if a single set of HC/CO standards were adopted, such as the statutory standards, then inequitable costs due to widely differing technology requirements could result. Therefore, a single set of HC/CO standards might be inappropriate because of significantly different costs between two engine types, while a single NOx standard might be appropriate because emission control costs are nearly the same for gasoline and diesel engines.

General Motors was concerned that the incentive for developing innovative technology could be diminished if the standards applicable to such new technology are overly stringent. When and if the Agency considers standards for new technology engines, it will need to consider this valid concern. However, this rulemaking does not involve new technology engines, and is unlikely to have an impact on the development of new technologies. Therefore, while the Agency may need to evaluate this concern in future rulemakings, the problem does not arise in this final rule.

General Motors' final concern was that if split standards were developed, then the Agency might consider as standards 90 percent reductions from uncontrolled levels for both diesel and gasoline engines. GM stated that a 90 percent reduction in HC and CO for diesels is technologically infeasible. We conclude that GM's concern is ill-founded. As already stated above, the CAA obviously established the same statutory standards for both engine classes. EPA recognizes that diesel engines are inherently low emitters of HC and CO. EPA always has and will continue to analyze the technical feasibility of standards it promulgates.

The Engine Manufacturers Association suggested that the Agency propose a rulemaking on split standards. EPA concludes that since the Agency has requested comment on this issue both at the public hearing and in a published notice (47 FR 12366), and has received substantial comment, the requirements for establishing the Agency's position have been met. Thus, a separate rulemaking on split standards is not necessary.

Conclusion

EPA concludes that the CAA gives the Administrator authority under §202(a)(3)(A)(iv) and §202(a)(3)(C)(i) to set split standards. Furthermore, while there may be in some cases potential problems concerning competitive advantage and innovative technology incentives, each situation must be analyzed on its own merits. Therefore, split standards will be employed where necessary and appropriate, as is the case for this rulemaking.

7. Issue: Cold Start Requirements

Summary of the Issue

The heavy-duty engine (HDE) emission test procedures applicable to 1984 and later model year HDEs require that the test begin with a cold engine, and that a 1/7 weighting be applied to the emissions measured from the cold start segment of the test. Commenters questioned the need for the cold start requirement and disagreed with the cold start weighting.

Summary of the Comments

Commenters stated that the cold start requirement for diesel engines is not necessary because the weighted emission results (1/7 of cold start and 6/7 of hot start) are almost identical to the emission results obtained from the hot start portion of the test. Comparisons of the results obtained either by individual manufacturers or from EMA/EPA round-robin tests were expressed in several forms to support the position that the cold start requirement is not necessary.

For diesel engines, the comparisons were expressed in terms of a correlation coefficient. Daimler-Benz expressed their results as a range of differences between the ratio of cold start results to hot start results. The Engine Manufacturers Association (EMA) analyzed the data to determine the predicted "error" at the 95 percent confidence level in the emission results if based upon only hot start test data. The projected errors were: 0.1 grams per brake horsepower-hour (g/BHP-hr) NOx, 0.08 g/BHP-hr HC, and 0.05 g/BHP-hr particulate. These errors were also noted to be less than the variations seen from one test to the next.

For gasoline engines, commenters made the comparison in terms of the ratio of hot start emissions to weighted emissions, and expressed the result as a percentage. All of the comments indicated that the cold start test had very little, if any, effect on total test results.

The reasons given by the commenters for the good agreement between hot test results and the weighted results (for both diesel and gasoline) were: 1) engine warm-up requires about five minutes, and this warm-up period occurs in the very first segment of the cold start portion of the test, 2) the exhaust mass flow rates are low during the first segments of both the cold start and hot start portions of the test, while being high and essentially equal during the third segment of both portions of the test, 3) the high exhaust gas mass flow rate of segment three tends to overpower the effects of the other segments, and 4) application of a weighting factor to the cold start portion of the test further reduces the overall effect of these emissions on the final weighted test result. Commenters agreed that HDEs are started from cold, but argued for the elimination of the cold start requirement because of its minimal impact on total test emissions.

Commenters stated that significant cost savings would be realized by manufacturers through removal of the cold start requirement. The cost savings would accrue from: 1) better utilization of test facilities, 2) fewer test cells would have to be built because of better test cell utilization, 3) reduction in the number of lost tests (instrumentation and hook-up of equipment cannot be checked prior to the start of a cold test), and 4) reduction in development and certification leadtimes. Forced cooldown does not solve the facility problem because it still requires four to five hours to perform and still results in only one test per day. Cummins provided an estimate of the costs attributable to lost tests associated with the cold start requirement. The estimate was between $160,000 and $200,000 per year.

Commenters also disagreed with the weighting applied by EPA to the cold start portion of the test. Commenters stated that the CAPE-21 data showed that 1.6 percent of total vehicle operation was with a cold engine. Commenters stated that if EPA believes that test engines must be cold started, it was recommended that the weighting for the cold start portion of the test be changed. Ford recommended that the weighting for the cold start portion of the test be 1/16 instead of 1/7. The 1/16 weighting was developed by making each of the four segments of the cold start portion of the test equal to 1.6 percent of the total with the resulting cold start portion equal to 6.4 percent or 1/16 of the total. As part of this issue, commenters also disagreed with the EPA methodology for determining the number of truck trips per day. Commenters stated that, on the basis of the CAPE-21 data, the average truck was used for nine trips per day (based upon mean values) and that it was an error to use the median number of truck trips per day, as EPA had done, as the basis for the cold start weighting.

In final comments submitted by May 6, 1983, EMA also presented a detailed reanalysis of the cold start weighting factors. EMA used mean values for calculating total operating time per day per CAPE-21 truck (EPA used median values), and alternately, used median values for operating time, but increased all median values to the extent necessary for median total accountable time to equal an 8-hour day. Using either method, EMA derived and recommended a cold cycle weighting factor of .03. (By deriving total operating time per day per truck, by assuming a single cold start per day, and by knowing reasonably well the warm-up time for a typical engine, the percentage of time an engine spends "cold" per day is easily calculated.) EMA recommended that EPA adopt the .03 weighting. Furthermore, considering the relative stringency of the HC standard, EMA argued that the entire cold start cycle be abandoned as unnecessary. "However, if EPA wishes to retain a check on new technical developments as they affect cold starting, then EPA should permit a much reduced cold start measurement effort. For example, EPA could adopt a method similar to the CO emission measurement waiver...."

Analysis of the Comments

Cold Start Requirement for Diesel Engines

Diesel engines designed to meet existing emission standards show good agreement between the hot start and the composite test results, as measured by the ratio of hot start results to composite test results.

For most current technology diesel engines, EPA agrees that there is little difference between the hot start segment result and the composite result. Comments submitted by EMA and Cummins substantiate this fact. For many diesel engines, EPA cannot find fault with the argument that the cold start cycle has a marginal effect on total test results. EPA also recognizes the economic implications of 100 percent cold start testing. A significant percentage of dynamometer space is idled while engines are cooling (thereby increasing the number of dynamometers necessary for a given program, and thus increasing the facility expenditures). Additional cost is involved both in running the extra cold cycle and in procuring equipment necessary for forced engine cooling. EPA concurs that it makes no sense to impose a costly cold start testing burden if no benefits are to be achieved.

On the other hand, EPA is reluctant to remove the cold start requirement entirely for heavy-duty diesel engines (HDDEs). Some engines do show a difference between cold and hot emissions. Furthermore, HDDEs have yet to experience the most technologically difficult emission reductions (i.e., NOx and particulate). These will probably require the use of new and elaborate emission control techniques. It is EPA's experience with other internal combustion engines that, as emission standards become more stringent, unique operational modes such as cold starts take on greater significance and contribute more to the total test result. This may also be observed in future HDDEs. If so, a cold start test will become increasingly necessary. However, if the cold start requirements are abandoned today, they will be administratively difficult to reimpose in the future when they may be most needed.

An alternative to the "all-or-nothing" approach has been suggested by EMA. EMA recommends that an approach be taken similar to that taken with the measurement of CO emissions from HDDEs. HDDEs emit CO well below the level of the applicable CO standards. In recognition of both this and the expenses incurred in measuring CO, EPA waived the requirement for HDDE manufacturers to report CO emission levels. This waiver was made with the explicit condition that CO emission standards still apply, and that the risk of non-compliance still rests with the manufacturer.

Such an approach is appropriate for heavy-duty diesel cold start test results. Under this approach, EPA could allow submission of only hot start data in certification applications. The official test procedure, however, will remain a cold/hot test which will still be run for all confirmatory tests. The manufacturer would then accept any jeopardy arising from potential differences in test results. As always, a manufacturer may run whatever tests deemed necessary for in-house development testing. In this way, the cold start testing burden is minimized if a manufacturer is confident that a cold start is actually insignificant. In fact, marginally greater cold start emissions may be adequately simulated much the same way that expected in-use deterioration is: by downwardly adjusting hot start emission target levels. On the other hand, if a cold start is indeed significant for a given engine, these are the very engines on which cold start testing should be performed. Since the jeopardy of non-compliance still would rest with the manufacturer, EPA has sufficient assurance that necessary testing will take place.

Cold Start Requirement for Gasoline Engines

EPA has reviewed the emission data collected during its baseline testing programs. For uncontrolled engines, about 11 percent of total hydrocarbons measured over the transient test were attributable to the cold start segment. In later testing (the 1979 current technology baseline), the cold start contribution to composite test results ranged from 4.5 to 37.7 percent for HC, and from 1.5 to 10.2 percent for CO. As total emissions decreased, the percentage contribution of the cold start was observed to increase. Finally, for emission tests on engines equipped with catalysts, the cold start test dominates total HC emissions, and becomes a greater percentage of total CO emissions. This finding is nothing new or surprising: all testing on catalyst-equipped vehicles substantiate the importance of the cold start on the emissions of gasoline-fueled vehicles.

The implications of this data are clear. For current and future technology heavy-duty gasoline-fueled engines (HDGEs), the cold start is not only significant for HC and CO emissions, in the future it will become the dominant source of HC emissions. This conclusion was challenged to some extent by the gasoline engine industry. Emissions data from prototype 1985 engines were submitted which indicated that the cold start had very little effect on total emissions. However, these data were collected on engines with cold start emission control; without a cold start test, such control would not be necessary and cold engine emissions would again be significant.

EPA continues to believe that the cold start test is critical for accurate characterization of HDGE emissions, and should be retained.

Cold Start Weighting

In the "Summary and Analysis of Comments to the NPRM: 1983 and Later Model Year Heavy-Duty Engines, Proposed Gaseous Emission Regulations" (December 1979), EPA showed that the average percentage cold operation observed in the CAPE-21 study for gasoline trucks was 5.5 percent and that for diesel trucks it was 4.3 percent. These values were developed from the median number of trips per day per truck (4.43 for diesels and 9.06 for gasoline), and the median time of each trip (26 minutes for diesels and 10 minutes for gasoline). EPA also assigned a cold operating period of five minutes only to the first trip of the day, thereby treating all other trips as hot start trips. (In practice, some of these other trips will be started from temperatures colder than fully warmed-up because of engine cooling between trips.) The Summary and Analysis of Comments document went on to determine the percentage of cold operation during the cold start portion of the test and compared these results to the CAPE-21 data. During the cold start segment of the test, cold operation was calculated to be 3.7 percent for gasoline engines and 3.6 percent for diesel engines. Based upon the comparison of the test cycle's percentage of time in cold operation to that of the CAPE-21 data, EPA concluded that the test slightly understated the on-road condition.

In recent comments, both EMA and the gasoline engine manufacturers have disputed the derivation and values of EPA's weighting factors. Ford recommended a cold start weighting of 1/16 (.0625); EMA recommended a weighting of .03. The differences between EPA's and the industry's weighting factors are based upon two differences in assumptions:

1. EPA used median CAPE-21 values as the necessary parameters to calculate a cold start weighting, while the industry used mean values; and

2. The industry assumed that the entire cold start test cycle was "cold", (i.e., the engine did not warm-up) and continued to produce cold emissions during the entire 20-minute cycle.

EPA believes that its assumption in 1. above is more reasonable than the industry's; EPA also believes that the industry's assumption in 2. above is incorrect.

The truck population sampled in CAPE-21 was highly diverse. Any given parameter, especially those used to determine the cold start weighting, was decidedly non-normal (see Figure 1.) In non-normal distributions, medians are far better indicators of central tendency (i.e., the "typical" truck). Means tend to be skewed by a small number of very different parameters. For this reason EPA's use of medians represents a more reasonable method of determining "typical" values.

Also, to hold that the engine remains cold during the entire cold start cycle is incorrect. Oil temperature data gathered by EPA, and EMA's own test data indicate that the engine reaches a warmed-up state somewhere between 5 and 10 minutes into the test. In other words, emissions during the remaining portion of the cold test cycle are no different than those of the warmed-up hot cycle, and for this period of time the weighting factor value is irrelevant. If we assume that the first five minutes, or 300 seconds, of the 1,199 second diesel test cycle are actually cold, then 300/1,199 or 25.0 percent of the cycle is cold. Since the entire cold cycle is then weighted by 1/7, the cold engine emissions are actually weighted by 1/7 x .250, or 3.6 percent of the total test result. If we continue to make the assumption that the engine warms-up in the first five minutes of operation, as did EPA when it derived its original weighting factors, we find that the percentage of cold operation in the test cycles are 3.6 percent for diesels and 3.7 percent for gasoline-fueled engines. If a 5-minute warm-up is similarly assumed for the first trip of the day from the CAPE-21 data, the actual percentages of on-road time spent with a "cold" engine are 5.5 percent for gasoline-fueled engines and 4.3 percent for diesels.

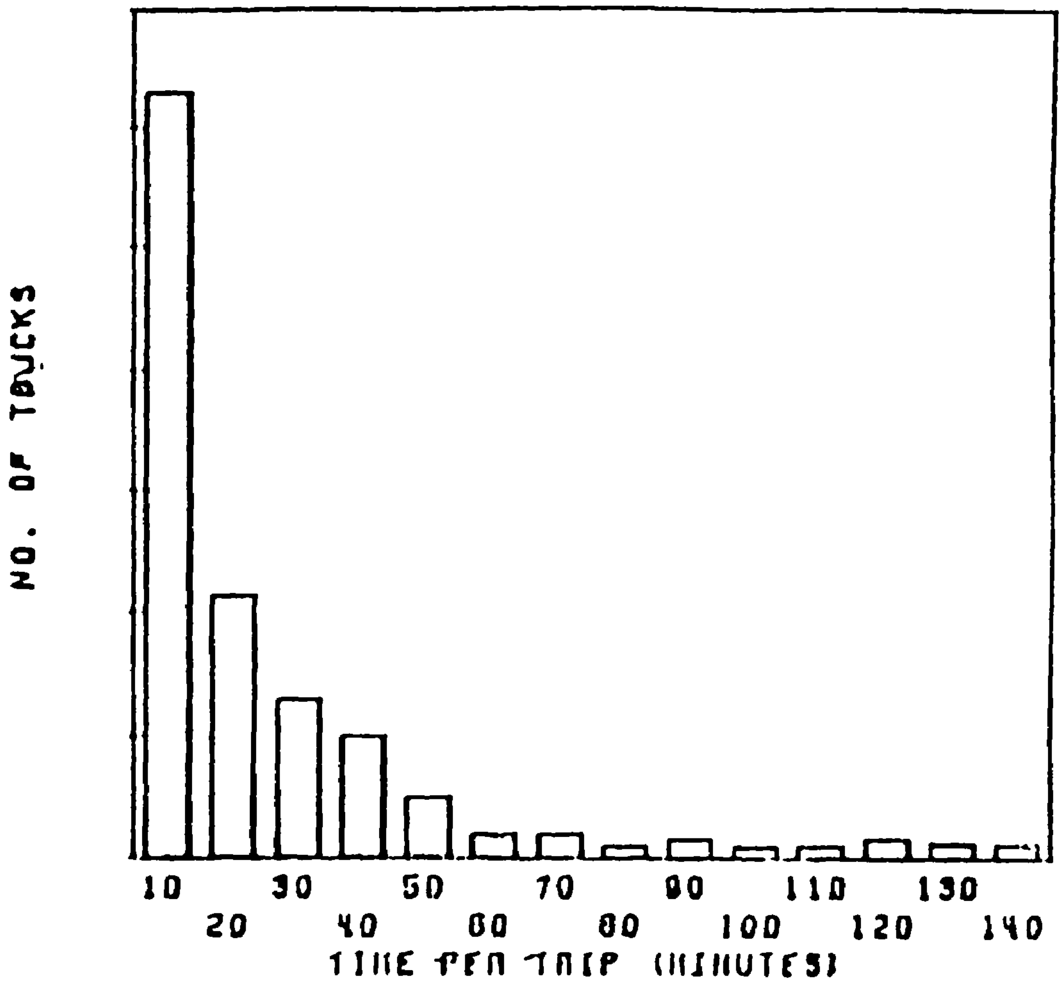
In summary, EPA cannot agree that the present cold start weightings are unrepresentatively high; if anything, they might understate those observed in CAPE-21.

Conclusions

1. The cold start requirement for both gasoline and diesel-fueled HDEs will be retained.

Figure 1

TIME PER TRIP DENSITY FUNCTION FOR NY GASOLINE



2. The present 1/7 cold start weighting will be retained.

3. Diesel engine manufacturers may report only hot start data when making application for certification. For confirmatory, SEA and recall testing, however, EPA will retain the option of using either the hot start or cold start tests; the cold start test will be retained as the official test.

8. Issue: Diesel Engine CO Measurement

Summary of the Issue

Measurement of CO emissions is currently required for all regulated vehicles and engines, including HDDEs, during both certification and SEA testing. All of the comments received on this issue were in agreement: the CO emissions of HDDEs are so far below all applicable standards, current and proposed, that any requirements for HDDE CO measurements are unnecessary and should be deleted.

Summary of the Comments

All of the commenters referred to the very low CO emissions of HDDEs, exemplified by the mean CO level of 3.27 g/BHP-hr for all 1981 model year certified HDDEs, less than one-sixth of the 25 g/BHP-hr standard applicable under the 13-mode test. The cost savings to the manufacturers resulting from deletion of the diesel CO test requirements are estimated at $20,000 annually per manufacturer by Mack and EMA. Cummins estimated that deletion of these requirements would result in a 25 percent annual reduction in their equipment, maintenance, and storage costs. Several manufacturers noted that valuable laboratory test time would also be made available if the CO test requirements are deleted for HDDEs.

The manufacturers also indicated that they feel that the deletion of diesel CO test requirements should be completed as soon as possible, rather than awaiting the final implementation of the transient test procedure as was originally proposed.

All of the manufacturers commenting noted that since HDDE CO emissions are inherently so low, they had no substantive comment on the proposed revisions to the level of the standard.

Analysis of the Comments

As was noted in several of the comments, EPA has already agreed to delete all certification and SEA CO measurement requirements for HDDEs. This action has been implemented through technical amendments to the regulations. Revision of the diesel CO measurement requirements took effect as soon as those amendments were issued (47 FR 49802, November 2, 1982). This action is appropriate as a regulatory relief measure, and is not expected to have any negative air quality impact.

Conclusion

No further action is necessary, since the requested changes have been made.

9. Issue: Parameter Adjustment

Summary of the Issue

The original FRM (45 FR 4136, January 21, 1980) contained regulations describing the parameters subject to adjustment during certification and SEA testing. Few comments were received on this issue. The only significant concern of the manufacturers appeared to be the possibility of manual choke settings being subject to the parameter-adjustment regulations.

Summary of the Comments

Two of the three manufacturers commenting indicated concern over the possibility that, under a strict interpretation of the current rules, the Administrator could require manual chokes to be adjusted over the full range of their authority during certification and SEA testing. The operation of a manual choke should not be confused with tampering, one manufacturer noted. A slight revision to the wording of §86.084-22(e)(1)(i) was suggested by the second manufacturer as a means of removing any ambiguity concerning the applicability of the parameter-adjustment regulations to manual chokes.

One manufacturer noted that EPA had previously determined that the parameter-adjustment regulations do not apply to idle speed or to ignition spark timing. The comment suggested that references to these two parameters be deleted from §86.084-22(e)(1)(i) in accordance with this determination.

Analysis of the Comments

EPA agrees that the manual choke should not be considered a parameter in the context of the parameter-adjustment provisions. While a manual choke is clearly an adjustable parameter, its operation is governed by Subpart N test procedure provisions and therefore manual chokes were not included in the list of adjustable parameters of §86.084-22(e)(1)(i). In fact, to add manual chokes to that list would require public notice and comment plus a minimum of two years of leadtime. Inclusion of choke operation under Subpart N is based upon viewing a manual choke as an operating control (as are, for example, shift points on a manual transmission) rather than a parameter subject to the parameter-adjustment provisions. EPA believes this is the appropriate approach.

EPA also believes that to subject manual chokes to the parameter adjustment provisions would in effect prohibit their use. At this time, EPA has no evidence of systematic improper use of chokes on HDEs to justify such an action. In addition, it is likely that as future emission reductions are required, manual chokes will gradually be phased out of use by manufacturers (similar to what has already happened for LDVs).

Concerning the request to delete idle speed and ignition spark timing from the regulations, the Agency has already taken the necessary steps to implement its findings that these two parameters need not be adjusted. Manufacturers were notified by two letters that these parameters would not be subject to adjustment under the parameter-adjustment requirements.[1,2] Since the list of parameters in §86.084-22(e)(1)(i) is discretionary rather than mandatory, EPA sees no need to make changes to the regulations.

Conclusions

In order to eliminate any possible ambiguity over the adjustment of manual choke settings during certification and SEA testing, EPA has decided to add a new paragraph §86.085-22(e)(1)(iv) to read, "Manual chokes will not be considered an adjustable parameter for HDEs subject to adjustment under this paragraph." In addition, EPA will revise paragraph §86.085-22(e)(1)(i) to read, "Except as noted in §86.085-22(e)(1)(iv), the Administrator may determine...." EPA has also decided not to change the references to idle speed and ignition spark timing in §86.085-22(e)(1)(i).

References

1. EPA Memorandum From Michael P. Walsh, OMSAPC, To Light-Duty Vehicle and Heavy-Duty Engine Manufacturers, August 22, 1980.

2. Deletion of Spark Timing Parameter Adjustment Requirement, EPA Memorandum From Michael P. Walsh, OMSAPC, To Light-Duty Vehicle, Light-Duty Truck and Heavy-Duty Engine Manufacturers, October 28, 1980.

10. Issue: Potential Impacts on Specific Manufacturers

Summary of the Issue

Several commenters claimed that even though EPA has proposed revisions to many of the 1984 HDE requirements, these provisions may still cause substantial harm to the industry. The impact of these revised regulations on the HDGE manufacturers' future product offerings and financial situations, based on the comments received, are discussed in this section. The impact of the rule on Chrysler is considered separately from the impact on the other manufacturers.

Summary of the Comments

Chrysler Corporation

In its initial submission to the docket, Chrysler indicated that it was planning to withdraw from the HDGE market in the near future. At that time, Chrysler stated that the potential profitability of the HDGE market in the 1980's was thought to be insufficient to justify directing scarce capital resources into the development of the necessary transient test facilities and the development of HDGE emission control systems capable of meeting the revised standards. More recent comments received from Chrysler indicate that, based on the improving financial condition of the corporation and a reassessment of the profit potential of manufacturing HDGEs, it is now planning to remain in the market.

However, these recent comments also include several reservations that Chrysler continues to have concerning the regulatory requirements. Primary among these is the claimed inability of Chrysler to develop transient test capabilities for at least three years. For this reason, Chrysler suggests the creation of a "small-volume manufacturer" category, defined as any HDGE manufacturer building only engines that are derived from passenger car engines; and that such "small-volume manufacturers" be allowed to certify under the steady-state procedure for up to three more years.

In its comments, Chrysler preliminarily rejected two additional options (beside the extension of the steady-state test option) that are available for compliance with these regulations. First, vehicles up to 10,000 lbs. GVWR and equipped with HDGEs may now be certified, at the manufacturer's discretion, to LDT emission standards under the light-duty chassis test procedure (FTP). During the public hearings, EPA asked Chrysler representatives whether an increase in the 10,000 lbs. maximum, for example to 11,000 lbs., would make it easier for Chrysler to take advantage of this certification option. Its answer was no; Chrysler does not currently plan to certify any of its 1984 vehicles in the 8,500-10,000 lbs. GVWR range as LDTs, and in its opinion, increasing the upper bound of this range offers no meaningful relief. The second option, to use outside engineering services to conduct transient testing and certification, was rejected by Chrysler on the basis of excessive cost and insufficient leadtime remaining before scheduled compliance.

In response to EPA's inquiry as to what would constitute an appropriate level for steady-state test emission standards, in the event that this procedure is allowed as an option to the transient test, Chrysler maintained that the present standards cannot be made more stringent if engines without catalysts are to meet them. It went on to state that with additional development it may be possible for Chrysler to meet the current steady-state standards without catalysts, but that the present standards appear to be at the limit of non-catalyst emission control technology. Chrysler does not feel that the 1984 California emission standards (0.5 HC, 25 CO, 4.5 HC+NOx) can be met on a steady-state test without catalysts.

Chrysler also noted that it is the only manufacturer now using catalysts on its HDGEs (5.2L and 5.9L engine families), a decision that was made on the grounds that development costs and manufacturing complexity would be minimized. Chrysler maintains that it is confident that "real-world" emissions from these engines are low; thus, it claims it is ironic that the proposed revisions to these rules, intended to make it possible to certify HDGEs without catalysts, may result in Chrysler being forced to withdraw from the market.

Other Commenters

In addition to Chrysler, comments on the potential impact of these rules were also submitted by IHC, American Motors Corporation (AMC), and the National Association of Van Pool Operators (NAVPO). These comments are summarized below.

International Harvester Corporation has already made public its intention to abandon the HDGE market when the revised HDGE regulations take effect, after which it will only manufacture HDDEs. This decision was based primarily on the rapid and continuing decline in the demand for HDGEs, although IHC noted that the implementation of a transient test procedure was a contributing factor. If these regulations were to take effect for the 1984 model year, as originally planned, IHC would leave the HDGE market at the end of the 1983 model year. Therefore, IHC has requested that the effective date of these regulations be delayed until the 1985 model year, thereby allowing it to plan a more orderly withdrawal from the HDGE market.

American Motors Corporation noted that it has not certified any HDGEs in recent years; however, Renault is planning the introduction of both HDGEs and HDDEs to the medium-duty truck market over the next few years. AMC does not have, or plan to acquire, transient test capabilities, but it will be responsible for the certification of the Renault HDGEs when they are introduced. Therefore it intends to contract for this work, although it expressed some concern over the availability of and competition for independent laboratory time. Given this background information, AMC requested that the implementation of the 1984 HD standards and test procedures be delayed until 1985, and that EPA "...consider waivers for low-volume (less than 10,000 units) domestic manufacturers."

The National Association of Van Pool Operators' comments were concerned entirely with the potential impact of these rules on the manufacturers' product offerings. They expressed concern over the possibility that the 12- to 15-passenger vans that are most economical for van-pooling programs may no longer be available if the emissions regulations applicable to them are strengthened. A later conversation between EPA and a representative of NAVPO revealed that their concern is focused on the larger passenger vans manufactured by the Chrysler Corporation.

Analysis of the Comments

Chrysler Corporation

As noted in the summary of Chrysler's comments, Chrysler has decided to remain in the HDGE market. This decision must have been based on the improving financial condition of the company, as well as the belief that the profit potential of HDGE manufacturing in the 1980's will be sufficient to justify the necessary capital expenditures. The significant stabilization of gasoline prices late in 1981 and in 1982, and the 1-year delay in the effective date of these regulations, may also have contributed to Chrysler's reevaluation of its decision.

EPA has estimated that the capital costs to Chrysler for transient test facilities, plus additional engineering costs for facilities checkout and engine development, would total approximately $2.9 million in 1982 dollars. Considering that Chrysler, in its first and second quarterly reports, showed profits of $256.8 million for the first six months of 1982, it appears that it currently has liquid assets adequate to underwrite this investment. While recognizing that the firm currently has major debt servicing obligations, and that therefore not all of these recent profits are available for capital expenditures, EPA can only conclude that Chrysler is capable of making these investments, given the decision by management to do so.

Chrysler maintains that it will be unable to develop in-house transient test capability for three years. It has preliminarily rejected the options of contracting with independent laboratories for the development and testing required during the next three years, and of certifying its HDGE vehicles under 10,000 lbs. GVWR to LDT emission standards. Claiming that both of these options are unacceptable, it requests that a "small-volume" category of HDGE manufacturers, defined so as to include Chrysler, be allowed to certify HDGEs under the steady-state test for the next three years. The implication is that Chrysler may not remain in the HDGE market unless such an exemption is granted.

Chrysler's position on whether to continue to compete in the HDGE market is primarily a business decision. The 1984 HDGE emission regulations have been discussed in the public forum for more than four years, and should have been taken into account in any earlier decisions by Chrysler regarding its HDGE manufacturing operations. Other affected manufacturers have made the capital investments necessitated by these rules (Ford, GM), or have determined that it is more economical for the work to be performed under contract (AMC), or have decided that the profit potential of the HDGE market is insufficient to justify further capital expenditures in this area (IHC). These decisions have been based on business considerations, as Chrysler's eventual decision should be. EPA notes that it appears that Chrysler could now afford to pursue either of the options discussed above, which it has preliminarily rejected, and thus that it has three approaches to meeting the requirements of these rules available to it.

In its comments, Chrysler also noted it has elected to equip two of its three current HDGE families (5.2L and 5.9L) with catalysts "...in order to minimize development costs and manufacturing complexity." While it might be ironic for the only HDGEs currently equipped with catalytic emission controls to be forced from the market by rules designed to negate the necessity of catalysts, EPA does not feel that this will be the case. Since production and sales of these catalyst-equipped engines has continued while other HDGE manufacturers did not use catalysts, the cost disadvantage resulting from catalyst use must be relatively small. Additional development work, aimed at improving the emission characteristics of Chrysler's

HDGEs, will have to be conducted if Chrysler really wishes to remain in the market.

Since Chrysler has decided that its position in the HDGE market warrants the decision to stay in that market, it must be willing to commit the necessary resources to the development of transient test facilities and improvement of its HDGE line. EPA cannot justify granting what would amount to a 3-year delay in the effective date of these regulations to some, but not all, HDGE manufacturers. This is particularly true since other firms, as noted above, have undertaken the investments required by these regulations, and since the financial condition of Chrysler has now improved. In addition, the 1-year delay in the effective date of these rules provides Chrysler (and the other manufacturers) additional time for compliance.

Other Comments

The major interest of IHC is that the effective date of these HDGE regulations be delayed for an additional year, so that its planned withdrawal from the market may proceed in an orderly fashion. Due primarily to leadtime considerations, this is being done. As was indicated by IHC, its decision to withdraw from the HDGE market was made more on the basis of financial considerations than on the effect of these regulations.

The position of AMC with respect to the certification of HDGEs manufactured by Renault is recognized as the basis for its decision to contract with independent laboratories for this work. As noted previously, the effective date of these standards is being delayed until the 1985 model year, as desired by IHC and AMC. However, AMC's request that EPA consider waivers for "low-volume domestic manufacturers" is unclear. Historically, EPA has rejected requests for waivers from the use of applicable test procedures, and EPA sees no other suitable way to determine compliance. On the other hand, waivers from durability testing requirements and certain other certification procedures have been granted in the past and would be available in this context. These waivers are available to manufacturers whose combined U.S. sales of LDVs, LDTs, and HDEs are under 10,000 units.

The National Association of Van Pool Operators' concerns about the availability of 12- to 15-passenger vans under the new regulations appear to be groundless. The only manufacturer of such vehicles that was considering dropping out of the HDGE market as a result of these regulations (Chrysler) has decided to remain, as noted above. Aside from that decision, none of Chrysler's passenger vans are currently certified as HDGEs--all are less than 8,500 lbs. GVWR--and so these rules should have no effect on the continued production of these vehicles.

Conclusions

For the reasons discussed in the preceding analysis, EPA does not feel that allowing Chrysler (or any of the other manufacturers) to use the steady-state test rather than the transient test for the next three years can be justified. Therefore, EPA rejects the "small-volume manufacturer" exemptions proposed by Chrysler and AMC.

The concerns of IHC about being able to plan its withdrawal from the HDGE market in an orderly manner, and of AMC about having adequate time to plan and contract with independent laboratories, are addressed by the delay in the effective date of these rules until the 1985 model year.

The concerns expressed by NAVPO are unfounded. EPA has decided not to make further changes in these rules based on the comments received from NAVPO.

11. Issue: Transient Test Procedure - Technical Details

Summary of the Issue

On June 17, 1981, EPA solicited manufacturers for information regarding operational aspects of running the transient test (46 FR 31677). On January 13, 1982, EPA reopened for comment all aspects of the transient test as part of the proposed revisions to the 1984 requirements.

In their comments, the heavy-duty industry recommended that large numbers of technical amendments be made to the transient test procedure. These amendments were justified as necessary on the basis of technical merit and cost reduction.

EPA has also recognized the need to modify specific sections of the transient test. This has become apparent as more actual testing exerience was gained by both EPA and the industry.

Summary and Analysis of the Comments

Each comment and technical amendment is not significant enough to justify devoting an individual section to its discussion. Collectively, the amendments represent a clarified, streamlined, and technically improved test procedure.

The format for this discussion will be a section-by-section breakdown of the transient test procedure (Subpart N). Specific modifications will be noted, as will the rationale for the changes. Note that some technical amendments were requested by industry, while others are being made by EPA's initiative.

Also note that some technical amendments were necessary in the heavy-duty diesel engine smoke test procedure (Subpart I) and the heavy-duty gasoline engine and light-duty gasoline truck idle test procedure (Subpart P). A list of these changes will follow those of the transient test procedure.

A. Subpart N - Transient Test Procedures for 1984 and Later Model Year Heavy-Duty Gasoline and Diesel Engines

Overview of Technical Amendments

Large numbers of technical amendments are being made to the transient test procedure.

In general, amendments have been made to correct errors and omissions, to clarify requirements, to minimize prior approvals by the Administrator for inconsequential deviations from the existing procedures, and to reduce costs associated with running the test.

All changes except corrections of typographical errors are listed below.

Specific Technical Amendments

The following sections from 40 CFR Part 86 are being amended:

§86.1308-84(a) Torque and speed accuracies rereferenced. Eliminated need for Administrator's approval for using dynamometer currents for torque measurement.

Most accuracies within the test procedure were respecified to provide greater traceability to NBS standards. Also, several manufacturers have developed methods for using dynamometer currents as surrogates for direct torque measurements; EPA is reasonably convinced that the techniques are technically acceptable and need not have advance EPA approval.

§86.1308-84(b) Torque cycle verification equipment accuracy changed from ±3 percent to ±2 percent (to equal speed cycle accuracy).

Torque cycle accuracy was changed to be comparable to that required for speed, to correct an earlier oversight.

§86.1308-84(e) Clarification of dynamometer calibration procedures, and rereferencing of accuracies.

Existing dynamometer calibration procedures were unclear, and required procedural clarifications. No substantive technical changes have been made. Again, accuracies were rereferenced to provide greater traceability to NBS standards.

§86.1308-84(f) Added specification for mass fuel flow measurement device for diesel engines.

The option for direct measurements of mass fuel flow for diesel engines was added; this addition required inclusion of an accuracy specification for the flow measurement equipment.

§86.1309-84(a)(5) Clarified required degree of compliance with analytical system schematic.

This change represents a simple clarification of minor deviations which are allowable under the existing equipment specifications. Previously, there was some uncertainty within the industry as to what deviations would be acceptable to EPA.

§86.1309-84(b)(1) and (c)(1) Clarified rationale and means of verifying that CVS-induced pressure variations on the exhaust system are not excessive.

Both the rationale for and the means of verifying this specification were questioned by the industry; this procedural change clarifies both the intent and the procedure itself.

§86.1309-84(b)(2) Rereferenced CVS gas mixture temperature accuracy from the temperature at the start of the test to the average operating temperature during the test.

This is a minor change, simply changing the reference temperature against which the temperature excursions of the dilute exhaust are measured. Because the temperatures during a test never go below the temperature at the start of the test, the previous specification was actually twice as stringent as needed be.

§86.1309-84(c) Clarified sensor accuracy requirements to include the signal transmission and readout equipment.

This amendment corrects a previous omission, and more correctly includes all sources of equipment error within required accuracy specifications.

§86.1309-84(c)(2) Relaxed temperature measurement system response time from 0.100 to 1.50 seconds; eliminated response time requirement for CVS equipment with heat exchange.

This response time relaxation reflects the uncertain commercial availability of fast-responding temperature sensors for CFV-CVSs. CVSs with heat exchangers do not require temperature sensors with fast response characteristics, and are thus exempted from the response time specification.

§86.1310-84(a) Permitted measurement of mass fuel consumption in lieu of CO_2 exhaust measurement. Clarified general sampling system requirements.

This option, requested by EMA, permits a manufacturer to measure mass fuel consumption in lieu of CO_2 exhaust concentration. Either of the two measurements is acceptable for calculation of exhaust emissions, however, the equipment for measuring mass fuel flow is much less expensive to procure and maintain. In addition, general sampling system requirements were clarified where ambiguous or misinterpreted by the industry.

§86.1310-84(a)(5) Clarified required degree of compliance with analytical system schematics.

The industry requested clarification of the degree of compliance which EPA requires for components of the exhaust analytical system. Specifically, minor deviations in equipment components are permitted; many of these deviations are indicative of the different equipment a manufacturer may use.

§86.1310-84(b)(2)(iii) Rereferenced CVS gas mixture temperature accuracy from the temperature at the start of the test to the average operating temperature during the test.

This is a minor change, simply changing the reference temperature against which the temperature excursions of the dilute exhaust are measured. Because the temperatures during a test never go below the temperature at the start of the test, the previous specification was actually twice as stringent as needed be.

§86.1310-84(a)(3) Removed requirements for Administrator approval for use of continuous sampling systems.

Many diesel engine manufacturers are already using continuous sampling systems, the viability of which have been demonstrated in EPA/EMA correlation programs. The test procedure already contains generalized specifications for continuous sampling systems; EPA feels that these are sufficient to guarantee correlatable test results, without the unnecessary step of requiring advance EPA approval.

§86.1310-84(b)(3)(i) Revised HC "overflow" technique to be an optional calibration, but mandatory zero and span check of the sampling system.

EPA's earlier requirement that the HC emissions analyzer be calibrated through the overflow system has been changed; calibration will now take place at the analyzer ports, with zero and span checks still being made through the overflow system. EPA believes that the revision is more technically correct, consistent with light-duty practice, and still adequately permits the identification of potential hang-up problems.

§86.1310-84(b)(3)(ii) Included provision for use of a single sample line.

The industry requested this change, and suggested wording which allowed only the use of a single sample pump. EPA's earlier requirement that different analyzers use different sample lines was based upon concern about potential errors arising from pressure fluctuations induced by more than one sample pump. The revised wording as suggested by the industry satisfies EPA's concern, and has been incorporated into the test procedure.

§86-1310-84(b)(3)(iii) Reduced HC "overflow" gas flow rate to at least 105 percent.

The earlier version of the test procedure required excessive overflow gas flow rates; the industry argued that this was wasteful of calibration gases, and that any quantity of gas greater than 100 percent total flow was sufficient. EPA concurs with this observation.

§86.1310-84(b)(3)(v)(A) Eliminated requirement that gaseous HC probe point only upstream.

The industry requested this modification because probes pointing upstream are susceptible to contamination by large particles (for example, collected particulate matter intermittently shaken off the walls of the exhaust system, engine parts, etc.). Exhaust gas flow is sufficiently isokinetic to allow the probe to point in any direction without impacting the accuracy of the measurement of gas concentration.

§86.1310-84(b)(3)(v)(C) Eliminated specific insulation requirement as the only means of maintaining sample probe wall temperature.

Measurement system integrity requires that the wall of the HC sample probe be maintained at a sufficiently high temperature. EPA's earlier requirement specifically dictated how that temperature was to be maintained; the revised test procedure simply requires that the temperature be maintained, and leaves the method of temperature maintenance to the discretion of the manufacturer.

§86.1310-84(b)(3)(vi) (A) and (B) — Clarified sensor accuracy requirements to include signal transmission and readout equipment.

This amendment corrects a previous omission, and more correctly includes all sources of equipment error within required accuracy specifications.

§86.1310-84(b)(3)(vi) (C) — Eliminated.

This paragraph was redundant, served no purpose to the test procedure, and was eliminated.

§86.1310-84(b)(3) (vii)(B) — Increased analyzer response time from no greater than 5.5 to no greater than 20.0 seconds.

The industry recommended this change, providing data that sampling system response times up to 20 seconds yielded equivalent emission results. EPA's original response time requirement reflected primarily a concern that the integrity of longer sample lines is more difficult to maintain, especially if heated. EPA believes, however, that sufficient requirements already exist within the test procedure for sample line heating, leak checks, and zero and span checks, in addition to the verification provided by the industry data, that increasing the sample system response time will not adversely affect test accuracy. In addition, the allowance of longer sample lines (by allowing greater system response times) gives the manufacturer much greater flexibility in modifying existing dynamometer cells for running the transient test.

§86.1310-84(b)(4) (ii)(F) — Eliminated requirement that gaseous HC probe point only upstream.

The industry requested this modification because probes pointing upstream are susceptible to contamination by large particles (for example, collected particulate matter intermittently shaken off the walls of the exhaust system, engine parts, etc.). Exhaust gas flow is sufficiently isokinetic to allow the probe to point in any direction without impacting the accuracy of the measurement of gas concentration.

§86.1310-84(b)(5)(ii)(B) Increased analyzer response time from from 5.5 to 20.0 seconds.

The industry recommended this change, providing data that sampling system response times up to 20 seconds yielded equivalent emission results. EPA's original response time requirement reflected primarily a concern that the integrity of longer sample lines is more difficult to maintain, especially if heated. EPA believes, however, that sufficient requirements already exist within the test procedure for sample line heating, leak checks, and zero and span checks, in addition to the verification provided by the industry data, that increasing the sample system response time will not adversely affect test accuracy. In addition, the allowance of longer sample lines (by allowing greater system response times) gives the manufacturer much greater flexibility in modifying existing dynamometer cells for running the transient test.

§86.1311-84(a) Clarified required degree of conformance with analytical system schematic.

The industry requested clarification of the degree of compliance which EPA requires for components of the exhaust analytical system. Specifically, minor deviations in equipment components are permitted; many of these deviations are indicative of the different equipment a manufacturer may use.

§86.1314-84(g) Allowed use of gas dividers, subject to accuracy requirements of ±1.5 percent of NBS gas standards.

Gas dividers were permitted under the old test procedure; however, accuracy specifications for their use were never provided, creating uncertainty within the industry as to what EPA actually required. This technical amendment corrects that omission by providing gas blending accuracy specifications.

§86.1316-84(c)(3) Added weekly check (not mandatory calibration) of torque feedback signals at steady-state operating conditions.

EPA believes that this procedural modification is easily performed, and reflects good engineering practice; this amendment is therefore made part of the test procedure.

§86.1318-84(b) Added required electronic check and adjustment of torque feedback signal before each test.

EPA believes that this procedural modification is easily performed, and reflects good engineering practice; this amendment is therefore made part of the test procedure.

§86.1319-84(a) Defined flowmeter traceable to NBS as a reference standard for CVS calibration; removed need for Administrator's approval.

EPA believes that any flowmeter traceable to NBS standards which conforms to EPA's accuracy specifications is technically acceptable, and does not require advance approval by EPA for its use.

§86.1319-84(c)(2)(i) Eliminated pump pressure tap specifications.

This part of the original test procedure was drafted verbatim from light-duty vehicle test procedures; in fact, this procedure is outdated, and is removed from the test procedure by EPA inititive.

§86.1319-84(c)(4) and (d)(3) Changed accuracy tolerances for measurements of barometric pressure (from ±.01 inches Hg to ±.10 inches Hg), pressure head at CVS pump outlet and inlet depression at CVS pump inlet (from ±.05 inches fluid to ±.13 inches fluid), and elapsed time for test (from ±.05 seconds to ±.5 seconds). Changed air temperature measurement tolerances from ±0.5°F to ±2.0°F for PDP-CVS, and from ±0.5°F to ±4.0°F for CFV-CVS.

EMA submitted data and calculations which argued that relaxed calibration accuracies would not impair overall test accuracy. The requirements that these measurement accuracies be very stringent necessitated the use of very accurate but very expensive calibration equipment. EPA has reviewed EMA's calculations, and agrees that no net impact on test accuracy would be incurred. In fact, the requirement for CVS system verification using propane will still serve as an overall system check. For these reasons, EPA accepts EMA's recommendations and relaxes the tolerances.

§86.1319-84(d) Added missing sections from light-duty CVS calibration procedure, but deleted correlation function between pump RPM and pressure differential.

During drafting of the original test procedure, several paragraphs were inadvertantly deleted; these paragraphs were substantially similar to CVS calibration procedures applicable to light-duty vehicles. These paragraphs have now been restored, with the exception of a single but unnecessary correlation function.

§86.1319-84(e)(1) Eliminated carbon monoxide as a recommended CVS verification gas.

Both EPA and industry use propane as a CVS verification gas; propane is adequate for all verification purposes. Given the adequacy of propane, and the risk to safety associated with the use of carbon monoxide, EPA no longer recommends its use.

§86.1319-84(e)(4) Corrected density of propane to 17.30 g/ft^3.

This is a minor numerical correction that makes the heavy-duty test procedure consistent with light duty.

§86.1321-84(b) Clarified requirements for HFID analyzer calibration.

This technical amendment eliminates the requirement for overflow calibration of the analyzer; the exact analyzer calibration procedure is reworded to reflect this change.

§86.1324-84(c) Permitted use of span gases for CO_2 analyzer calibration.

Span gases are "named" to a lesser degree of accuracy than calibration gases, and for this reason, calibration gases have always been used to maximize accuracy of analyzer calibrations. EMA has provided evidence that slightly less accurate calibration of the CO_2 analyzer will not affect overall test results. (CO_2 emissions measurements are used only to calculate overall dilution factor and fuel consumption.) EPA concurs with EMA's analysis, and specifically allows use of span gas for the CO_2 analyzer calibration.

§86.1327-84(d)(4) Eliminated prior approval of Administrator for inclusion of engine accessories.

Since the heavy-duty transient test is based upon normalized engine parameters, EPA is no longer concerned about parasitic effects of engine accessories. EPA therefore allows their inclusion on certification engines if the manufacturer so desires, without the requirement for advance EPA approval.

§86.1327-84(d)(5) Eliminated mandatory use of production starter.

The earlier test procedure required the use of a production starter motor at the beginning of the transient test sequence. The industry has argued for some time that this represents an unnecessary test burden. EPA no longer believes that use of a dynamometer to start the engine will significantly impact overall test results, especially since the dynamometer will be required to simulate the characteristics of a production starter.

§86.1327-84(f) Clarified and modified exhaust system requirements.

Significant clarifications to exhaust system requirements for diesel engines have been made. Specifically, use of a facility exhaust system in lieu of a chassis-type exhaust system has been required. This change has been made to provide uniformity with future exhaust system requirements which will be necessary for the measurement of particulates.

§86.1330-84(a)(1) Permitted dilution air temperatures above 86°F.

This change has been made to accommodate problems several manufacturers were having in maintaining a CVS dilution air temperatures below 86°F, especially in the summer months. Rather than force the installation of expensive air cooling equipment, EPA is eliminating the upper temperature limit of the CVS dilution air temperature. EPA does not believe that this will have any impact on test results. (Note that the dilution air temperature can readily exceed 200°F when mixed with engine exhaust.)

§86.1330-84(a)(3) Permitted test cell and engine intake air to exceed 86°F if no temperature dependent auxiliary emission control devices are used.

This modification applies almost certainly to diesel engines only, and will preclude the installation of expensive air handling and temperature conditioning equipment where such equipment is not necessary.

§86.1330-84(b) Eliminated need to control test cell, engine intake, and CVS dilution air humidity.

EPA is specifically providing the use of a humidity correction factor for both gasoline and diesel engines; for this reason, control of humidity during the test sequence is no longer necessary or required.

§86.1330-84(e) Specified inlet and exhaust restrictions for diesel engines, both naturally aspirated and turbocharged.

This technical amendment represents a clarification of earlier requirements, and was recommended by EMA. This amendment constitutes no net change in the test procedure.

§86.1330-84(f) Clarified pre-test procedures.

This amendment specifically addresses when certain operational checks of the engine and other procedural steps may be performed during the test sequence.

§86.1332-84(b) Minimum mapping speed redefined as curb idle speed.

This technical amendment eliminates the need to map the engine below idle speed. This eliminates engine and equipment stresses associated with running the engine at full load at very low speeds. No compromise in test accuracy is incurred, because very few of the engine speeds required during transient testing actually lie below idle.

§86.1332-84(d)(2)(vii) Added ±20 rpm tolerance to 100 rpm mapping steps.

This accuracy tolerance was requested by Ford because EPA had provided no tolerance in the earlier test procedure.

§86.1332-84(d)(2)(x) and (d)(3)(viii) Added allowance for avoiding lengthy engine warm-up before mapping if the engine is already warm.

This technical amendment was requested by MVMA as a means of avoiding unnecessary warm-up required under the earlier test procedure. Since EPA's intent is merely that certain portions of the test be conducted with a warm engine, EPA is allowing that these portions of the test be conducted without warm-up, provided that certain engine temperature specifications are met.

§86.1332-84(d)(3)(iv) Eliminated mandatory 10-minute minimum time for temperature stabilization.

EPA is eliminating this unnecessary requirement on its own initiative. That the engine temperature be stabilized is the only necessary criterion; if this criterion is achieved in less than 10 minutes, there is no need to maintain warm-up for the full 10 minutes.

§86.1332-84(e)(1) Added goodness of fit criteria for cubic spline technique.

MVMA requested this amendment, so that EPA would provide an accuracy specification where the original test procedure had failed to do so.

§86.1332-84(f) Removed requirement for Administrator approval for alternate mapping techniques based upon safety or representativeness criteria.

EPA is removing the requirement that alternate mapping techniques be approved in advance by EPA, if such techniques are in the manufacturer's judgment required to maintain test safety or representativeness. General guidelines for alternate mapping techniques are provided, along with the requirement that the specific mapping technique used be reported to EPA in the manufacturer's application for certification.

§86.1332-84(g) Added conditions under which remapping need not occur.

EPA has added this clarification because several manufacturers had misinterpreted the earlier test procedure to require that an engine be mapped before each and every test. This was never EPA's intent, nor EPA's test practice.

§86.1333-84(d)(3) Clarified point deletion allowances.

This technical amendment represents a clarification of earlier requirements.

§86.1333-84(f) Added clutch allowance.

EPA has specifically added to the test procedure the allowance to use a clutch during engine testing. The earlier procedure never specifically precluded the use of a clutch; indeed, EPA recommends its use in certain circumstances. Several manufacturers, however, had misinterpreted EPA's earlier procedure, and requested that EPA specifically address the use of a clutch to alleviate any uncertainty.

§86.1333-84(g) Added required method of calculating measured rated rpm, or usage of manufacturers' specified rated rpm, whichever is greater.

EPA is initiating this technical amendment. In testing practice, EPA has found this revised methodology to be less susceptible to errors induced by unusual engine mapping curves.

§86.1335-84(c)(1)(ii) Clarified requirements for cooling water temperature.

This correction of the forced cooldown procedure permits the cooling medium to temporarily exceed the required temperature limits at the very beginning of the cooldown, as is almost always observed.

§86.1335-84(c)(2)(ii) Clarified requirements for cooling air temperature.

This correction of the forced cooldown procedure permits the cooling medium to temporarily exceed the required temperature limits at the very beginning of the cooldown, as is almost always observed.

§86.1335-84(e) Clarified means of oil temperature measurement, and when direct forced cooling of engine oil is permitted.

This amendment clarifies the method of oil temperature measurement for the forced cooldown procedure. In addition, it specifically allows the use of direct cooling of engine oil for engines with displacements greater than 500 cubic inches. This reflects the difficulty in cooling very large engines using only air and the coolant water.

§86.1336-84(a) Allowed use of dynamometer for engine starting.

The earlier test procedure required the use of a production starter motor at the beginning of the transient test sequence. The industry has argued for some time that this represents an unnecessary test burden. EPA no longer believes that use of a dynamometer to start the engine will significantly impact overall test results, especially since the dynamometer will be required to simulate the characteristics of a production starter.

§86.1336-84(b)(2) Eliminated need for approval by Administrator of longer cranking times.

EPA is eliminating the need for prior Administrator approval for engine cranking times which are longer than nominal, but nevertheless typical of the engine.

§86.1336-84(b)(3) and (4) Eliminated need to report malfunctions during engine start to the Administrator.

EPA considers this to be an unnecessary requirement and eliminates it.

§86.1336-84(c) Clarified action to be taken during engine stalling.

This amendment represents a clarification of the earlier test procedure.

§86.1337-84(a)(10) and (21) Added requirement that sampling systems continue sampling until system response times have elapsed.

This amendment goes hand in hand with EPA's allowance for longer sampling system response times. This amendment assures that emissions generated by the engine are not lost at the very end of the test, as they would be if sampling systems with longer response times were shut down simultaneously with the engine.

§86.1337-84(b) Eliminated mandatory time increments for emission tests using more than one bag or mode.

EPA sees no need to require manufacturers to conform with specific time increments for modal analysis.

§86.1337-84(c) Added clarification of conditions under which an engine on which a void test was run may be recooled and retested.

This amendment represents a clarification of the earlier procedure.

§86.1338-84(a)(2) Added procedure for calibration below 15 percent of analyzer's full scale.

This procedure was requested by the industry to provide clarification of the specific conditions and applicable procedures for calibrating analyzers below 15 percent of full scale. This amendment represents no net change in procedure accuracy.

§86.1338-84(b)(1) Clarified permissible deviations from requirement that analyzer response remain between 15 and 100 percent of full scale.

This amendment represents a clarification of the earlier procedure, as requested by the industry.

§86.1340-84(a)(1) Clarified stability requirement for background sample response.

This amendment corrects an inadvertantly stringent specification contained within the original test procedure; a more reasonable stability requirement is promulgated.

§86.1340-84(a)(2) Eliminated need to store all ADC input; only an average integrated value need be stored.

This amendment corrects an overly burdensome requirement contained within the original test procedure. EPA now requires only that a manufacturer record a single emission value for a given test cycle, and not the second-by-second ADC output. (This is conceptually identical to the requirements imposed for bag sampling.)

§86.1340-84(d) and (e) Reorganized the procedures for clarity, and modified continuous HC sampling and hang-up check procedures.

This amendment represents a clarification of the original test procedure.

§86.1340-84(f) Changed hang-up check to include entire sample probe.

This technical amendment makes the hang-up check more technically correct, and better able to verify the integrity of the entire sample probe.

§86.1341-84(h) Added to address the handling of closed rack torque reference points in cycle validation. Clarified method of validation for BHP points when torque reference calls for motoring.

This amendment addresses the treatment of certain feedback points in the cycle performance regression analyses; these specific points and their treatment in the regressions were inadvertantly ignored in the original test procedure.

§86.1341-84 Figure N84-11 — Clarified regression analysis point deletions for diesels at closed rack; specifically allowed use of clutch. Original Figure N84-11 deleted, and original Figure N84-12 substituted in its place. Regression line tolerances clarified to represent a percentage of power-map values. An additional torque and power deletion added if closed throttle and torque feedback greater than torque reference

These amendments reflect clarifications, elimination of an unnecessary figure, and the inclusion of an additional point deletion allowance which EPA has determined to be appropriate.

§86.1342-84(c) — Corrected omission of humidity correction factor from flow compensated NOx measurement calculations.

This corrects an error in the earlier test procedure, and reflects EPA's provision of a humidity correction factor for diesel engines.

§86.1342-84(d)(3) — Added calculation for mass fuel flow to be used in approximating dilute exhaust CO_2.

This option, requested by EMA, permits a manufacturer to measure mass fuel consumption in lieu of CO_2 exhaust concentration. Either of the two measurements is acceptable for calculation of exhaust emissions, however, the equipment for measuring mass fuel flow is much less expensive to procure and maintain.

§86.1342-84(d)(5) and (6) — Added dilution factor calculation based upon approximated dilute exhaust CO_2. Specified humidity correction factors for diesel engines.

This additional calculation was necessitated by the allowance that mass fuel flow measurement be substituted for exhaust CO_2 measurement. In addition, the newly provided humidity correction factor for diesel engines is specifically included here.

§86.1342-84(i) — Added calculations for dry to wet exhaust concentration conversion, accounting for both dilution air humidity and approximate exhaust H_2O concentration.

This correction calculation was suggested by the EMA as an improvement. EPA concurs with their recommendation, and believes that the omission of this calculation from the earlier procedure was an error.

§86.1344-84(e)(6) Added requirement for description of mapping technique.

This requirement has been added by EPA to ensure that the manufacturers inform EPA in their application for certification if an alternate mapping technique has been used.

Appendix I(f)(1) An optional driving cycle for heavy-duty gasoline engines has been added.

(See Chapter 3.A.3 of this Summary and Analysis of Comments.)

B. Subpart I - Heavy-Duty Diesel Engine Smoke Test Procedure

Overview of Technical Amendments

The following sections from 40 CFR Part 86 (as printed July 1, 1982) are being superseded, and are hereby deleted:

Sections

86.877-1	86.877-13
86.877-2	86.877-14
86.877-3	86.879-5
86.877-4	86.879-6
86.877-5	86.879-7
86.877-6	86.879-8
86.877-7	86.879-9
86.877-8	86.879-10
86.877-9	86.879-11
86.877-10	86.879-12
86.877-11	86.879-13
86.877-12	86.879-14

The following sections are being added to 40 CFR Part 86 (as printed July 1, 1982). Aside from changes in references, specific allowances for the use of automated data collection equipment and electric dynamometers, and changes to permit consistency with Subpart N and other 1984 rules, no significant change distinguishes this procedure from earlier versions:

Sections

C. Subpart P - Heavy-Duty Gasoline Engine and Light-Duty Gasoline Truck Idle Test Procedure

Overview of Technical Amendments

In general, the following changes were made throughout the entire subpart:

1. All references to diesels were deleted; references to and procedures for light-duty trucks were added.

2. Miscellaneous clarifications were made.

3. References to Subparts N, B, and D were clarified.

4. Requirements were made consistent with Subparts N and B where possible.

Specific Amendments

The following sections from 40 CFR Part 86 Subpart P were modified enough to merit specific mention. These modifications represent no substantive change to the fundamental test procedure:

86.1514-84 Analyzer gas specifications made consistent with Subpart N and B.

EPA considers it to be unnecessary to have differential requirements for calibration and span gases for all emission test procedures applicable to any given vehicle or engine. This amendment makes analyzer gas requirements consistent between applicable test procedures.

86.1516-84(b) Minimum calibration frequency changed from weekly to monthly as in Subpart N.

This amendment makes calibration procedures consistent between subparts, such that the same equipment can be used for either test.

86.1516-84(c) Check interval changed from daily to before each test.

This amendment makes calibration procedures consistent between subparts, such that the same equipment can be used for either test.

86.1527-84(a) Clarified test run sequence, especially for light-duty trucks.

The earlier test procedure addressed light-duty trucks only by reference, and left much of the test sequence unspecified. This amendment corrects that omission, and provides a specific test sequence for light-duty trucks.

86.1527-84(b) Ambient test cell requirements made consistent with those of Subpart N and B.

This amendment allows the use of the same equipment in the same test cells for testing conducted under either subpart.

86.1542-84 Information requirements made consistent with Subparts N and B.

This amendment allows the manufacturer to more easily combine test results in a single application for certification.

12. Issue: Possible "Migration" from Class IIB to Class III

Summary of the Issue

In the March 1983 staff paper, EPA proposed a split-class approach to HDGE HC/CO control. In that proposal, HDGEs intended for use in Class IIB and III applications (up to 14,000 lbs. GVW) would be required to meet the statutory standards of 1.3 HC/15.5 CO in 1987, while HDGEs intended for use in heavier applications (over 14,000 lbs. GVW) would continue to meet non-catalyst standards (assumed to be 2.5 HC/35 CO). Commenters disagreed with the choice of "break point," maintaining that Class III (10,001-14,000 lbs. GVW) HDGEs should be included with the heavier HDGE applications, and therefore allowed to meet the non-catalyst standards rather than the statutory standards.

The critical problem with lowering the "break point," as advocated in the comments, is the possibility that LDTs in the upper portion of the Class IIB weight range (8,501-10,000 lbs. GVW) could be slightly "redesigned" so as to be heavy enough to be included in Class III. This "migration" of Class IIB vehicles into Class III, thereby avoiding the catalyst-forcing statutory HC/CO standards, has been discussed in some detail elsewhere.[1] The discussion below is limited to where the classes should be split, and how the potential problem of "migration" should be addressed.

Summary of the Comments

Of the comments submitted in response to the staff paper, only Ford and GM specifically addressed the issue of where the "break point" should be set under EPA's proposed split-class approach.

Ford suggested that a more logical "break point" would be at 10,000 lbs. GVW; in other words, Class IIB HDGEs would meet the catalyst-forcing statutory standards while all other HDGEs (Classes III-VIII) would meet the proposed non-catalyst standards. Ford acknowledged the validity of EPA's concern over "migration" under this HDGE split, but maintained that HDGEs in dual rear-wheel and fifth-wheel ("pop-truck") Class III applications are more appropriately grouped with the heavier HDGEs. This is due to the in-use service environment of such vehicles, a significant portion of which is spent operating at full-load, WOT conditions. Ford indicated that the high temperatures characteristic of these conditions render catalyst use infeasible.

General Motors responded to the staff paper with an entirely new proposal, maintaining the general notion of splitting HDGEs into two groups but having little else in common with the split-class approach described in the staff paper. Other aspects of the GM proposal are dealt with in detail elsewhere;[1] only the choice of "break point" is discussed here.

General Motors paralled Ford in proposing that the "break point" be set at 10,000 lbs. GVW, and claimed that its proposal is responsive to two of the concerns expressed by EPA. As identified by GM from the staff paper, these concerns are: First, that the majority of HDGEs as currently defined be subject to the catalyst-based statutory standards; and second, that the air quality benefits resulting from implementation of the statutory standards not be significantly reduced by "migration" of HDGEs below, but close to, the "break point" to just above that point.

General Motors noted that HDGEs in Class IIB represent about 65 percent of all HDGEs; thus, the IIB/III-VIII "break point" would continue to require a majority of HDGEs to be catalyst-equipped. Citing the small HDGE sales in Class III, GM stated that "insignificant air quality improvement" would occur, relative to its proposal, if the "break point" is set at 14,000 lbs. GVW. GM also indicated, although less specifically, a concern similar to that expressed by Ford: that the use patterns and operating conditions characteristic of Class III applications are likely to result in higher temperatures than catalyst technology can endure.

General Motors also claimed that not only would there not be a "migration" problem, but that there would actually be strong incentives not to move vehicles to higher GVW classes. As justification for this assertion, GM states that the cost increase for catalyst technology on HDGEs meeting the statutory standards would be comparable to the cost increase for added non-catalyst emission control technology on the heavier HDGEs. In addition, raising the GVW would involve cost increases for the upgrading of other vehicle components (e.g., springs, axles), thus further reducing any possible motivation for vehicles to "migrate" from Class IIB to Class III.

Analysis of the Comments

EPA acknowledges that the air quality impact of control of HC and CO to catalyst-forcing levels for HDGEs in Class III applications will be small compared to the control from Class IIB vehicles (because of sales). The selection of 14,000 lbs. GVW as the "break point" was based on EPA analysis of where

HDGE types change, in terms of use and application. EPA was also concerned over possible HDGE "migration" if the dividing line between catalyst-based and non-catalyst based standards were set at the lower level (10,000 lbs. GVW).

The comment by Ford about the similarity of use patterns and operating environments for some Class III applications and the Classes IV-VIII applications is a valid concern. However, EPA does not believe that lowering the "break point" to 10,000 lbs. GVW is the best approach to dealing with this concern, since it fails to address how "migration" might be avoided. A method of accounting for both EPA's concern over "migration," and Ford's concern over the inappropriateness of requiring catalyst technology on some HDGEs in Class III applications, is to maintain the "break point" as EPA proposed (14,000 lbs. GVW) while providing for reclassification of a limited number of HDGE configurations. This is explained in more detail below.

The disincentives to "migration" cited in the GM comments are based on assumptions contained in the GM counter-proposal, not on the EPA split-class proposal. While the arguments may sound reasonable on first examination, EPA's concerns over "migration" are not alleviated. Previous "migration" of Class IIA vehicles up to Class IIB, to avoid more stringent emission standards and fuel economy regulations, demonstrates the validity of EPA's concern. This earlier trend of "migration" is evidenced by the relatively large concentration of vehicles with GVWs in the 8,501-8,600 lbs. range,[1] which can logically be assumed to have "migrated" above 8,500 lbs. GVW for the reasons cited above.

In EPA's analysis of the GM counter-proposal,[1] an attempt to estimate the potential magnitude of the "migration" of Class IIB into Class III is made. Although these estimates must be considered "soft," due to the unavailability of sales data for Class IIB alone, they do provide an estimate for consideration. The analysis showed that roughly 70 percent of Class IIB vehicles have GVWs of 9,000 lbs. or more, which means that they could conceivably be redesigned so as to enter Class III. How much actual "migration" would occur if the "break point" were set at 10,000 lbs. GVW is difficult to predict with any certainty. However, EPA believes that the potential for migration is strong because of the number of vehicles sold near the Class IIB upper GVW limit, coupled with a desire by manufacturers to apply catalyst systems to as few vehicles as possible (if for no other reason than because of an anticipated strong buyer preference for non-catalyst vehicles). Further, EPA finds the risk of migration avoidable.

EPA believes that the concerns of both the Agency and the industry over the inclusion of Class III vehicles in the proposed new Classes IIB-III subcategory can be adequately addressed by a fairly simple modification to the approach developed in the staff paper. The "break point" between catalyst and non-catalyst HDGES should remain at 14,000 lbs. GVW, as proposed by the staff paper. However, whereas that proposal effectively contained no exemption provisions, EPA recommends modifying the proposal so that manufacturers would be permitted to reclassify a limited portion of their Classes IIB and III configurations to Class IV. The choice of configurations to be reclassified would be left to the discretion of the manufacturers, providing them maximum flexibility in choosing the configurations where catalyst application would be the most difficult. However, the size of the reclassified group would have to be limited by EPA to insure that no significant environmental losses would occur.

The limit on reclassification would be expressed as a percentage of all sales in Classes IIB and III. Based on the actual 1980 and projected 1990 sales data used in the staff paper, this limit would be in the range of 2 to 7 percent, approximating Class III sales as a fraction of combined sales in Classes IIB and III. There is a tendency in the sales projections for this ratio to increase slowly over time; however, as was noted by Ford in its comments, it is not necessary for <u>all</u> Class III HDGEs to be exempted from the statutory standards. Balancing these considerations, EPA has decided to limit to 5 percent of combined Classes IIB and III sales the reclassification of Classes IIB and III HDGEs to Class IV.

Under the split-class approach, modified as detailed above, there should be little change of air quality benefits from the staff paper proposal, while the legitimate concerns of the manufacturers over a limited number of Class III applications would be addressed. In fact, the manufacturers will gain an added degree of flexibility in compliance with the new regulations. They will be able to minimize their costs by reclassifying the more severe applications.

Conclusions

EPA will maintain the LHDGE/HDGE "break point" at 14,000 lbs. GVW, as was proposed in the staff paper. EPA will include provisions for up to 5 percent of combined sales of HDGEs in Classes IIB and III to be reclassified and certified to non-catalyst levels, on a configuration-specific basis.

References

1. Evaluation of General Motors' Heavy-Duty Engine Proposal, EPA Memo from Chester J. France, Standards Development and Support Branch, to Richard D. Wilson, Office of Mobile Sources, May 16, 1983.

13. Issue: Diesel Engine Closed Crankcase Requirements

Summary of the Issue

The regulations promulgated on January 21, 1980 presently require that all naturally aspirated heavy-duty diesel engines have closed crankcases (i.e., zero crankcase emissions are to be discharged into the ambient atmosphere).

Summary of the Comments

General Motors claimed that no technology was available to safely allow closing of the crankcase for 2-stroke heavy-duty diesel engines. General Motors' primary concern is that the internal fuel system used in these engines may leak. This would create a safety problem if fuel overflows into the engine intake through the crankcase ventilation system and causes an uncontrolled engine runaway.

General Motors also noted that 2-stroke engines require a blower to induct intake air into the cylinders. To route crankcase emissions into the intake air would require either an expensive pumping system to force the crankcase vapors into the higher pressure air downstream of the intake blower, or, if crankcase vapors were ventilated into the intake air upstream of the blower, fouling and deterioration of the blower may occur. These problems led EPA to decide not to finalize closed crankcase requirements for turbocharged diesel engines in December of 1979.

General Motors recommended that the closed crankcase requirement for these engines be rescinded.

Analysis of the Comments

There are two aspects to the closed crankcase issue for 2-stroke HDDEs: feasibility and cost effectiveness.

EPA notes that GM engine families, other than 2-stroke engines, utilize internal fuel systems. GM has stated to EPA that a safe closed crankcase system for its internally fueled 8.2L engine, while presenting an initial challenge to designers, will likely be available for the 1985 model year. Given GM's claim that a feasible closed crankcase system can be applied to its 8.2L engine in 1985, it is difficult to accept GM's assertion that the application of such systems to 2-stroke engines will be permanently infeasible. On the strict basis of feasibility, EPA finds no merit in GM's request that 2-stroke engines be permanently excluded from closed crankcase requirements.

On the other hand, the parallel drawn by GM between 2-stroke and turbocharged engines is valid. Both engines would require similar closed crankcase systems in the sense that a more expensive pumping system is needed to overcome the high pressure intake air. Otherwise, turbocharger/blower fouling may occur if crankcase effluents are added to the intake air upstream of the turbocharger/blower. EPA recognized this problem in the January 21, 1980 rulemaking: such a system for turbocharged engines would be roughly ten times the cost of a closed crankcase system for naturally aspirated engines. For this reason, EPA did not finalize closed crankcase requirements for turbocharged engines at that time. It was not a question of feasibility, but rather an acknowledgement of the poor cost effectiveness of the requirement.

Failure to include all engines which rely upon forced induction of intake air with this deferral of closed crankcase requirements occurred mainly because the manufacturers did not raise it as a significant issue. (GM and other manufacturers never raised such an issue during the earlier rulemaking.) However, it would now be technically appropriate to make this change to the regulations. Furthermore, the number of engines affected by this (i.e., the number of naturally aspirated 2-stroke engines) is quite small, and getting smaller as turbochargers become more universally adopted. (Only 3.3 percent of GM's 1983 sales were naturally aspirated 2-stroke engines; no other manufacturer makes 2-stroke engines.) Given this small impact, and given the technological similarity between the 2-stroke and turbocharged engines with respect to closing the crankcase, EPA concurs that closed crankcase requirements should not apply to 2-stroke engines until a similar requirement for turbocharged engines is promulgated. This conclusion is based entirely on the relative cost effectiveness of closing the crankcase on engines which require turbochargers, blowers, etc., to induct intake air.

Conclusion

The closed crankcase requirements should not apply to 1985 and later model year heavy-duty diesel engines which require forced induction of intake air (e.g., by turbochargers, blowers, etc.).

Appendix A

Draft Technological Feasibility Analysis from the NPRM "Revised Gaseous Emissions Regulations for 1984 and Later Model Year Light-Duty Trucks and Heavy-Duty Engines"

CHAPTER II

TECHNOLOGICAL FEASIBILITY/ ATTAINABLE NON-CATALYST STANDARDS

A. Introduction

In this chapter, EPA analyzes available technologies and projects what levels of HC and CO emissions for heavy-duty gasoline (HDG) engines are attainable for 1984, assuming that oxidation catalysts are not employed.

B. Current HC and CO Emission Rates

To properly evaluate potential non-catalyst emission reductions from HDG engines, current emission rates must be reviewed. Because absolute emission levels are inherently affected by the test procedure over which they are measured, a review of the transient emission test is appropriate.

1. Overview: The Transient Test

The transient test is performed on a computer-controlled engine dynamometer. During the test, the engine is driven through continuously-varying speeds and loads according to prescribed cycles. These speed and load cycles were developed from in vehicle performance data taken from 57 urban HDG trucks: 30 in the joint industry/EPA CAPE-21 study in New York City, and 27 in the EPA-conducted Los Angeles CAPE-21 study. These trucks were actual commercial vehicles operated by their own drivers; the performance data was taken in the course of their daily business. These data were then used to generate driving cycles representative of the input data.

There are several key aspects of the transient test:

a. It is engine specific,

b. It is composed of subcycles, each of which retains the characteristic driving patterns of specific urban localities, and,

c. It is performed on a "cold" engine, and then repeated with the engine in a warmed-up state.

Each of the above characteristics is critical in evaluating current and future emission trends.

Engine specific means that the cycles are defined in terms of percent speed and percent load, i.e., any two engines are required to deliver identical <u>percent</u> powers throughout the cycle even though their absolute power levels may be different. This, and the fact that emissions are expressed as mass per output work

(work is simply power multiplied by the time at that power), make emission results between engines comparable, regardless of their specific rated power and varying performance characteristics.

Secondly, the cycle is actually four subcycles joined end to end, each one characteristic of a particular geographic area and type of driving:

Subcycle	Duration (sec)	Characteristics
1. New York Non-Freeway (NYNF)	272	low power; stop-and-go; 45% idle; avg. spd. 7.8 mph
2. Los Angeles Non-Freeway (LANF)	309	moderate power, transient; 26% idle; avg. spd. 15.1 mph
3. Los Angeles Freeway (LAF)	316	high-speed, high-power cruising; avg. spd. 45.54 mph
4. New York Non-Freeway (NYNF)	272	repeat of 1.

Each subcycle demands different performance from the engine, and produces different absolute emission levels. These performance demands can be isolated and their emissions impact reasonably estimated.

Thirdly, the heavy-duty engine dynamometer test is similar to the light-duty vehicle test in that the total emission results are derived from a weighted average of a "cold" engine cycle and a hot engine cycle. For the heavy-duty test, the cold start emission cycle consists of the above four subcycles (NYNF, LANF, LAF, NYNF), and is weighted 1/7 of the total; the hot start cycle is identical to the cold, begins 20 minutes after shut down of the engine from the cold start, and is weighted 6/7 of the total. These weighting factors were derived from the observed in-use ratio of cold starts to hot starts in the CAPE-21 survey. Since a cold engine characteristically emits higher amounts of HC and CO, the cold start cycle is significant when discussing current and future emission levels.

2. Current Technology Engines

Table II-1 presents a list of 1979 MY HDG engines tested by EPA on the transient cycle. Table II-2 presents subcycle by subcycle HC emission breakdowns for each engine, along with a percent contribution of each subcycle to the total emission results. Table II-3 presents the same data for CO.

Immediately noticeable in Table II-1 are the high levels of HC and CO emissions. Note that the engines were certified for 1979 at 1.5 g/BHP-hr HC and 25 g/BHP-hr CO, but on the 9-mode steady-state test procedure. In complying with any motor vehicle emission standard, the design approach is to match the engine calibration and emission control system to the test procedure itself. This is the case in light-duty (see Reference 2), and indeed in heavy-duty. Table II-4 presents comparative HC and CO emission data for both transient and 9-mode test procedures for the current technology (1979) engine baseline. The large differences in measured emissions are explainable by the readily identifiable differences in required engine performance under each test.

3. The 9-Mode Test

The 9-mode test procedure consists of nine steady state engine operating modes which are weighted into a composite emission number:

Mode	Speed (RPM)	% Power	Weighting Factor
1	Idle	0	.232
2	2000	25	.007
3	2000	55	.147
4	2000	25	.077
5	2000	10	.057
6	2000	25	.077
7	2000	90	.113
8	2000	25	.007
9	2000	Closed Throttle	.143

The 9-mode is performed with the engine in a warmed-up state, at only one engine speed (except idle). To date, it can be firmly stated that on all current production engines all efforts at emission control on HDG engines have been directed primarily at these modes.

There are three major areas of engine operation which the transient test contains, but not the 9-mode:

a. Full power operation;

b. Transient operation, at all speeds and loads;

c. Cold engine operation.

These areas give rise to the measurable emission differences, and reflect where control technology will need to be directed for 1984. In this analysis we will show that full power (power enriched) LA Freeway modes are the major source of CO emissions in current technology engines, and also a significant source of HC on the higher emitting engines. Secondly, the major source of HC on the lower HC emitting engines will be shown to be the cold engine operation. Finally, on the lower-emitting engines, it will be shown that non-cold start HC and the remaining CO emissions are not as attributable to any one mode or source, and are primarily relatable to inadequately controlled mixture calibration as the engine undergoes transients at all speeds and loads throughout the entire test cycle.

4. Full Power Operation

Under wide open throttle (WOT) conditions, additional fuel is added to the combustion mixture. This power enrichment causes richer than stoichiometric mixtures, thereby promoting power and driveability, but drastically increasing unburned fuel (HC) and partially oxidized fuel (CO) emissions due to lack of oxygen. Present day engines certified to the 9-mode were emission controlled *primarily* up to 90 percent power (at only a single speed); note that current technology engine power valves are calibrated to cause power enrichment above 90 percent power. Thus, full power emissions on current technology engines are uncontrolled.

This observation is demonstrated by the data presented in Tables II-2 and II-3. In both tables, data from all twelve current technology engines tested at EPA are presented. In addition, the engines are also grouped into three categories: high, medium, and low emitters of a given pollutant. Note mode 7, the LA Freeway (LAF) in the hot-start portion of the test: 29.6 to 65.7 percent of brake specific CO (BSCO) emissions are attributable to this high-power segment. More interesting are the trends observed in segment percentage contributions from the highto the low-emitting engines. As the average composite BSCO emissions go from 105.5 g/BHP-hr (higher emitters) to 46.1 (lower emitters), i.e., a 2.3 *fold decrease*, all other subcycle model percentages increase by approximately two-fold except for the LAF mode, which decreases in contributing percentage from 56.3 to 36.7 percent (i.e., a lower percentage of a lower composite number). Had all modes decreased proportionally, the model percentages should remain constant. Clearly the major difference between high and lower CO engines is the amount of CO generated during the LAF segment. This is primarily a result of power enrichment in the carburetor during the LAF's characteristic high speed, high power operation. (Perhaps most indicative is the actual mass of CO generated during the LAF segment. Note in Table II-3 that total grams of CO generated in the LAF segment are 50-650 percent higher than those of the next highest hot start segment.)

The data for HC (Table II-2) is less dramatic with regards to LAF dominance, but the trends are nevertheless the same. Every high CO engine, (i.e, those with LAF dominance of CO emissions) also has dominant LAF HC emissions (ranging from 23.7 to 36.0 percent total contribution). This is logical since in this operational mode both emissions arise primarily from inadequate oxygen for total combustion in the fuel-enriched mixture. Again, the lower the total HC emissions are, the lesser the percent contribution of the LAF segment to that total.

In summary, power enrichment occurs at the high power points throughout the entire transient test cycle, but the majority of this high power operation is found in the LA Freeway segment. Emissions performance over this segment is the major differentiating factor between lower and higher emitting engines. Control or power enrichment is the first and most effective step in reducing CO emissions with or without a catalyst. This will be discussed further below.

5. Transient Operation/All Speeds and Loads

As the LAF emissions contribution drops when going from the higher to lower emitting engines, the contribution from other segments tend to increase until no single segment is dominant. (The obvious exception to this is cold start HC, which is discussed below.) Aside from certain physical factors,* these emissions arise from less than accurate fuel metering and mixing as the engine drives over the entire test cycle. If the fuel flow does not precisely match the engine inlet air flow at any instant in time, then too lean or too rich mixture conditions prevail, along with ensuing lean misfire (high HC) or incomplete combustion (high HC and CO). This matching is complicated by the inevitable need to closely match the fuel and air flows at continually varying speeds and loads while also maintaining power and driveability. All current technology engines were emission optimized at idle, and at eight different steady-state power modes at 2000 RPM. This represented a reasonably simple design/calibration problem, as evidenced by the engines' emission performance over the 9-mode test. Once outside that limited regime of emission-optimized modes, however, such as on the road or on the transient test, emissions remain virtually uncontrolled. Little design attention with respect to emissions has been given to the majority of the engines' operating ranges.

Precise matching of fuel and air flows under varying conditions, including transient enrichment by the accelerator pump for driveability, is a major emission-related problem of mixture control. Another is the problem of achieving as homogeneous (perfectly mixed) a fuel/air (F/A) mixture as possible. Incomplete mixing (including liquid fuel deposition on the manifold or combustion chamber walls) produces localized pockets of rich and lean mixtures, resulting in an overall increase in HC and CO emissions. Complete mixing is also critical to achieving uniform A/F ratios from cylinder to cylinder, again to optimize overall emission performance.

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* Combustion chamber design affects wall quenching. Inlet manifold design affects mixture distribution between cylinders, fuel deposition in the manifold, and heat exchange characteristics. All of these in turn affect HC and CO emissions.

The above problems are not new, are well recognized, and have already been addressed in the light-duty passenger car fleet. Experience with the light-duty fleet has indicated, however, that there exists a definite limit to the amount of HC and CO emission reductions achieveable through recalibration before power, driveability, and/or fuel economy become unacceptable. For this reason, catalysts become inevitable at lower emission standards, both for their effectivenss and the flexibility in engine calibration their effectiveness permits.

6. Cold Engine Operation

Cold start emissions are substantially higher than those of a fully warmed-up engine, and usually require separate attention during control system design. Again referring to Tables II-2 and II-3, we note that cold start HC contributions are high, and become dominant at lower overall levels of HC emissions. Cold start CO on the other hand has a relatively minor effect on an overall basis. This phenomenom is typical, though perhaps exaggerated by the lack of design control in the past, and is attributable to the fact that a very rich mixture is needed for starting and driveability in a cold engine, to compensate for deposition of a large part of the fuel on cold manifold walls. This rich mixture is provided by the choke mechanism, either manual or automatic. Emissions arise both from this overall rich mixture, misfire, and from the eventual evaporation of the condensed fuel. Emissions have not been a design constraint in the past for cold starting, only startability, driveability, and power. The transient test procedure itself is demanding, requiring both emission control and high power driveability early in the cold start cycle.

C. Available Control Techniques

1. Overview

Widespread introduction of new non-catalyst technologies is assumed to be an unrealistic scenario for the 1984 model year. This is a function of the remaining leadtime, and cost - the intent of this rulemaking is to ease the capital expenditure burden on the industry. Technologies which EPA expects to be implemented for 1984 will not be new, but rather will represent refinements, recalibrations, and optimizations of current technologies.

2. Improvements to Fuel Metering

By and large, fuel metering improvements will be the single most effective strategy for reducing overall HC and CO emissions in 1984 engines, especially when optimized for the transient test. These improvements include modifications to carburetors to achieve more precise F/A ratio control, and recalibration to leaner F/A ratios on an overall basis, and especially under transient conditions and WOT.

Figure II-1 presents the CO emission distribution of the 1979 baseline engines. Note that two mutually exclusive sets of carburetors are found above and below 70 grams/BHP-hr, representing higher and lower emitting engines. Some carburetors (those below 70 g/BHP-hr) meter fuel more accurately under transient conditions even though also optimized for the 9-mode. Power enrichment, sometimes observed at 4-6 percent CO (40,000 to 60,000 ppm in the raw exhaust) contributes substantially to these CO levels, as shown above in Table II-3. At any rate, we infer from Figure II-1 that since two groups of carburetors produce two radically different emission rates on a test procedure for which neither was optimized, the higher emitting group is unrepresentative of current technology and should not be considered a realistic starting point when extrapolating achieveable emission reductions. They represent excessive power enrichment/inaccurate fuel metering producing twice the CO emissions of other engines of equivalent power and displacement. The realistic current technology CO baseline is, therefore, presumed to be in the range of 40-60 g/BHP-hr. It is from this range downward in which development work will be concentrated.

The prime result of recalibration will need to be leaner mixture calibration, and leaner WOT and transient enrichment, thereby reducing both HC and CO emissions.

3. Improved Mixture Distribution

As overall calibrations get leaner, it becomes more important from a power, driveability, and emissions standpoint that the F/A mixture be as homogeneously mixed as possible and the mixture distribution to each cylinder is uniform. Localized rich or lean "pockets" in the mixture should be eliminated by the time it enters the cylinder. Assuring uniform F/A mixture distribution to each cylinder is also important. Too lean a mixture in one or more cylinders will force recalibration to a richer operating point to accommodate the needs in that cylinder, which will in turn cause too rich a mixture in other cylinders.

This is essentially a problem of improving the mixing of air and fuel in the manifold prior to cylinder induction. The liquid fuel must be vaporized and then mixed, requiring heat energy and substantial turbulence. Deferring the problem of cold starting until later, heat energy arises from the air itself and from the warm manifold. Improvements would come from redesign of the manifold to increase turbulent mixing, and to increase heat transfer (perhaps by heating intake air by drawing it across the exhaust manifold) to the intake air or air/fuel mixture.

4. Other Physical Modifications

Other physical changes to the engine have been proven to reduce unburned fuel emissions, such as decreasing surface-to-volume ratio of the combustion chamber to minimize wall quenching, reductions in cylinder "dead" volume, etc. Although these may be per formed on some engine families, we do not consider fleetwide physical redesign of engine combustion chambers for all families to be realistic or necessary for 1984.

5. Other Calibration Optimizations

As mixture calibration optimization reaches its limit with respect to attainable reductions, other calibrations - notably spark timing - can be utilized to further reduce HC and CO. Ironically, these reductions are made possible by the other 1984 MY emission standard for heavy-duty engines: the NOx standard of 10.7 grams/BHP-hr. NOx emissions at this level are relatively uncontrolled, and will allow ignition timing calibration to be set near MBT* - the most efficient calibrations. The higher NOx standard permits both lean mixtures and optimum timing advance - both of which increase NOx but decrease HC and CO emissions and fuel consumption.

Furthermore, spark timing can also be optimized for the cold start portion transient test procedure. The light duty fleet currently uses electronically-controlled spark timing to optimize ignition under all engine operating conditions in the Federal Test Cycle to minimize emissions and maximize fuel economy. The methodology and technology is entirely applicable, if necessary, to HDG engines on the transient test.

6. Improved Warm-up Characteristics

As emission levels decrease with mixture and ignition timing optimizations, the limiting factor for HC reductions is clearly the engine's performance on the cold start portion of the transient test. As Table II-2 above indicated, cold start HC emissions are the dominant fraction of engine-out HC.

Two strategies exist for reducing cold start emissions: restrict the amount of cold mixture enrichment, and increase the warm-up rate of the engine. The former is straightforward, and limited by the amount of leaning a cold engine can withstand and still maintain the high driveability and performance both the road and the transient test require. This is done by choke recalibration. Increasing the warm-up rate of the engine can be accomplished in primarily two ways: decrease the efficiency of the overall combustion cycle, and use exhaust gas heat to rapidly warm the intake manifold and/or intake air. Cycle efficiency reductions are best achieved by changing spark timing as a function of engine temperature: less efficient spark timing calibrations reduce engine efficiency, and increase the amount of waste heat rejected to the combustion products and thereby conducted to the engine itself. The result is a faster warm-up; less time spent in a cold state reduces cold emissions.

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* "MBT" denotes the minimum timing retard (i.e. maximum timing advance) at which maximum power is obtained without inducing knock reactions.

Cold start HC emissions, as elaborated above, are presently uncontrolled, and generally dominate at lower overall HC emission levels. Table II-5 lists current technology engines, and the percent increase in composite total transient test HC and CO emissions attributable to the cold start cycle. (The cold start cycle is identical in every way to the hot cycle, with the sole exception of engine temperature.) From this we can infer the amount of emissions generated by the "cold"* engine temperature. Figure II-2 graphically portrays the percentage attributable to cold engine temperature versus the total composite test result, and illustrates the general trend of increasing impact of cold HC emissions with lower overall HC emission rates. (Note that there are exceptions to the trend). All of the 1979 baseline engines tested by EPA were equipped with automatic chokes; the high degree of scatter in the Table II-5 data indicates that varying choke calibrations are possible. Since the varying engine calibrations were not optimized for either a transient test or a cold start, the available data does not lend itself to determining the exact contribution of the cold start to overall test results at any given emission level. The data do indicate, however, that it can be significant (probably 10-40 percent). The real question is to what degree cold start HC emissions can be reduced by choke recalibration/improved warm-up. Experience tells us that significant reductions are achievable from uncontrolled engines.

7. Summary of Possible Control Techniques

Based on the discussion above EPA has identified a number of potential means of reducing HC and CO emissions from HDG engines. These are summarized below.

a. Carburetion - modifications and improvements to the power enrichment, accelerator pump, and general fuel metering systems.

b. Calibrations - spark timing, A/F ratio, and EGR flow rate calibrations.

c. Manifold/Combustion Chamber Redesign - intake manifolds could be redesigned to improve the homogeneity of the F/A ratio. Combustion chamber surface-to-volume ratio could be decreased and cylinder dead volume minimized to lessen fuel quenching on cylinder walls.

d. Air Injection System - Increased air injection to the exhaust manifolds will increase the HC and CO oxidation. This system could be further improved by an air modulation system and possible recalibrations of the pressure relief and diverter valves. Some exhaust manifold modifications may also aid the efficiency of the air injection system.

* "Cold," for laboratory test procedure purposes, is a temperature between 68° and 86°F.

e. Automatic Choke - the use of a properly calibrated automatic choke would decrease cold start HC and CO emissions and improve warm-up time.

f. Early Fuel Evaporation (EFE) - this system involves the use of exhaust gases to warm the air-fuel mixture by directing some of the exhaust gases through a passage below the carburetor. A warmer A/F mixture improves the fuel distribution to the cylinders and results in lower emission levels and shorter warm-up periods.

g. Heated Air Intake - heated air intake or a modulated air cleaner system uses exhaust gases to warm the intake air to the carburetor. This improves engine warm-up time and reduces emissions by allowing leaner carburetor calibrations.

h. Exhaust Gas Recirculation (EGR) - EGR primarily used for NOx control, can also be beneficial with regards to HC control. Besides its overall leaning effect on the mixture, it also permits recombustion of a percentage of the exhaust gases. Similarily, increased valve overlap works as a form of "internal EGR."

The effectiveness of modifications and hardware of this type has been demonstrated in the light-duty vehicle and light-duty truck fleets for several years. These control strategies should be available for the 1984 model year HDG engines and should provide substantial HC and CO reductions over current levels.

8. Tradeoffs

The emission control strategies discussed above have tradeoffs with respect to fuel economy, power, and driveability. Leaner mixtures, less power enrichment, and quicker engine warm-up all improve fuel economy, but when carried to excessive degree could impair power and driveability. An increase in air injection would also cause a small fuel economy loss. EPA now believes that the fuel economy impacts of these regulations will be basically neutral. The limits to emission reduction will be determined equally by power requirements and driveability needs in addition to any fuel economy concerns.

D. Attainable Reductions/Proposed Emission Standards

As described above, several relatively simple and effective means of emission control are available. At this time, EPA has limited data as to the absolute effectiveness of a given technique on heavy-duty gasoline engines. For example, no testing has been performed to date on a current engine where mixtures were leaned out, spark timing curves optimized, power enrichment limited, and fast warm-ups or fast opening chokes were initiated. It is difficult to quantitatively predict attainable emission reductions without results of such testing.

One approach to deriving achievable standards would be to use an engineering estimate of the efficiencies of the previously described reduction techniques. These efficiency estimates could then be applied to the current baseline emissions data to calculate what emission levels could be reached. Lacking any other substantive data or technique at this time this methodology will be used.

The emission reduction efficiencies used in this analysis are those expected from the lower emitting engines in the current technology baseline (see Tables II-2 and II-3) so the average HC and CO emission rates from the low emitting engines will serve as the baseline levels. One might question the use of the lower emission levels as not being representative of the average emission levels. However for the higher emitting engines the efficiency estimates would in turn be substantially larger. We have chosen to use the lower emitting engines because they already reflect what could easily be achieved on other current technology engines with even minor calibration changes.

Tables II-2 and II-3 clearly indicate that the HC and CO emission levels in certain modes are so large that they require specific attention in this analysis. HC emissions could be divided into "cold/warm start" and "other." CO emissions could be divided into "LAF" and "other." Table II-6 lists the emission reduction techniques together with the modes in which they will be effective in gaining emission reductions. This information will serve as a background for the discussion which follows.

1. Hydrocarbons [3]

As shown in Table II-2 cold/warm start emissions account for 49 percent of the HC emissions. Thus the remaining 51 percent comes from the "other" six portions of the test. In terms of the average of the low emitting engines from Table II-3 the "cold/warm start" portions account for 0.92 g/BHP-hr and the "other" portions account for 0.96 g/BHP-hr.

With the emission control strategies shown in Table II-6 we believe that substantial reductions in HC emission levels are easily achievable. Our current belief is that reductions of 50-60 percent are possible in the "cold/warm start" portions of the test through the means shown in Table II-6. For all practical purposes "start" emissions are uncontrolled on the current test procedure. EPA also believes that reductions of 30-40 percent are also available on the other portions of the test procedure. Assuming the ranges of engineering estimates of reduction efficiencies given above, achievable emission levels can be calculated.

a. Cold/Warm Start Reductions

High Estimate: (0.92 g/BHP-hr)(60%) = 0.55 g/BHP-hr

Low Estimate: (0.92 g/BHP-hr)(50%) = 0.46 g/BHP-hr

New Range: 0.37 - 0.46 g/BHP-hr

b. Reductions in Other Portions

High Estimate: (0.96 g/BHP-hr)(40%) = 0.38 g/BHP-hr

Low Estimate: (0.96 g/BHP-hr)(30%) = 0.29 g/BHP-hr

New Range: 0.58 - 0.67 g/BHP-hr

c. Achievable Emission Levels

Using "High Estimate": 1.88 - 0.55 - 0.38 = 0.95 g/BHP-hr

Using "Low Estimate": 1.88 - 0.46 - 0.29 = 1.13 g/BHP-hr

Emission levels in the 0.95 - 1.13 g/BHP-hr range would support an HC emission standard of 1.3 g/BHP-hr.

Using a full life multiplicative deterioration factor of 1.2 and an HC variability of 10 percent, the expected target HC levels are 1.1 g/BHP-hr for 1984 (no SEA) and 1.0 g/BHP-hr when SEA begins in 1986. The range of achievable emission levels shown above supports the feasibility of these targets and thus the 1.3 g/BHP-hr standard.

2. Carbon Monoxide

As shown in Table II-3 the "LAF" (LA Freeway) CO emissions account for 43.2 percent of the total. Thus the remaining 56.8 percent arises from the "other" portions of the test. When these percentages are applied to the average low CO engines of Table II-3, the "LAF" accounts for 19.9 g/BHP-hr and the other portion accounts for 26.2 g/BHP-hr.

With the emission control strategies shown in Table II-6 substantial reductions in CO emission levels are easily achievable. Reductions of 40-50 percent are possible in the "LAF" portion of the test through the means in Table II-6. Emissions under the high-speed, high-power operation characteristic of the LAF portion are relatively uncontrolled because of the limited power demands of the 9-mode test procedure. Reductions of 30-40 percent are also possible from the "other" portions of the test procedure. Given the engineering estimates of reduction efficiencies shown above, achievable emission levels can be calculated.

a. LAF Reductions

High Estimate: (19.9 g/BHP-hr)(50%) = 10 g/BHP-hr

Low Estimate: (19.9 g/BHP-hr)(40%) = 8 g/BHP-hr

New Range: 9.9 - 11.9 g/BHP-hr

b. Reductions in Other Portions

High Estimate: (26.2 g/BHP-hr)(40%) = 10.5 g/BHP-hr

Low Estimate: (26.2 g/BHP-hr)(30%) = 7.9 g/BHP-hr

New Range: 15.7 - 18.3 g/BHP-hr

c. Achievable Emission Levels

Using "High Estimate": 46.1 - 10 - 10.5 = 25.6 g/BHP-hr

Using "Low Estimate": 46.1 - 8 - 7.9 = 30.2 g/BHP-hr

Emission levels in the 25.6 - 30.2 g/BHP-hr range would support a CO emission standard of about 35 g/BHP-hr. Using a full life multiplicative deterioration factor of 1.1 and a CO variability of 20 percent, the expected target CO levels are 31.8 g/BHP-hr for 1984 (no SEA) and 25.5 g/BHP-hr when SEA begins in 1986. The range of achievable emission levels shown above supports the feasibility of these targets and thus the 35 g/BHP-hr standard proposed here.

Considering all of the factors bearing on this analysis (cost, fuel economy, leadtime, power, and driveability), EPA believes that the standards herein discussed are achievable for all HDG engines for the 1984 model year. However if during the comment period further data and information would prove the standards to be infeasible the option for further relaxation for final rulemaking exists.

E. Idle Emission Standard

For heavy-duty gasoline engines, the 1984 idle CO standard is 0.47 percent (raw exhaust composition). Table II-7 presents the current technology idle CO baseline. Note that five of twelve engines already comply. Given the fact that substantial leaning of mixtures will be performed to meet the transient standards, there is no reason to believe the idle circuits of the remaining engines cannot be improved. EPA judges compliance with the idle standard to be relatively straightforward and will pose no problems to manufacturers even considering any small deterioration factor which may need to be included.

Table II-1

1979 HDG Current Technology Baseline

Engine	Family	HC* (g/BHP-hr)	CO* (g/BHP-hr)
Ford 400	6.6L "E"	4.89 (H)**	112.4 (H)
Chrysler 440	RBM	3.83 (H)	112.4 (H)
Ford 370	6.1L "E"	3.51 (H)	47.8 (L)
IHC 446	MV8	3.27 (H)	90.4 (H)
GM 350	113	3.14 (M)	118.1 (H)
Chrysler 360	LA1	2.67 (M)	96.1 (H)
GM 350	113	2.48 (M)	64.8 (M)
IHC 345	V345	2.44 (M)	34.4 (L)
GM 454	114	2.30 (M)	51.6 (L)
GM 366	114	2.16 (L)	43.4 (L)
GM 292	112	2.12 (L)	55.0 (L)
GM 454	115	1.31 (L)	78.5 (M)

* Average of several tests.

** Engines are classified as high (H), moderate (M), or lower (L) emitters of a given pollutant. Note that a high HC engine is also usually a high CO engine, but not in every case.

Table II-2

Engine by Engine Transient HC Emission Breakdown

		Cold Start				20	Hot Start				Composite	High
		1	2	3	4	Minute	5	6	7	8	Test	Medium, or
		NYNF	LANF	LAF	NYNF	Pause	NYNF	LANF	LAF	NYNF	Result	Low Emitter[e]
	1[a]	24.73	17.11	15.10	5.55		9.66	11.14	12.53	5.71	-	
IHC 446	2[b]	23.26	6.97	1.81	5.23		10.65	4.61	1.50	5.36	3.32	H
	3[c]	.289	.188	.166	.061		.677	.736	.830	.373	3.32	
	4[d]	8.7%	5.6%	5.0%	1.8%		20.4%	22.2%	25.0%	11.2%	100%	
	1.	25.50	9.09	4.93	3.80		4.82	6.29	4.64	3.40	-	
IHC 345	2.	64.84	5.51	0.78	5.20		7.14	3.40	0.75	4.38	2.35	M
	3.	.40	.13	.07	.06		.44	.54	.42	.29	2.35	
	4.	17.0%	5.5%	3.0%	2.6%		18.7%	23.0%	17.9%	12.3%	100%	
	1.	47.86	12.73	5.95	2.61		4.96	4.89	5.07	2.62	-	
GM 366	2.	94.7	6.24	0.81	2.69		5.69	2.28	0.69	2.74	2.22	L
	3.	.64	.16	.08	.03		.39	.36	.37	.19	2.22	
	4.	28.8%	7.2%	3.6%	1.4%		17.6%	16.2%	16.7%	8.6%	100%	
	1.	61.49	12.57	6.42	2.81		4.71	6.50	4.56	2.74	-	
GM 350	2.	95.0	6.30	.92	3.06		5.56	3.16	.65	2.95	2.57	M
	3.	.86	.17	.08	.04		.37	.49	.35	.21	2.57	
	4.	33.5%	6.6%	3.1%	1.6%		14.4%	19.1%	13.6%	8.2%	100%	
	1.	32.91	16.16	14.67	6.68		8.62	10.11	13.17	5.69	-	
F 400	2.	46.77	9.66	2.60	9.38		12.10	5.77	2.33	8.02	4.80	H
	3.	.56	.26	.24	.11		.87	.96	1.25	.55	4.80	
	4.	11.7%	5.4%	5.0%	2.3%		18.1%	20.0%	26.0%	11.5%	-	
	1.	20.11	8.13	7.39	1.71		8.05	7.65	6.96	3.46	-	
F 370	2.	52.25	5.29	1.35	2.47		13.37	4.78	1.26	5.02	3.31	H
	3.	.36	.14	.13	.03		.85	.76	.69	.35	3.31	
	4.	10.9%	4.2%	3.9%	.9%		25.7%	23.0%	20.8%	10.6%	100%	

Table II-2 (cont'd)

Engine by Engine Transient HC Emission Breakdown

		Cold Start				20 Minute Pause	Hot Start				Composite Test Result	High Medium, or Low Emitter
		1 NYNF	2 LANF	3 LAF	4 NYNF		5 NYNF	6 LANF	7 LAF	8 NYNF		
	1.	8.56	7.18	8.22	3.63		10.23	6.41	7.87	3.52	-	
C 360	2.	13.11	3.42	1.08	3.96		13.54	2.99	1.04	3.77	2.45	H
	3.	.11	.09	.10	.05		.80	.47	.58	.28	2.45	
	4.	4.5%	3.6%	4.0%	2.0%		32.7%	19.2%	23.7%	10.2%	100%	
	1.	17.38	10.57	24.67	7.76		10.25	9.32	22.22	9.10	-	
C 440	2.	20.12	4.10	2.78	7.41		11.32	3.65	2.40	8.69	3.81	H
	3.	.19	.11	.26	.08		.67	.57	1.37	.56	3.81	
	4.	5.0%	2.9%	6.8%	2.1%		17.6%	15.0%	36.0%	14.7%	100%	
	1.	16.38	3.88	5.34	1.68		4.94	2.39	4.95	1.57	-	
GM 454	2.	19.06	1.74	.63	1.83		5.82	1.07	0.60	1.72	1.29	L
	3.	.20	.05	.06	.02		.35	.17	.33	.11	1.29	
	4.	15.5%	3.9%	4.7%	1.6%		27.1%	13.2%	25.6%	8.5%	100%	
	1.	47.31	4.33	2.08	1.64		4.12	3.71	1.95	1.83	-	
GM 292	2.	65.65	2.62	0.39	2.08		6.17	2.20	0.37	2.33	2.12	L
	3.	.80	.07	.03	.03		.43	.37	.20	.19	2.12	
	4.	37.7%	3.3%	1.4%	1.4%		20.3%	17.5%	9.4%	9.0%	100%	
	1.	44.54	15.43	6.80	6.43		11.85	6.97	5.65	5.80	-	
GM 454	2.	62.38	5.75	0.68	5.83		11.24	2.52	0.57	5.25	2.46	H
	3.	.44	.15	.06	.06		.70	.39	.33	.33	2.46	
	4.	17.9%	6.1%	2.4%	2.4%		28.5%	15.9%	13.4%	13.4%	100%	

Table II-2 (cont'd)

Engine-by-Engine Transient HC Emission Breakdown

		Cold Start 1 NYNF	2 LANF	3 LAF	4 NYNF	20-Minute Pause	Hot Start 5 NYNF	6 LANF	7 LAF	8 NYNF	Total Test Composite	High Medium, or Low Emitter	Average HC Emission Level
	1.	21.04	6.13	10.39	3.69		3.66	5.01	9.51	3.71	-		
GM 350	2.	31.48	3.53	1.71	5.34		5.18	2.93	1.57	4.51	2.66	M	
	3.	.34	.09	.16	.06		.34	.46	.87	.34	2.66		
	4.	12.8%	3.4%	6.0%	2.3%		12.8%	17.3%	32.7%	12.8%	100%		
Average: All Engines	4.	17.0%	4.8%	4.1%	1.9%		21.1%	18.4%	21.7%	11.0%	100%	(12 engines)	2.78
Average: High HC Engines	4.	9.1%	4.5%	5.2%	1.8%		20.5%	20.1%	27.0%	12.0%	100%	H (4 engines)	3.61
Average: Med. HC Engines	4.	17.1%	5.0%	3.7%	2.2%		21.4%	18.9%	20.3%	11.4%	100%	M (5 engines)	2.50
Average: Low HC Engines	4.	27.3%	4.8%	3.2%	1.5%		21.7%	15.6%	17.2%	8.7%	100%	L (3 engines)	1.88

[a] Total grams per subcycle.
[b] Grams per brake-horsepower-hour per subcycle.
[c] Subcycle contribution, in effectively-weighted grams per brake-horsepower-hour, to the composite test result. (When added together, all subcycle contributions add up to the composite test result). For methodology, see Reference 1, pp. 4-5.
[d] Relative percentage of subcycle contribution (3) to the total composite test result.
[e] In grams per brake-horsepower-hour: High (H) > 3.3
3.3 > medium (M) > 2.3
Low (L) < 2.2

Table II-3

Engine-by-Engine Transient CO Emission Breakdown

		Cold Start				20-Minute Pause	Hot Start				Composite Test Result	High Medium, or Low Emitter[e]
		1 NYNF	2 LANF	3 LAF	4 NYNF		5 NYNF	6 LANF	7 LAF	8 NYNF		
	1[a]	236.4	245.2	774.8	127.2		123.3	200.0	708.1	122.7	-	
IHC 446	2[b]	222.4	99.9	93.0	119.9		135.9	82.7	84.7	115.1	92.88	H
	3[c]	2.79	2.73	8.63	1.42		8.73	13.3	47.1	8.20	92.88	
	4[d]	3.0%	2.9%	9.3%	1.5%		9.4%	14.3%	50.7%	8.8%	100%	
	1.	90.3	84.7	153.2	60.0		39.7	60.2	150.6	56.1	-	
IHC 345	2.	229.6	51.4	24.2	79.2		58.9	32.5	23.2	72.3	32.8	L
	3.	1.40	1.24	2.24	.88		3.70	5.29	13.11	4.94	32.8	
	4.	4.3%	3.8%	6.8%	2.7%		11.3%	16.1%	40.0%	15.1%	100%	
	1.	143.7	140.7	187.7	86.1		88.0	113.3	167.0	88.2	-	
GM 366	2.	284.3	69.1	25.5	88.8		100.8	52.9	22.8	92.1	41.9	L
	3.	1.9	1.8	2.4	1.1		6.9	8.7	12.5	6.6	41.9	
	4.	4.5%	4.3%	5.7%	2.6%		16.5%	20.8%	29.8%	15.8%	100%	
	1.	171.2	155.2	404.5	102.6		111.6	130.2	376.6	95.3	-	
GM 350	2.	264.5	77.7	57.8	116.6		131.9	63.4	53.9	102.5	67.8	M
	3.	2.4	2.1	5.3	1.4		9.3	10.1	29.7	7.4	67.8	
	4.	3.5%	3.1%	7.8%	2.1%		13.7%	14.9%	43.8%	10.9%	100%	
	1.	222.9	162.4	620.6	130.6		103.5	161.6	582.3	127.3	-	
F 400	2.	316.7	97.0	109.9	183.5		145.4	92.2	103.0	179.6	113.2	H
	3.	3.8	2.6	10.0	2.1		10.6	15.6	56.2	12.3	113.2	
	4.	3.4%	2.3%	8.8%	1.9%		9.4%	13.8%	49.6%	10.9%	100%	
	1.	85.2	106.6	230.7	21.4		38.8	80.1	206.7	40.3	-	
F 370	2.	221.5	69.4	42.1	30.9		64.4	50.0	37.4	58.4	45.0	L
	3.	1.5	1.8	3.9	.4		4.2	8.1	21.0	4.1	45.0	
	4.	3.3%	4.0%	8.7%	.9%		9.3%	18.0%	46.7%	9.1%	100%	

Table II-3 (cont'd)

Engine-by-Engine Transient CO Emission Breakdown

		Cold Start 1 NYNF	2 LANF	3 LAF	4 NYNF	20-Minute Pause	Hot Start 5 NYNF	6 LANF	7 LAF	8 NYNF	Composite Test Result	High Medium, or Low Emitter
	1.	107.5	144.7	868.6	61.2		56.6	127.9	783.0	58.5	-	
C 360	2.	164.7	68.8	113.8	66.7		76.3	59.5	103.3	62.6	92.0	H
	3.	1.4	1.8	10.8	.8		4.6	9.6	58.6	4.4	92.0	
	4.	1.5%	2.0%	11.7%	.9%		5.0%	10.4%	63.7%	4.8%	100%	
	1.	228.3	203.6	1262.0	100.6		75.2	161.1	1217.2	94.1	-	
C 440	2.	264.3	78.9	142.1	96.0		83.0	63.0	131.7	89.9	115.6	H
	3.	2.5	2.1	13.1	1.0		5.0	10.0	75.9	5.9	115.6	
	4.	2.2%	1.8%	11.3%	.9%		4.3%	8.7%	65.7%	5.1%	-	
	1.	250.3	86.2	769.6	65.2		86.9	102.8	714.1	69.7	-	
GM 454	2.	291.3	38.7	91.3	71.1		102.4	45.8	87.2	76.2	81.9	M
(Short	3.	3.1	1.0	9.0	.8		6.4	7.2	49.5	4.9	81.9	
Block)	4.	3.8%	1.2%	11.0%	1.0%		7.8%	8.8%	60.4%	6.0%	100%	
	1.	315.0	115.7	159.4	64.7		89.4	111.0	161.5	70.0	-	
GM 292	2.	437.1	69.9	30.2	81.9		133.7	65.9	30.5	89.1	55.0	L
	3.	5.6	2.0	2.7	1.1		9.6	11.2	16.3	7.1	55.0	
	4.	10.2%	3.6%	4.9%	2.0%		17.5%	20.4%	29.6%	12.9%	100%	
	1.	204.8	175.6	376.1	144.6		153.9	157.1	366.2	138.2	-	
GM 454	2.	286.9	65.5	37.9	131.1		146.1	56.7	36.9	124.9	55.9	L
(Tall	3.	2.1	1.7	3.6	1.4		9.3	9.0	20.9	7.9	55.9	
Block)	4.	3.8%	3.0%	6.4%	2.5%		16.7%	16.1%	37.4%	14.1%	100%	

Table II-3 (cont'd)

Engine-by-Engine Transient CO Emission Breakdown

		Cold Start 1 NYNF	Cold Start 2 LANF	Cold Start 3 LAF	Cold Start 4 NYNF	20-Minute Pause	Hot Start 5 NYNF	Hot Start 6 LANF	Hot Start 7 LAF	Hot Start 8 NYNF	Total Test Composite	High Medium, or Low Emitter	Average HC Emission Level
GM 350	1.	196.1	108.9	805.5	68.1		92.1	104.8	640.8	64.8	-		
	2.	293.3	62.6	132.21	98.6		130.1	61.4	106.0	78.8	101.5	H	
	3.	3.2	1.7	12.1	1.1		8.5	9.7	59.2	6.0	101.5		
	4.	3.2%	1.7%	11.8%	1.1%		8.4%	9.6%	58.3%	5.9%	100%		
Average All Engines	4.	3.9%	2.8%	9.5%	1.7%		10.7%	14.2%	47.9%	9.9%	100%	(12 engines)	75.7
Average High CO Engines	4.	2.6%	2.1%	12.6%	1.2%		7.1%	11.1%	56.3%	7.0%	100%	(5 engines)	105.5
Average Mod CO Engines	4.	3.7%	2.2%	9.4%	1.6%		10.8%	11.9%	52.1%	8.5%	100%	(2 engines)	74.9
Average Low CO Engines	4.	5.2%	3.7%	6.5%	2.1%		14.3%	18.3%	36.7%	13.4%	100%	(5 engines)	46.1

[a] Total grams per subcycle.
[b] Grams per brake-horsepower-hour per subcycle.
[c] Subcycle contribution, in effectively-weighted grams per brake-horsepower-hour, to the composite test result. (When added together, all subcycle contributions add up to the composite test result). For methodology, see Reference 1, pp. 4-5.
[d] Relative percentage of subcycle contribution (3) to the total composite test result.
[e] In grams per brake-horsepower-hour: High (H) > 90
$90 >$ medium (M) ≥ 60
Low (L) < 60

Table II-4

9-Mode Versus Transient Emissions

Current Technology Engines[1][2]

Engine	BSHC 9-Mode	BSHC Transient	BSCO 9-Mode	BSCO Transient
1979 GM 292	0.42	2.12	26.86	54.98
1979 GM 454	0.39	2.30	17.33	51.55
1979 GM 350	0.79	3.14	14.62	118.07
1979 IHC 446	0.42	3.27	24.28	90.40
1979 GM 366	0.50	2.16	17.40	43.43
1979 IHC 345	2.73	2.44	17.68	34.44
1979 GM 350	0.59	2.48	20.40	64.76
1979 Ford 400	2.15	4.89	53.16	112.43
1979 Ford 370	1.20	3.51	37.12	47.75
1979 Chrysler 360	1.18	2.67	21.38	98.14
1979 Chrysler 440	0.83	3.83	10.47	112.38
1979 GM 454	0.47	1.31	20.11	78.49

[1] Engines were tested as received from the manufacturers.

[2] All levels are undeteriorated.

Table II-5

Cold Start Contribution to Composite Emission Results

Engine	HC Composite HS	HC Composite Total Test	HC % Due To CS	CO Composite HS	CO Composite Total Test	CO % Due To CS
Ford 400	4.26	4.80(H)	11.3%	110.4	113.2	2.5%
Chrysler 440	3.70	3.81(H)	2.9%	112.5	115.6	2.7%
Ford 370	3.10	3.31(H)	6.3%	43.5	45.0	3.3%
IHC 446	3.06	3.32(M)	7.8%	90.5	92.9	2.6%
GM 350	1.71	2.57(M)	33.5%	66.0	67.8	2.7%
Chrysler 360	2.46	2.45(M)	neg.	90.0	92.0	2.2%
GM 350	2.36	2.66(M)	11.3%	97.2	101.5	4.2%
IHC 345	1.98	2.35(M)	15.7%	31.3	32.8	4.6%
GM 454	1.14	1.29(L)	11.6%	79.8	81.9	2.6%
GM 366	1.55	2.22(L)	30.2%	40.4	41.9	3.6%
GM 292	1.38	2.12(L)	34.9%	51.2	55.0	6.9%
GM 454	2.04	2.46(M)	17.1%	54.8	55.9	2.0%

HC Averages:		
	High (H):	6.3%
	Med. (M):	14.2%
	Low (L):	25.6%

* Grams/BHP-hr, results of individual tests, unweighted.

Table II-6

Test Portions/Emission Reduction Technologies

	HC		CO	
	Cold/Warm Start[1]	Other[2]	LAF[3]	Other[4]
Carburetion	X	X	X	X
Calibrations	X	X	X	X
Manifold/Combustion Chamber	X	X	X	X
Air Injection		X	X	X
Automatic Choke	X			X
EFE	X			X
Heated Air Intake	X			X
EGR		X		

[1] Sample Bags 1 & 5

[2] Sample Bags 2, 3, 4, 6, 7, 8

[3] Sample Bags 3 & 4

[4] Sample Bags 1, 2, 4, 5, 6, 8

Table II-7

Idle CO Current Technology Baseline Emissions

Engine	Idle CO (%)	Complies with 1984 standard?
IHC 446	.299	yes
IHC 345	.402	yes
GM 366	.913	no
GM 350	1.158	no
Ford 400	1.853	no
Ford 370	.515	no
Chrysler 360	.226	yes
Chysler 440	1.279	no
GM 454	.596	no
GM 292	.308	yes
GM 454	.888	no
GM 350	.242	yes

Figure II-1

CO Distribution of 1979 Baseline Engines

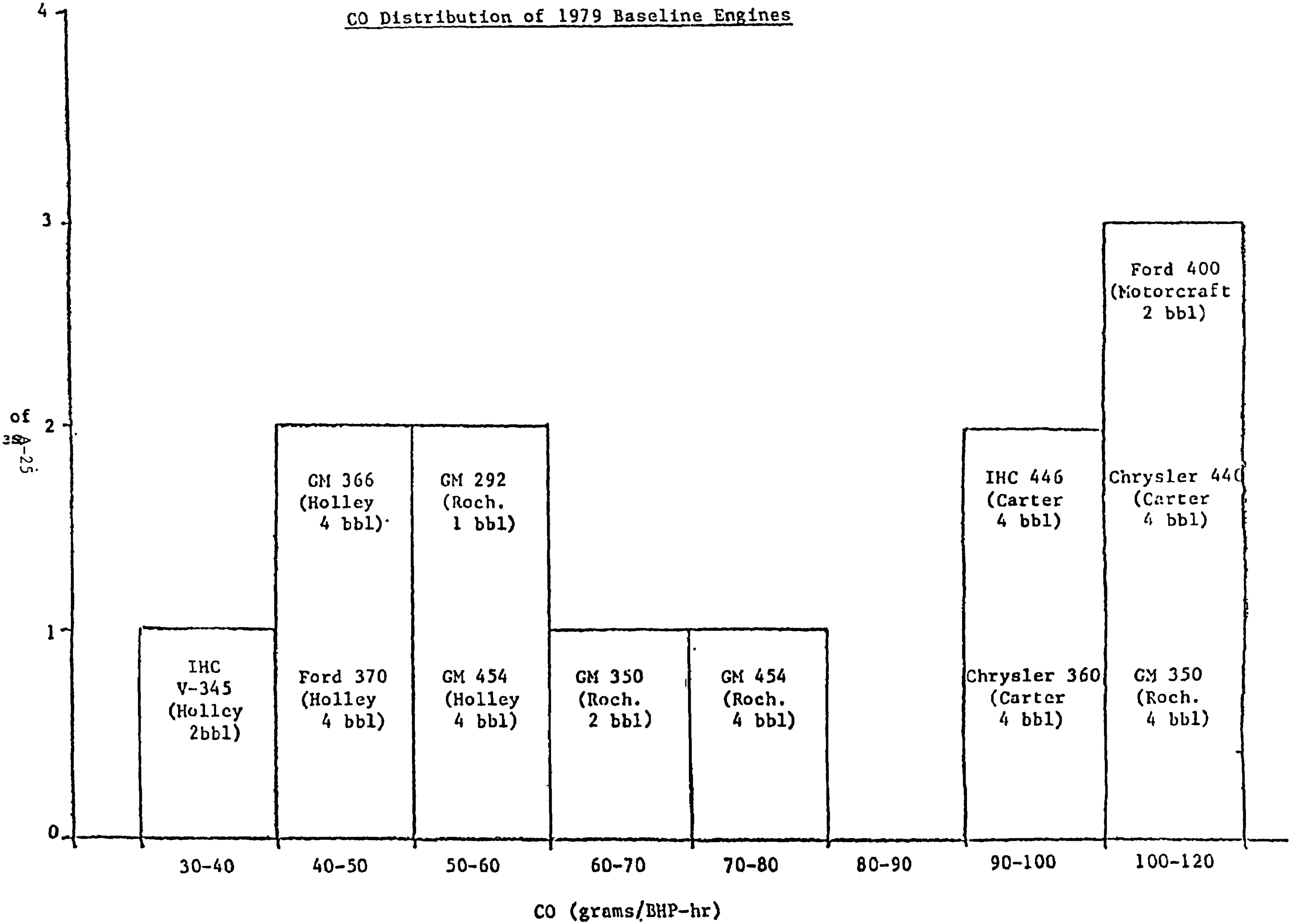
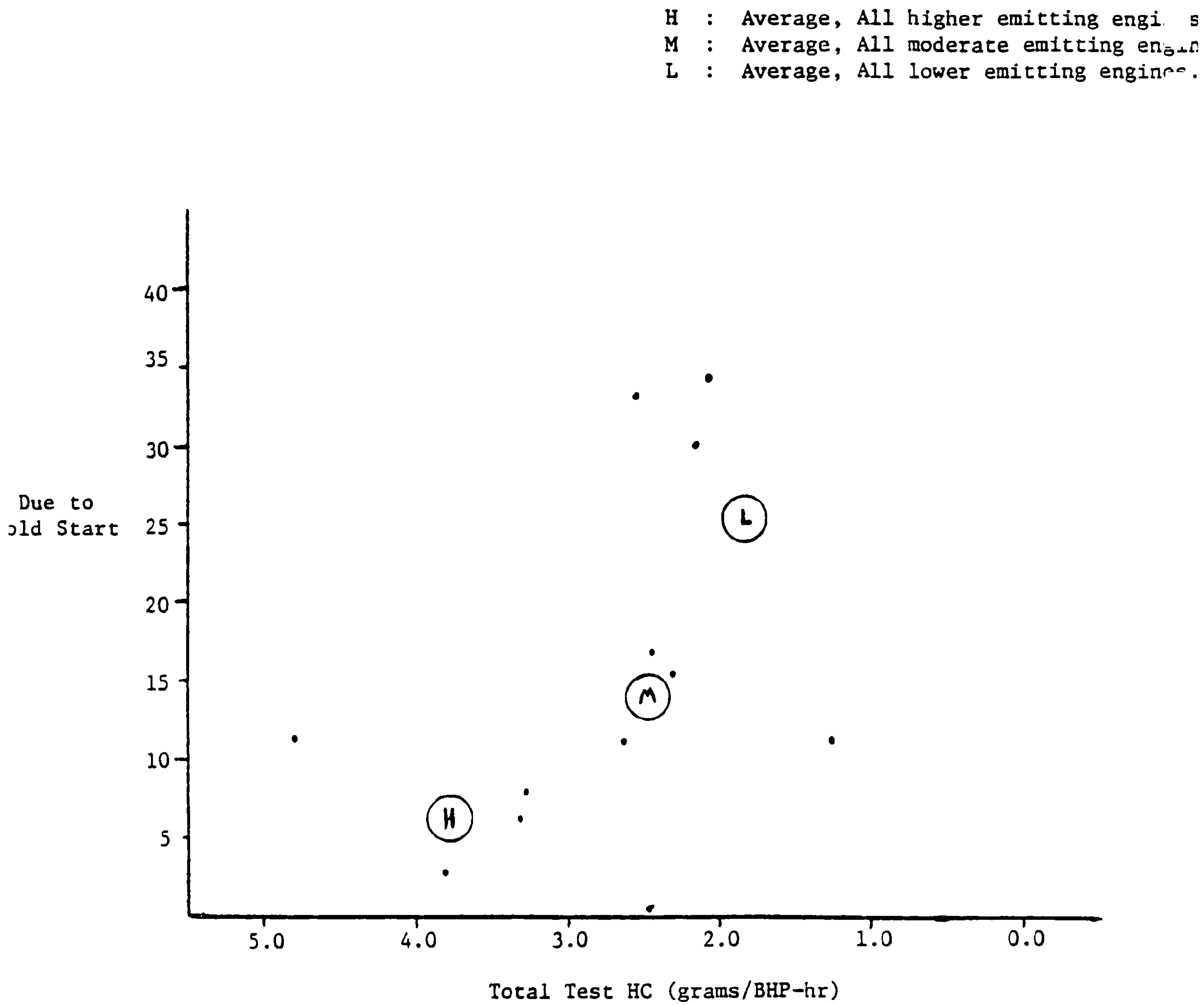


Figure II-2

Cold Start Contribution to Total Test
HC Emissions as a Function of Total Test Emissions



References

1. Cox, Timothy P., "Heavy-Duty Gasoline Engine Emission Sensitivity to Variations in the 1984 Federal Test Cycle," SAE No. 801370.

2. Auiler, J., et. al., "Optimization of Automotive Engine Calibration for Better Fuel Economy-Methods and Applications," SAE Paper No. 770076.

3. Here we are addressing total hydrocarbon emissions and a total hydrocarbon emission standard. EPA intends to propose an optional non-methane hydrocarbon standard for HDEs in a future rulemaking.

4. The terms "High Estimate" and "Low Estimate" refer to the range of reduction efficiencies. The percent figures shown are the actual efficiencies.