# REGULATORY ANALYSIS AND ENVIRONMENTAL IMPACT OF FINAL EMISSION REGULATIONS FOR 1984 AND LATER MODEL YEAR LIGHT-DUTY TRUCKS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL

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FINAL EMISSION REGULATIONS FOR 1984 AND

LATER MODEL YEAR LIGHT-DUTY TRUCKS

PREPARED BY

OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL

APPROVED BY

Michael P. Walsh

Michael P. Walsh, Deputy Assistant Administrator for
Mobile Source Air Pollution Control

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## Important Notice

This Regulatory Analysis was completed prior to the EPA decision to delay the model year of compliance from 1983 to 1984. Thus, the analyses presented here were done under the assumption that LDTs would meet the standards beginning in the 1983 model year. While shifting the first model year of compliance to 1984 will have an effect on the analyses and their conclusions, they still remain valid. (The following paragraphs illustrate the kinds of effects which occur.) For this reason we have chosen to go ahead and publish the document as it is.

The delay in the regulations has an effect on the environmental and economic analyses of Chapter IV and V because of the dependence of the analyses on various growth projections. Given another year, the objective criteria surrounding the arrival of new LDT control systems will have changed slightly. For example, the constantly changing mix of emission contributions to urban air quality will be a little different in 1984 than 1983. Likewise, the increased production of LDTs which we expect to happen during 1984-88 relative to 1983-87 will mean that the aggregate cost of the package over 5 years will be slightly greater; the cost per vehicle, on the other hand, will be slightly less, since more vehicles will share the aggregate cost. These kinds of effects on the environmental and economic analyses are not great, and hence, we do not feel a need to adjust them to reflect the 1-year shift in the regulations.

As a final note, the cost-effectiveness numbers computed in Chapter VII should not be affected by the delay in the regulations. This is simply because the changes in the economic cost and environmental benefit (which make up the calculation) are so small that their ratio is not noticeably affected.

## NOTE

This document has been prepared in satisfaction of the Regulatory Analysis required by Executive Order 12044 and the Economic Impact Assessment required by Section 317 of the amended Clean Air Act. This document also contains an Environmental Impact Statement for the Final Rulemaking Action.

## Table of Contents

Table of Contents (cont'd)

# CHAPTER I

## SUMMARY

As the total amount of urban emissions from light-duty vehicles is reduced, the portions which light-duty trucks (LDTs) and heavy-duty vehicles (HDVs) contribute becomes increasingly significant. For example, it is expected that the LDT and HDV fractions of total mobile source urban hydrocarbon (HC) emissions will climb from 14% and 12%, respectively, in 1976 to 22% and 21% in 1995. The carbon monoxide (CO) fractions will increase from 13% and 15%, for LDTs and HDVs respectively to 28% and 18%. Nitrogen oxides fractions will increase from 9% and 23% to 10% and 39%. It is in light of these expectations that Congress has mandated stricter controls on the gaseous emissions from heavy-duty engines used in HDVs and from light-duty trucks in the 6,000 to 8,500 lbs. GVWR range (hereafter called "heavy" light-duty trucks). It is also in light of these expectations that EPA is considering stricter controls on emissions from light-duty trucks in the under-6,000 lbs. GVWR range (hereafter called "light" light-duty trucks).

This rulemaking follows in part from the Congressional requirement that EPA prescribe by regulation standards for heavy LDTs which by 1983 will require 90% reductions in HC and CO emissions, relative to a baseline of uncontrolled (1969) heavy LDTs. The remaining part of the rulemaking follows from the general Congressional directive that EPA establish standards for emissions from new motor vehicles which cause or contribute to air pollution which endangers public health or welfare.

The purpose of this regulatory analysis is to present the results of EPA analyses of the environmental and economic impacts and the cost effectiveness of the proposed regulations. The reader will find chapters devoted as well to the make-up of the light-duty truck industry and to alternative actions considered by the Agency.

The regulations include the statutory 1983 HC and CO 90 percent reduction standards for heavy light-duty trucks. These standards are 0.8 g/mi HC and 10 g/mi CO.

The regulations also include several other standards. These are (1) HC and CO standards for light LDTs, equal to the standards for heavier LDTs; (2) idle CO standards applicable to gasoline-fueled LDTs; and (3) a zero-emissions standard for crankcase emissions from all diesel LDTs.

Although some of the standards for heavy LDTs are being proposed under one statutory authority while the remaining standards are being proposed under another statutory authority, the levels of all standards will be the same for all LDTs. The class will remain a single class, with a single test procedure and a single set of certification test vehicles.

Selective Enforcement Auditing (SEA) procedures for LDTs are being revised in this package to conform to the improved sampling system recently enacted for heavy-duty engines and vehicles. These revisions include a 10% acceptable quality level (AQL) to replace the current 40% AQL applicable to LDTs.

Additional changes appear in the rule. A new definition of "useful life" is introduced. "Useful life" will be the average period of use up to vehicle retirement or engine rebuild or replacement, to be determined by the manufacturer and stated on the tune-up label. Revisions to the restrictions on the maintenance performed on vehicles during durability testing and recommended to purchasers are also promulgated.

## A. Industry Description

The light-duty truck industry uses both gasoline and diesel engines and consists at present of five domestic manufacturers which together account for 94 percent of the U.S. market and five foreign manufacturers. All of the manufacturers with the exception of International Harvester also produce passenger cars. The LDT market is dominated by GM, Ford, and Chrysler, who together account for about 88 percent of sales. Imports are a small but rapidly increasing fraction of the market.

Sales of LDTs in 1978 were about 3.37 million units. LDT sales have been increasing faster than sales of passenger cars over a period from 1974 to 1978. However the growth rate is not expected to be the same in later years. In the past two years energy availability and price has effected the sale of LDTs, whose fuel economy is lower than LDVs. Extrapolation of sales growth over the past decade predicts that 1984 sales will be about 3.5 million units. By 1987, the last year covered by the cost analysis of this document, sales will be about 4.0 million units. Light-duty diesel truck sales are estimated at over .3 million; the 1987 sales estimate will double to over .6 million.

Vehicles in the light-duty truck class are mainly pick-up trucks and vans used primarily for personal transportation. Those produced by the manufacturers which also produce passenger cars share many components with those cars. Emission control technology used on passenger cars has generally been easily adapted for use on light-duty trucks. This is expected to be the case in the future as well.

## B. Impact on the Environment

The projected improvement in light-duty truck emissions and the ensuing decrease in total urban emissions will have a significant positive effect on the environment. Light-duty trucks will exhibit by 1999 reductions of 55% in HC emissions, and 62% in CO emissions, relative to their performance if the 1979 standards and other certification requirements were not changed.

On the basis of these reductions and the air quality models currently approved for use by the states, EPA estimates that as a result of the final rulemaking, by 1999 urban ambient levels of oxidant will be reduced by 1 percent to 2 percent, levels of carbon monoxide by 4 percent.

Secondary emission effects; water, noise and energy consumption effects; and commitments of scarce resources as a result of promulgation of the 1984 regulations are all expected to be negligible. Effects on urban areas are expected to be limited to the improvement in urban air quality stated in the previous paragraph.

C. Costs

The increased costs which manufacturers of light-duty trucks will have to bear, before passing them on to their customers, as a result of the 1983 regulations consist primarily of the cost of installation of new emission control systems. Development programs and certification testing are the other components of the costs to manufacturers, but are much smaller.

Selling prices for LDTs are estimated to increase by an average of about $95 as a result of the proposed action.

Aggregate cost for the first five year's of compliance will be about $1.29 billion (present worth on January 1, 1983, assuming a 10% discount rate). The aggregate cost per light-duty truck sold in the first five years will be about $95 (present worth on January 1 of the year of production).

The 1983 regulations will increase the average retail selling price of a vehicle by about 1 percent to 2 percent. The Ford Econometric Model which accounts for elasiticity of demand, increased first costs and greater ownership costs, gives an average long term sales decrease of about 0.2 percent due to the proposed regulations. The impact on both price and sales volume will be far less than normal annual changes. There should be no noticeable effect on industry employment or productivity.

The increase in the selling price of light-duty trucks is estimated to contribute about 0.0075 percentage points of rise in the Consumer Price Index in 1983. As the public will receive air quality benefits in exchange for higher LDT prices, this rise in the Consumer Price Index cannot properly be termed inflation.

D. Alternatives

The alternatives evaluated are in three areas: 1) Alternative Standards, 2) Alternatives to Specific Elements of the Rulemaking, 3) Alternative Timing for Implementation.

1. Alternative Standards - Two options were available. The first option concerned the stringency of the standards; the second

involved dividing the light-duty truck class into subcategories and establishing separate standards for each subcategory. EPA does not wish to promulgate standards more stringent than those of the NPRM, nor has it identified any basis for a less stringent level. Concerning the option of class subdivisions, it would be outside the range of the rulemaking to change the class limits at this time.

2. Alternatives to Specific Elements of the Rulemaking - Alternatives including the redefinition of useful life, in-use durability testing, allowable maintenance regulations, AQL, and diesel crankcase control are not discussed in this document but are referred to the appropriate sections of the Summary and Analysis of Comments.

3. Alternatives Timing for Implementation - EPA proposed the light-duty truck regulation for 1983. A detailed analysis concerning the provisions of the 1977 Clean Air Act and their relations to any minimum leadtime was referred to the Summary and Analysis of Comments. The conclusion reached is that the 1983 model year is a readily attainable compliance deadline and that there are no legal barriers to EPA's promulgation.

E. Cost Effectiveness

An analysis of the cost effectiveness of each major element of the regulation package and the overall package has been done. The analysis developed benefits expressed as tons of pollutant removed (HC or CO) over the average lifetime of an individual vehicle along with total costs for the same lifetime.

The overall incremental lifetime cost effectiveness has been established at $164/ton for HC and $12/ton for CO. Incremental lifetime benefits are set at about .3 tons/vehicle for HC and about 4 tons/vehicle for CO.

# CHAPTER II

# INTRODUCTION

## A. Light-Duty Truck Emission Regulation History and Background

### 1. History to Date

The first Federal regulations for the control of motor vehicle emissions placed trucks and similar vehicles having gross vehicle weight ratings (GVWR) of 6,000 pounds or less (typically "half ton" pick-ups and vans) in the light-duty vehicle (LDV) class. The LDV class also included passenger cars, and so, beginning in the 1968 model year, trucks of 6,000 pounds GVWR or less were subject to the first Federal passenger car emission standards. Under this classification, these vehicles would have been required to meet the same statutory emission reductions for hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) as passenger cars, on the same schedule. However, lawsuits were filed by the manufacturers disputing EPA's classification. These challenges were successful, and as a result, EPA created the light-duty truck class (to 6,000 pounds GVWR) effective for the 1975 model year. The numerical standards for the new class were slightly greater than for the light-duty vehicle class (see Tables II-A and B for summaries of Federal and California standards for light-duty vehicles and light-duty trucks).

While the 1975 LDT standards were numerically greater, and therefore in some cases less stringent than standards for passenger cars of the same year, they were more stringent than the heavy-duty engine standards, which applied to trucks on the upper side of the 6,000 pound GVWR dividing line. Manufacturers elected to "shift" part of their pick-up and van production to the other side of this dividing line by building larger numbers of trucks and vans over 6,000 pounds GVWR (heavy "half ton" and three quarter ton vehicles). The motivation was a less costly emission control system and the elimination of the need for catalysts (and their resulting need for unleaded gasoline). In response to this GVWR "migration", EPA expanded the light-duty truck class to include most vehicles up to 8,500 pounds GVWR. This change, effective for the 1979 model year, brought the vast majority of "personal use" light trucks into one homogeneous class for the first time. The LDT standards for HC, CO and NOx were revised for the same year to reflect advances in emission control technology as demonstrated on light-duty vehicles. EPA considered the larger weights and road loads (aerodynamic and tire drag) typical of light-duty trucks when it set the 1979 standards. The standards also reflected certain test procedure revisions.

The fuel evaporative emission standards for the LDT class have followed a somewhat different schedule. The first evaporative emission standard was set at 2 grams per test for the 1975 model

Table II-A

Emission Standards for Light-Duty Vehicles
(g/mile)

| | Federal | | | | | | California | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOx | Evap. 1/ | Particulate 9/ | | HC | CO | NOx | Evap. 1/ |
| 1972 | 3.4 | 39 | -- | 2.0 | -- | | 3.2 | 39 | 3.0 | 2.0 |
| 1973 | 3.4 | 39 | 3.0 | 2.0 | -- | | 3.2 | 39 | 3.0 | 2.0 |
| 1974 | 3.4 | 39 | 3.0 | 2.0 | -- | | 3.2 | 39 | 2.0 | 2.0 |
| 1975 | 1.5 | 15 | 3.1 | 2.0 | -- | | 0.9 | 9.0 2/ | 2.0 | 2.0 |
| 1976 | 1.5 | 15 | 3.1 | 2.0 | -- | | 0.9 | 9.0 | 2.0 | 2.0 |
| 1977 | 1.5 | 15 | 2.0 | 2.0 | -- | | 0.41 | 9.0 | 1.5 | 2.0 |
| 1978 | 1.5 | 15 | 2.0 | 6.0 3/ | -- | | 0.41 | 9.0 | 1.5 | 6.0 3/ |
| 1979 | 1.5 | 15 | 2.0 | 6.0 | -- | | 0.41 | 9.0 | 1.5 | 6.0 |
| 1980 | 0.41 | 7.0 | 2.0 | 6.0 | -- | | 0.41 4/ | 9.0 | 1.0(1.5) 6/ | 2.0 3/ |
| 1981 | 0.41 | 3.4 7/ | 1.0 8/ | 2.0 | -- | A 5/ | 0.41 | 3.4 | 1.0(1.5) 6/ | 2.0 |
| | | | | | | B | 0.41 | 7.0 | 0.7 | 2.0 |
| 1982 | 0.41 | 3.4 7/ | 1.0 8/ | 2.0 | 0.6 | A | 0.41 | 7.0 | 0.4(1.0) 6/ | 2.0 |
| | | | | | | B | 0.41 | 7.0 | 0.7 | 2.0 |
| 1983 | 0.41 | 3.4 | 1.0 8/ | 2.0 | 0.6 | | | 7.0 | 0.4(1.0) 6/ | 2.0 |
| 1984 | | | | | 0.6 | | | | | |
| 1985 | | | | | 0.2 | | | | | |

1/ Gasoline vehicles only (g/test).
2/ Federal standard instituted as part of the 1975 waiver.
3/ SHED test.
4/ Compliance with 0.39 g/mile non-methane is optional. 1980 and later
5/ Manufacturer must elect one option (A or B) for both 1981 and 1982.
6/ Optional 100,000 mile durability NOx standard.
7/ Possible waiver to 7.0 g/mile.
8/ Possible diesel waiver to 1.5 g/mile.
9/ Diesel vehicles only.

Table II-B

Emission Standards for Light-Duty Trucks
(g/mile)

Federal

| Year | HC | CO | NOx | Evap. 1/ | Particulate 8/ |
|---|---|---|---|---|---|
| 1968-74 7/ | | | | | |
| 1975 | 2.0 | 20 | 3.1 | 2.0 | -- |
| 1978 | 2.0 | 20 | 3.1 | 6.0 2/ | -- |
| 1979 3/ | 1.7 | 18 | 2.3 | 6.0 | -- |
| 1981 | 1.7 | 18 | 2.3 | 2.0 2/ | -- |
| 1982 2/ | 1.7 | 18 | 2.3 | 2.0 | .6 |
| 1983 6/ | .8 | 10 | 2.3 | 2.0 | .6 |
| 1985 6/ | .8 | 10 | 75% | | .26 |

California

| | | 0-6,000 GVWR | | | 6,001-8,500 GVWR | | | All |
|---|---|---|---|---|---|---|---|---|
| Year | IW | HC | CO | NOx | HC | CO | NOx | Evap. 1/ |
| 1975 | All | 2.0 | 20 | 2.0 | Same as HD | | | |
| 1976 | All | 0.9 | 17 | 2.0 | | | | |
| 1977 | All | 0.9 | 17 | 2.0 | | | | |
| 1978 | All | 0.9 | 17 | 2.0 | 0.9 | 17 | 2.3 | 6.0 2/ |
| 1979 | 0-3999 | 0.41 4/ | 9.0 | 1.5 | 0.9 | 17 | 2.3 | 6.0 |
| | 4000-6000 | 0.50 | 9.0 | 2.3 | 0.9 | 17 | 2.3 | 6.0 |
| | 6001-8500 | -- | -- | -- | 0.9 | 17 | 2.3 | 6.0 |
| 1980 | 0-3999 | 0.41 4/ | 9.0 | 1.0(1.5)5/ | 0.9 | 17 | 2.3 | 2.0 2/ |
| | 4000-6000 | 0.50 | 9.0 | 2.0(2.3)5/ | 0.9 | 17 | 2.3 | 2.0 |
| | 6001-8500 | -- | -- | -- | 0.9 | 17 | 2.3 | 2.0 |
| 1981 | 0-3999 | 0.41 4/ | 9.0 | 1.0(1.5)5/ | 0.41 4/ | 9.0 | 1.0(1.5)5/ | 2.0 |
| & | 4000-6000 | 0.50 | 9.0 | 2.0(2.3)5/ | 0.50 | 9.0 | 1.5(2.0)5/ | 2.0 |
| 1982 | 6001-8500 | -- | -- | -- | 0.60 | 9.0 | 2.0(2.3)5/ | 2.0 |
| 1983 | 0-3999 | 0.41 4/ | 9.0 | 0.4(1.0)5/ | 0.41 4/ | 9.0 | 0.4(1.0)5/ | 2.0 |
| | 4000-6000 | 0.50 | 9.0 | 1.0(1.5)5/ | 0.50 | 9.0 | 1.0(1.5)5/ | 2.0 |
| | 6001-8500 | -- | -- | -- | 0.60 | 9.0 | 1.5(2.0)5/ | 2.0 |

1/ Gasoline vehicles only (g/test).
2/ SHED test.
3/ Federal LDT class was expanded for 1979 MY to include most vehicles up to 8,500 lbs. GVWR.
4/ Compliance with 0.39 g/mi non-methane is optional.
5/ Optional 100,000 mile durability NOx standard.
6/ Clean Air Act requires 90% HC and CO reduction in 1983 and 75% NOx reduction in 1985 for vehicles over 6,000 lbs. GVWR.
7/ Prior to 1975 LDTs up to 6,000 lbs. GVWR were classified as LDVs.
8/ Diesel vehicles only.

year, measured using a carbon trap procedure. For 1978 a better measurement procedure (the SHED test) was adopted and the standard was set at 6 grams per test which, with the more accurate test procedure, was more stringent than the old 2-gram standard. In 1979, trucks in the 6,000 to 8,500 pound GVWR range came under this 6-gram standard. A 2-gram, SHED-based standard has recently been set for the 1981 model year.

Finally, standards for particulate emissions from diesel light-duty trucks have also recently been promulgated. These standards are required by the Clean Air Act as amended, but the Act left EPA to determine their level. EPA has set a standard of 0.60 grams per mile for 1982, and a tighter standard of 0.26 grams per mile for 1985.

It should be pointed out that the state of California, under waivers granted by EPA, has instituted stricter standards with earlier implementation dates than the nationwide levels. California also has divided the under-8,500 GVWR group into several narrower subclasses, each with its own set of emission standards. While EPA puts a curb weight ceiling of 6,000 pounds on the light-duty truck class, California does not. However EPA allows vehicles above this ceiling, which could be certified to the less stringent heavy-duty engine standards, to be certified to the LDT standards and test procedures. This mitigates the effect of the curb weight disparity on manufacturers.

2. Clean Air Act Provisions

From the rulemaking which established the separate light-duty truck class up until this rulemaking, light trucks have been regulated under the general authority in the Clean Air Act. Congress had set no specified reductions for these vehicles to meet. This general statutory authority is as follows:

> The Administrator shall by regulation prescribe (and from time to time revise) . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles . . . which in his judgement cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. . .
>
> Any regulation . . . shall take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period.
>
> (Section 202(a) of the Clean Air Act)

With the Clean Air Act Amendments of 1977, Congress created a statutory heavy-duty class. All vehicles over 6,000 pounds GVWR are considered to be "heavy-duty" under the Clean Air Act. Further, these vehicles are required to meet a minimum 90% reduction in HC and CO by the 1983 model year. A minimum 75% decrease in NOx is also required by 1985. These reductions are measured from gasoline-fueled "heavy-duty" vehicles produced in "baseline" model years: 1969 for HC and CO, and 1973 for NOx. These reductions closely parallel those required for light-duty vehicles. However, EPA is allowed to give manufacturers more time to apply the appropriate technology to "heavy-duty" vehicles than Congress itself gave for manufacturers of light-duty vehicles. As a result of this legislation, the top portion of EPA's light-duty truck class, the 6,000-8,500 pound GVWR portion, is Congressionally defined as "heavy-duty". As such, it is required to meet the statutory reductions set forth above. (EPA is meeting the statutory requirements for the remainder of the Congressionally defined "heavy-duty" class in a separate rulemaking.)

The Clean Air Act provides a mechanism for dealing with the situation which would arise if EPA later found that compliance with standards based on the minimum reductions in HC, CO and NOx set by the Act could not be achieved on schedule. The Act allows EPA to revise the 90%-reduction HC and CO, and 75%-reduction NOx standards towards less stringency, but only if the EPA Administrator finds,

> . . . that compliance with the emission standards otherwise applicable for such model year cannot be achieved by technology, processes, operating methods, or other alternatives reasonably expected to be available for production for such model year without increasing cost or decreasing fuel economy to an excessive and unreasonable degree.

(Section 202(a) of the Clean Air Act)

Revised standards may apply only for a period of three years, after which either more stringent revised standards or the original statutory standards must be established.

In addition to this mechanism for revising the statutory standards should they prove infeasible, the Clean Air Act provides for a system of nonconformance penalties. Such penalties would be paid by a manufacturer who, by necessity or by choice, produces vehicles which do not comply with the statutory standards. In exchange, the manufacturer would be permitted to certify and sell such nonconforming vehicles. EPA must make this system operational only if the Administrator does not determine the statutory standards to be practicable.

The law is completely mute on either a definition or standards for vehicles which, because their GVWR is less than 6,000 pounds are not "heavy-duty" vehicles, and, because of the court decision which required EPA to remove them from the light-duty vehicle class are not light-duty vehicles. These vehicles, the bottom portion of the light-duty truck class as EPA's regulation define it, are still included in the general statutory authority described above.

The general statutory authority also includes the "heavy-duty" class during the period until 1983 for HC and CO and until 1985 for NOx. For model years prior to 1983, the Clean Air Act gives guidance as to how the general authority is to be applied to the "heavy-duty" class.

> The Administrator shall prescribe regulations . . . applicable to emissions of carbon monoxide, hydrocarbons, and oxides of nitrogen from classes or categories of heavy-duty vehicles . . manufactured during and after model year 1979. Such regulations applicable to such pollutants from such classes or categories of vehicles or engines manufactured during model years 1979 through 1982 shall contain standards which reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of such technology.
>
> (Section 202(a) of the Clean Air Act)

For model years 1983 and 1984, only the very general guidance applicable to all emission standards applies (in addition to the minimum 90% HC and CO reductions).

All motor vehicle emission standards established under the Clean Air Act must apply to vehicles or engines for their "useful life." The Act directs the EPA Administrator to prescribe regulations under which the useful life will be determined. The Act constrains the useful life of vehicles in the light-duty truck class (both above and below 6,000 pounds GVWR) to be 5 years or 50,000 miles (or the equivalent), whichever first occurs, unless the Administrator determines that a longer period is appropriate.

## B. Description of Final Rulemaking

### 1. Revised and New Emission Standards

EPA has established HC and CO exhaust emission standards for light-duty trucks for the 1983 and later model years and has chosen to implement the statutory 90 percent reduction in HC and CO emissions. A "baseline" emissions testing program was designed and conducted as a means of finding the level of emissions from earlier, uncontrolled LDT's. Using this baseline, the resulting 90 percent reduction standards are 0.8 g/mi for HC and 10 g/mi for CO.1/

After the completion of testing and the proposal of these standards, we discovered that the contractor which conducted the testing had adjusted a number of carburetors improperly. After ten of the trucks were readjusted and tested again, a recalculation of the average baseline emission results revealed that the properly adjusted vehicles produced a somewhat "cleaner" baseline than the original sample. The finalized standards, .8 g/mi for HC and 10 g/mi for CO, represent reductions of 88 percent for HC and 87 percent for CO from the final baseline. Because of the delays that would be involved in reproposing the standard at a lower level, combined with the relatively small environmental benefit which might be realized, the standards are being finalized as proposed.

EPA also sets new standards for emissions of CO under idle operation. EPA set the level of this standard to be equal to 10% of a sales-weighted average of idle emissions of 1969 heavy-duty engines. EPA has tested a sample of 1969 heavy-duty engines.3/ Since there is no reason to suppose that 1969 light-duty trucks have significantly different idle emissions, it would be redundant to test the latter when the heavy-duty engine baseline will be available. Based on testing the heavy-duty testing the idle standard will be approximately as follows:

| Pollutant | Level |
| --- | --- |
| CO | 0.47 percent at curb idle |

EPA also promulgates a zero-emissions standard for crankcase emissions (blowby) from diesel LDTs.

The revised HC and CO standards and idle standards, as they apply to the 6,000 to 8,500 lbs. GVWR portion of the LDT class are mandated by statute. The HC and CO standards and idle standards, as they apply to the under-6,000 lbs. GVWR portion and the diesel crankcase emission standard, are promulgated under the general authority of the Clean Air Act.

EPA does not revise the fuel evaporative emission standard of 2.0 grams per test now scheduled to take effect in 1981, the 1982 exhaust particulate standard (diesel vehicles only) of 0.6 grams per mile, nor the prohibition against crankcase emissions from gasoline-fueled vehicles. The practical effect of these standards on the design of light-duty trucks may be affected by other aspects of this action, notably the revisions to the AQL and the existing definition of "useful life".

2. Idle Test Procedures

Accompanying the idle standard are testing procedures for measuring vehicle idle emissions. Identical to the idle test procedures published in the heavy-duty regulations (45 FR 4136), the procedures are less restrictive than the standard Federal Test Procedure.

The recently adopted "short test" for idle emissions from light-duty trucks (45 FR 34802) is compatible with this test procedure. Differences between the two test procedures allow the certification procedure to be performed using the CVS/bag sampling equipment employed for the standard Federal Test Procedure. The certification procedure also uses somewhat more stringent instrument specifications than the short test to allow for more precise repeatability of certification data than is needed for a field test procedure. Vehicles passing the certification test procedure should also pass the short test.

3. Revised Definition of "Useful Life"

EPA is amending the current definition of "useful life" for light-duty trucks. The amendment would bring the period of use specified in the definition into closer agreement with the periods of use actually seen by light-duty trucks before they are scrapped or their engines are replaced or rebuilt. The proposed definition states that the useful life of a light-duty truck is the average period of use of the truck before vehicle retirement or engine replacement or rebuild. The manufacturer will determine what this period of use is in terms of years, miles, or hours of operation. However, the minimum useful life will be 5 years or 50,000 miles (the minimum required by the Clean Air Act) or the period of the basic mechanical warranty covering the engine assembly, whichever is greater.

The amended definition will apply to the warranty, recall, and certification provisions of the Clean Air Act. That is, manufacturers will be required to furnish owners with Section 207(a) and 207(b) (once 207(b) is implemented) warranties covering the period of use specified in the amended definition. A manufacturer would also be liable for recall of a category of its light-duty trucks if the EPA Administrator determines that a substantial number of the category does not conform to the emission standards during that period. And the longer useful life definition will be incorporated into the certification procedures via deterioration factors, as described in the next subsection.

4. Revised Certification Requirements Regarding Durability

EPA had proposed a substantially revised durability test procedure with this rulemaking. However, EPA is delaying the finalization of this proposed procedure to optimize all components of the program. A revised durability test procedure is expected to be implemented in conjunction with the statutory Light-Duty Truck NOx emission standard.

Beginning in 1983, and until finalization of a revised durability test procedure, the burden of durability testing will be on the manufacturers. The manufacturers will determine their deterioration factors in programs which they design and submit these deterioration factors to EPA as part of the certification process.

5. Revised Requirements Regarding Maintenance

EPA is revising the existing requirements regarding maintenance that may be performed on test vehicles and recommended to purchasers of LDTs. The revision will deregulate a number of maintenance items for which EPA currently prescribes minimum service intervals. Manufacturers will be free to recommend any service intervals for these items, but will still be required to follow their own recommendations when maintaining test vehicles. Not all maintenance items are to be deregulated, however. Emission-related maintenance items, the neglect of which has an immediate effect on emission levels or can have irreversible effects on other parts of the emission control system, will continue to be regulated. The manufacturer will be required to show that it's service intervals for these maintenance times are technologically necessary before it may perform the items on its test vehicles or recommend them to its customers.

6. Selective Enforcement Audit Program (SEA), Production Compliance Auditing (PCA) and Nonconformance Penalties (NCP)

The SEA program is an assembly-line emissions testing program used to aid in ensuring that light-duty trucks produced meet the emissions level to which they are certified. The process of conducting an SEA begins with a test order issued by EPA to a manufacturer. Each manufacturer will be assigned a limit on the number of test orders which EPA may issue during a model year, based on its projected annual sales. The goal of SEAs is to ascertain whether or not the production LDTs tested meet a 10 percent Acceptable Quality Level. An AQL of 10 percent allows for emissions measurement error and quality control aberrations which can not be totally eliminated at the assembly-line. Therefore, a 10 percent AQL in effect requires every LDT to meet applicable emission standards.

Failure of an SEA audit may result in suspension or revocation of the certificate of conformity for that configuration. To have the certificate reinstated subsequent to a suspension, or reissued subsequent to a revocation, the manufacturer must demonstrate, by passing a follow-up SEA audit, that improvements, modifications, or replacement have brought the original LDT configuration, the modified LDT configuration, or its replacement into compliance. The regulations include hearing provisions which allow the manufacturer to challenge EPA's suspension or revocation decision based on application of the sampling plans or the manner in which the tests were conducted.

In the NPRM EPA had proposed a mechanism for production compliance audits (PCA) and nonconformance penalties (NCP) applicable to LDTs above 6000 pounds GVWR. Since the proposed emission standards were considered feasible for all manufacturers to meet, NCPs were not to be made available in the system as proposed. In finalizing the rulemaking package, EPA continues to find the standards feasible for all manufacturers. The role of NCPs in this situation, however, is still under review by the Agency. Therefore, the PCA/NCP portions of the proposal are not being finalized in the present rulemaking.

## C. Organization of the Regulatory Analysis

This Regulatory Analysis presents an assessment of the environmental and economic impacts of the proposed light-duty truck regulations. It provides a description of the information and analyses used to review all reasonable alternative actions.

The remainder of this document is divided into five major sections. Chapter III presents a general description of light-duty trucks, a description of the manufacturers of this equipment, and the market in which they compete.

An assessment of the primary and secondary environmental impacts attributed to the proposed LDT regulations is given in Chapter IV. The degree of control reflected by the promulgated standards is described and a projection of air pollutant emission factors for the national LDT population, with the promulgated standards in place through 1999, is presented. The impacts of these regulations on urban emissions and the expected air quality benefits are considered. Secondary effects on other air pollutant emissions, water pollution and noise are also discussed in this section, as are commitments of scarce resources and impacts on urban areas.

An examination of the cost of complying with the regulations is presented in Chapter V. These costs include those incurred to develop and install emission control equipment on light-duty trucks, the costs to certify, and any increased vehicle operating costs which are expected to occur. Analysis is made to determine aggregate cost for the 1983-87 time frame. Finally, the impact that this regulation will have on industry and consumers will be reviewed, including the impact on the general level of prices in the economy.

Chapter VI will identify and discuss the alternatives to the proposed action, their expected impacts, and the reasons none has been adopted instead of the actual final regulations.

Chapter VII will present a cost effectiveness analysis of the final action and compare the results of this analysis with those done on other mobile source control strategies.

## References

1/ EPA Contract No. EPA 68-03-2683, "Baseline Characterization of Emissions from Medium-Duty Gasoline Vehicles Tested on a Chassis Dynamometer," with EG&G Automotive Research, Inc.

2/ A more complete discussion of the baseline program is contained in Issue K - "Numerical Standards and Standard Derivation," found in the Summary and Analysis of Comments document.

3/ T. Cox, G. Passavant, and L. Ragsdale, "1969 Heavy-Duty Engine Baseline Program and 1983 Emission Standards Development," EPA report, May 1979.

# CHAPTER III

# DESCRIPTION OF THE PRODUCT AND THE INDUSTRY

## A. Description of Light-Duty Trucks

### 1. Definition of Light-Duty Trucks

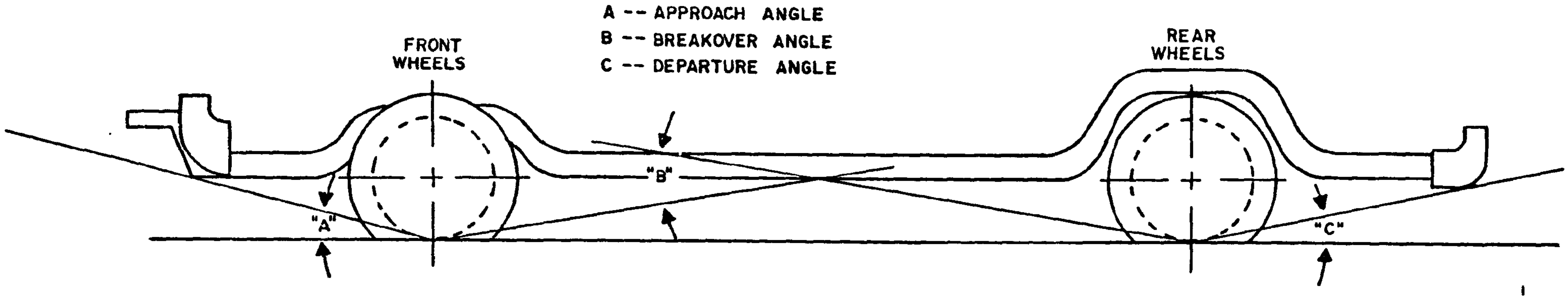
The light-duty truck (LDT) class includes all motor vehicles which have a gross vehicle weight rating (GVWR) of 8,500 pounds (3,546 kg) or less, have a vehicle curb weight of 6,000 pounds (2,722 kg) or less, have a basic vehicle frontal area of 45 square feet (4.3 square meters) or less, and which are: (1) designed primarily for purposes of transporting property or are derived from such vehicles, (2) designed primarily for transporting persons and have a seating capacity of more than 12, or (3) are available with special features enabling off-street or off-highway operation and use. Heavier light-duty trucks are those with GVWRs greater than 6,000 but less than or equal to 8,500 pounds.

Initially, Federal regulations classified all vehicles with GVWRs of 6,000 pounds or less as light-duty vehicles (LDVs); vehicles with GVWRs greater than 6,000 pounds were subject to heavy-duty engine (HDE) requirements. Beginning with the 1975 model year, non-passenger car vehicles with GVWRs of 6,000 pounds or less were reclassified as light-duty trucks. This ruling resulted in an increase in the number of vehicles certified with GVWRs greater than 6,000 pounds, since these vehicles would then be subject to standards less stringent than those applicable to the LDT class. As a result of this migration, EPA expanded the LDT class GVWR ceiling to 8,500 pounds, effective for the 1979 model year. The above definition reflects this change.

The proposed emission regulations for 1983 and later model year light-duty trucks contain a definition of what is meant by the phrase: "special features enabling off-street or off-highway operation and use." This is meant to include those vehicles which: (1) have four-wheel drive, and (2) have at least four of the following characteristics (calculated when the vehicle is at curb weight, on a level surface, with the front wheels parallel to the vehicle's longitudinal centerline, and with the tires inflated to the manufacturer's recommended pressure): (a) an approach angle of not less than 28 degrees, (b) a breakover angle of not less than 14 degrees, (c) a departure angle of not less than 20 degrees, (d) a running clearance of not less than 8 inches, and (e) front and rear axle clearances of not less than 7 inches each (see Figure III-A).1/

The automotive and truck industries have traditionally used GVWR categories for vehicle classification purposes. Historically, classes I and II have included vehicles with GVWRs between 0 and 6,000 pounds, and between 6,001 and 10,000 pounds, respectively.

Figure III-A


A -- APPROACH ANGLE
B -- BREAKOVER ANGLE
C -- DEPARTURE ANGLE
FRONT WHEELS
REAR WHEELS
"A"
"B"
"C"

Since all vehicle production and sales data are still reported on the basis of these categories, an estimate must be made concerning the percentage of those trucks with GVWRs between 0 and 10,000 pounds which also have GVWRs greater than 8,500 pounds. Based upon production data for recent years, EPA has estimated this percentage to be approximately 5.5 percent. It is anticipated that this figure will increase to roughly 13 percent in the next few years as manufacturers re-rate some of their vehicles to GVWRs greater than 8,500 pounds in order to make them subject to less stringent emission and fuel economy standards.2/

2. Use of Light-Duty Trucks

Light-duty trucks are produced in a wide variety of body-types encompassing a wide variety of possible functions. Virtually all light-duty trucks have two axles and four wheels, and most are equipped with gasoline-powered engines and two-wheel drive. A small number make use of diesel engines, and an increasing percentage are equipped with four-wheel drive. The three largest categories of light-duty trucks are, in order: pickups, vans, and utility vehicles. Together, these categories comprise approximately 95 percent of all U.S. light-duty truck sales (see Table III-A). The remaining sales include station wagons built on truck chassis, passenger carriers, and multi-stop vehicles.

Pickups have an enclosed cab, with varying amounts of seating and storage space. Behind the cab is an open, flat load-bed, with a hinged rear gate. Pickups can be equipped with caps which enclose the load-bed or with camper units of varying size. The pickup category includes three major types: conventional, compact, and car-type pickups. The compact pickups are, so far, nearly all either foreign or captive imports. Car-type pickups have a cab and front end similar to those of a passenger vehicle.

Vans have an enclosed load area which is typically connected with the driver's compartment, and can be used for transporting cargo and/or passengers, and for personal and recreational purposes. Most vans have very short hood lengths, allowing improved visibility and maneuverability.

The third major category of light-duty trucks is composed of general utility vehicles such as the Cherokee, Scout II, Blazer, Bronco, etc. These vehicles, in general, are capable of transporting both passengers and cargo, and of pulling fairly large trailers. Approximately 95 percent of the utility vehicles sold in 1978 were equipped with four-wheel drive.3/ Table III-A shows a breakdown of U.S. new truck retail deliveries by body type for the years 1976 to 1978.

Since they are available in a variety of styles, and because of their versatility, light-duty trucks are capable of being put to

Table III-A

U.S. New Truck Retail Deliveries by Body Type, 1976-1978
(GVWR ≦ 8,500 pounds)

| Body Type | 1976 | % | 1977 | % | 1978 | % |
|---|---|---|---|---|---|---|
| Conventional Pickup | 1,610,139 | 62.7 | 1,834,440 | 62.5 | 1,961,120 | 59.7 |
| Compact Pickup | 94,737 | 3.7 | 125,960 | 4.3 | 132,996 | 4.1 |
| Car-Type Pickup | 63,000 | 2.5 | 72,762 | 2.5 | 78,928 | 2.4 |
| Van and Cut-Away Chassis | 494,060 | 19.2 | 544,294 | 18.5 | 636,630 | 19.4 |
| Utility | 201,600 | 7.8 | 238,158 | 8.1 | 335,832 | 10.2 |
| Station Wagon (Truck Chassis) | 69,240 | 2.7 | 82,959 | 2.8 | 94,873 | 2.9 |
| Passenger Carrier | 4,984 | 0.2 | 5,728 | 0.2 | 6,492 | 0.2 |
| Multi-Stop | 31,678 | 1.2 | 33,209 | 1.1 | 36,092 | 1.1 |
| Other | 430 | - | 4 | - | - | - |
| Total | 2,569,868 | 100.0 | 2,937,514 | 100.0 | 3,282,963 | 100.0 |

Source: Estimated from Ward's Automotive Yearbook.

a wide range of uses, both private and commercial. Most can be used for transporting either heavy and/or bulky loads or moderate numbers of passengers. Some, with various possible configurations, can perform both functions (such as a passenger van with removable seats). Because of their heavy construction, LDTs are often well-suited for trailer-towing. Also, many LDTs are capable of rough, off-road use and operation under adverse driving conditions, particularly when equipped with four-wheel drive. In general, LDTs are better able to perform these functions than are passenger cars, which have limited load and passenger-carrying capacity, are lighter in construction, have less-powerful engines, and are usually confined to on-road use. Clearly, these characteristics make LDTs much more attractive and capable than passenger cars for performing certain functions.

Private uses can include such activities as personal transportation, moving and hauling, travel, sport and recreation, etc. Commercially, LDTs are used for such purposes as delivery of goods and services, public and personal transport, moving and hauling, trailer-towing, off-road service, etc., and find such uses in a variety of businesses and industries. Table III-B shows a percentage breakdown of light trucks by major use in 1972.

An important consideration with respect to the use of LDTs is the use and non-use of their capabilities. Clearly, many of the needs currently met by LDTs could not be reasonably met by other means or modes of transportation, and it can be expected that this will continue to be the case. In many other instances, however, consumers may buy a LDT because of anticipated requirements it can fill, but may then fail to make efficient use of its capabilities. For instance, a buyer, attracted by its utility, versatility, and durability, might purchase a 1-ton pickup when he may have only occasional light hauling to do. In this case, a smaller pickup may be sufficient to meet the user's requirements, with greater use of the vehicle's capability. As economic and energy constraints become more pronounced, it is likely that consumers will tend to purchase LDTs more suited to the jobs they will be required to perform. This trend would result in higher sales of smaller, lighter, more fuel-efficient LDTs, with (consequently) lower emissions.2/4/

## B. The Light-Duty Truck Industry

### 1. Structure

Light-duty trucks can be divided into two primary categories: domestic and imported. There are five manufacturers of LDTs in the United States; these are: General Motors (GM), Ford, Chrysler, American Motors (AMC), and International Harvester (IHC). With the exception of International Harvester, these manufacturers also produce light-duty vehicles (passenger cars), resulting in much common technology between the two types. General Motors and Chrysler each operate two LDT-producing divisions: for GM,

Table III-B

Percentage Breakdown of Light Truck Class by Major Use, 1972
(GVWR $\leqq$ 10,000 pounds)

| Use | % |
|---|---|
| Personal Transportation | 53.4 |
| Agriculture | 20.1 |
| Services | 7.7 |
| Construction | 6.9 |
| Wholesale and Retail | 6.1 |
| Utilities | 2.5 |
| Manufacturing | 1.3 |
| For Hire | 0.6 |
| Forestry and Lumbering | 0.5 |
| Mining | 0.2 |
| All Other | 1.2 |

Source: Census of Transportation, 1972, Truck Inventory and Use Survey: U.S. Summary; U.S. Bureau of the Census.

Chevrolet and GMC; and for Chrysler, Dodge and Plymouth. American Motors operates the Jeep division. International Harvester, which also produces a large number of heavy-duty vehicles, markets its LDTs under the name of Scout. The domestic manufacturers' relative market shares (see Table III-C) have been rather stable over the past few years, although the penetration by foreign manufacturers has been increasing significantly.

The two foreign manufacturers with the largest sales of LDTs imported for sale under their own names are Toyota and Nissan (Datsun). Another company, Toyo Kogyo, manufactures and sells a moderate number of trucks under the Mazda name. Toyo Kogyo, Isuzu, and Mitsubishi manufacture large numbers of trucks for sale by domestic companies (captive imports). Other foreign companies which produce LDTs for sale in the United States are Suzuki and Volkswagen; these companies have, so far, had small sales or have only recently entered the market. Nearly all of the trucks produced by these companies, as either foreign or captive imports, are compact pickups. A large number of LDTs are manufactured in Canadian plants of domestic companies and imported into the United States; these trucks will be considered as part of the domestic production.

2. Sales and Revenues

Financial sales data show the largest of the domestic LDT manufacturers to be General Motors, followed by Ford, Chrysler, International Harvester, and American Motors. Table III-D shows for each of these companies their total sales, net income, and average total number of employees (1978 data). It must be recognized that these figures are company-wide totals, and not just those pertaining to LDT production.

The only company showing a net loss for 1978 was Chrysler, with a loss of 204.6 million dollars. Because of its weak financial condition, Chrysler has sought, with some success, government-sponsored financial aid.

As was stated previously, International Harvester, although a manufacturer of light- and heavy-duty trucks, is not a manufacturer of automobiles. There has traditionally been a large carryover of technology from the light-duty vehicle industry to the light-duty truck industry. Because of this, IHC lacks the broad technological base which is available to the other LDT manufacturers, all of whom also market automobiles. This situation was a primary factor in NHTSA's decision to subject IHC LDTs to fuel economy standards less stringent than those applicable to the rest of the industry for 1981.2/

3. Employment

In addition to financial data, Table III-D shows corporate average employment levels in 1978 for the five domestic LDT

Table III-C

U.S. LDT Sales by Manufacturer, 1978
(GVWR $\leqq$ 8,500 pounds)

| Manufacturer | Sales | % Total |
|---|---|---|
| Domestic | | |
| GM | 1,434,011 | 42.6 |
| Ford | 1,152,610 | 34.2 |
| Chrysler | 382,046 | 11.4 |
| AMC | 154,553 | 4.6 |
| IHC | 34,081 | 1.0 |
| Total Domestic | 3,157,301 | 93.8 |
| Imported | | |
| Toyota | 94,882 | 2.8 |
| Nissan (Datsun) | 93,336 | 2.8 |
| Toyo Kogyo (Mazda) | 4,708 | 0.1 |
| Other | 17,340 | 0.5 |
| Total Imported | 210,266 | 6.2 |
| TOTAL | 3,367,567 | 100.0 |

Source: Estimated from *Ward's Automotive Yearbook*, 1979; *Automotive News*, 1979 Market Data Book Issue.

Table III-D

1978 U.S. Vehicle Manufacturer Information

| Company | Total Sales ($) | Net Income ($) | Employees |
|---|---|---|---|
| AMC | 2,585,428,000 | 36,690,000 | 27,517 |
| Chrysler | 13,618,300,000 | -204,600,000 | 157,958 |
| Ford | 42,784,100,000 | 1,588,900,000 | 507,000 |
| GM | 63,221,100,000 | 3,508,000,000 | 839,000 |
| IHC | 6,664,350,000 | 186,680,000 | 95,450 |

Source: Moody's Industrial Manual, 1979.

manufacturers. Because of the high degree of integration between the LDV and LDT industries (except in the case of IHC), only an estimate can be made regarding the number of employees involved in the production of LDTs. This estimate was made as follows: the corporate employment figures of GM, Ford, Chrysler, and AMC were totaled (1,531,000), and this figure was divided by the total number of vehicles produced by these four companies (18,640,700); a ratio of 0.082 employees per vehicle was obtained. This is a rough approximation of the number of employees required for the production of each vehicle. This same ratio of employees to vehicles was assumed to be applicable to LDT production. Multiplying this figure by the total number of LDTs produced in the United States during 1978 (3,083,647) yields an industry-wide employment estimate of approximately 253,000. A similar analysis indicated an approximate yearly payroll of 5.5 billion dollars for the U.S. LDT industry in 1978. (Base data for this analysis was obtained from Ward's Automotive Yearbook, 1979.)

## C. Light-Duty Truck Sales

### 1. Historical Sales

The past few years have seen a tremendous increase in LDT sales. This growth has been greater than that for light-duty vehicles. From Table III-E, it can be seen that from 1974 to 1978, LDT sales increased by nearly 58 percent, while passenger car sales increased by about 27 percent. The growth in total LDT sales can be attributed to an increase in the sale of heavier LDTs (those with GVWRs greater than 6,000 pounds). Since 1974, sales of LDTs with GVWRs less than or equal to 6,000 pounds have actually decreased, as Table III-F shows, while sales of trucks with GVWRs between 6,001 and 10,000 pounds have increased by 37 percent.

A closer look will now be taken at some of the constituents of these sales figures. First, California LDT sales will be considered. Table III-G shows California and 49-state sales for 1973-1978. These figures are for heavy as well as light-duty trucks, but it is assumed that the percentages would be nearly the same for only light-duty sales. As can be seen, California sales as a percentage of total U.S. sales decreased from 1973 to 1977, but showed a slight increase in 1978. Sales projections for 1980 indicate an increase to 9.4 percent (see Table III-J).

Sales broken down on the basis of domestic, captive, and imported LDTs are shown in Table III-H for the years 1975-1978. These figures show that sales in each of the three categories increased significantly during this time period.

Another way in which to consider LDT sales is on the basis of manufacturer. Table III-I shows LDT sales by manufacturer for the period 1974-1978. With the exception of IHC, all LDT producers increased their sales during these years.

Table III-E

U.S. New Car and Truck Sales, 1974-1978

| Year | Cars | LDTs* |
|---|---|---|
| 1978 | 11,258,400 | 3,356,000 |
| 1977 | 11,077,500 | 2,949,500 |
| 1976 | 10,053,200 | 2,574,600 |
| 1975 | 8,551,100 | 1,984,500 |
| 1974 | 8,818,000 | 2,131,900 |

* Estimated.

Source: Ward's Automotive Yearbook, 1979; Automotive News, 1979 Market Data Book Issue.

Table III-F

U.S. Truck Sales, 1974-1978

| Year | 0-6,000 lb GVWR | 6,001-10,000 lb GVWR |
|---|---|---|
| 1978 | 1,143,064 | 2,408,269 |
| 1977 | 1,218,094 | 1,903,103 |
| 1976 | 1,284,876 | 1,439,103 |
| 1975 | 1,204,259 | 895,758 |
| 1974 | 1,616,309 | 639,689 |

Source: *Automotive News*, Market Data Book Issues.

Table III-G

California and 49-State Truck Sales, 1973-1978

| Year | California | 49-State | California Sales as Percent of Total |
|---|---|---|---|
| 1978 | 347,245 | 3,616,095 | 8.70 |
| 1977 | 303,049 | 3,206,279 | 8.64 |
| 1976 | 264,937 | 2,793,072 | 8.72 |
| 1975 | 213,404 | 2,184,013 | 8.90 |
| 1974 | 241,897 | 2,415,021 | 9.10 |
| 1973 | 315,483 | 2,638,424 | 10.68 |

Source: *Ward's Automotive Yearbook*, 1979, p. 178.

Table III-H

U.S. LDT Sales, 1975-1978
(rounded to nearest hundred)

| Year | Total, 0-8500 lb* | Domestic | Captive | Import |
|---|---|---|---|---|
| 1978 | 3,356,000 | 3,005,000 | 140,700 | 210,300 |
| 1977 | 2,949,600 | 2,630,400 | 133,300 | 185,900 |
| 1976 | 2,574,600 | 2,334,900 | 100,300 | 139,400 |
| 1975 | 1,984,500 | 1,744,000 | 102,800 | 137,700 |

* Estimated.

Source: Ward's Automotive Yearbook; Automotive News, Market Data Book Issue.

Table III-I

U.S. LDT Sales by Manufacturer, 1974-1978
(estimated for GVWR $\leqq$ 8,500 pounds)

| | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|
| Chevrolet | 759,651 | 730,569 | 955,751 | 1,033,745 | 1,166,066 |
| GMC | 134,242 | 132,902 | 211,496 | 225,230 | 267,942 |
| Ford | 718,536 | 627,731 | 822,368 | 993,761 | 1,152,610 |
| Dodge | 244,342 | 237,056 | 314,875 | 367,012 | 374,473 |
| Plymouth | 4,277 | 4,141 | 4,609 | 5,559 | 7,572 |
| AMC/Jeep | 91,509 | 80,487 | 101,575 | 117,977 | 154,553 |
| IHC | 69,605 | 41,555 | 32,225 | 30,559 | 34,081 |
| Miscellaneous* | 116,392 | 137,705 | 139,357 | 185,912 | 210,274 |

* Includes non-captive imports.

Source: Automotive News, Market Data Book Issue.

Several important factors become apparent from these data. A slump in vehicle sales (both car and truck) is clearly noticeable for the years 1973 to 1975. This is most likely due to the combined effects of an economic slowdown and gasoline supply and price problems. These inter-related factors can have considerable influence on the automotive industry. Also of interest is the remarkably rapid growth of LDT sales in the late 1970's. A large factor in this surge must be the sudden "popular" image of LDTs, particularly of vans and sport/utility vehicles. An increased number of LDTs were being used for sport and recreation purposes. Another trend worthy of consideration is the increased sales of heavier LDTs. While lighter LDT sales dropped from 1974 to 1978, heavier LDT sales rose significantly. An obvious spur to this was the re-rating of some vehicles to higher GVWs in order to circumvent emission and fuel economy regulations.

2. Projected Sales

It can be expected that factors which influenced LDT sales in the past will continue to do so in the future. Primary among these will be energy availability and price. In the past two years, gasoline prices have practically doubled, and supply has at times been a problem. This undoubtedly has an effect on the sale of LDTs, whose fuel economy is lower than that of LDVs. By all indications, 1979 LDT sales will be down considerably from 1978 levels. Also of primary importance are economic influences. Historically, economic slow-downs and recessions have had a pronounced impact on the automotive industry. This will obviously continue to be the case.

Other factors, possibly of secondary importance, include fuel economy and emission standards, re-rating, and social influences. Manufacturers may find it necessary to shift production toward smaller, lighter LDTs, if not to meet government regulations, then perhaps to meet increased public demand for more efficient vehicles and to compete with foreign manufacturers. There will, of course, always be some demand for larger LDTs by those whose needs can not be met by smaller trucks. In addition, manufacturers are likely to re-rate some of their trucks in order to make them subject to less stringent regulations. Social factors will also continue to be felt by the LDT industry. If a negative image of truck ownership and use develops, for whatever reason, a significant decline in sales could result. Conversely, a positive image would be likely to have a boosting effect on sales.

Given the dependence of LDT sales on a variety of complex variables, the difficulties in forecasting such sales can be recognized. A number of such efforts have been undertaken, with wide variations in results. EPA's projections, based on information from Data Resources Inc., NHTSA, previous EPA studies, and historical data, are presented in Table III-J. Although total LDT sales are expected to increase through 1987, domestic production is anticipated to level off around 1985, while import, captive, and

Table III-J

LDT Sales Projections (millions)

Total U.S. Sales

| | 0-10,000 lb GVW 1/ | 0-8500 GVW 2/ | Domestic Gas LDT 5/ | Import/Captive LDT 4/ | LDDT 3/ |
|---|---|---|---|---|---|
| 1983 | 3.60 | 3.13 | 2.46 | .39 | .28 |
| 1984 | 3.97 | 3.45 | 2.69 | .43 | .33 |
| 1985 | 4.25 | 3.70 | 2.82 | .46 | .42 |
| 1986 | 4.42 | 3.85 | 2.84 | .48 | .53 |
| 1987 | 4.58 | 3.99 | 2.83 | .50 | .66 |
| 1988 | 4.81 | 4.18 | 2.81 | .52 | .85 |

49 States (non-California)

| | 0-8500 GVW 6/ | Domestic Gas LDT 8/ | Import/Captive LDT 7/ | LDDT 8/ |
|---|---|---|---|---|
| 1983 | 2.84 | 2.29 | .29 | .26 |
| 1984 | 3.13 | 2.50 | .32 | .31 |
| 1985 | 3.35 | 2.62 | .34 | .39 |
| 1986 | 3.49 | 2.64 | .36 | .49 |
| 1987 | 3.61 | 2.63 | .37 | .61 |
| 1988 | 3.79 | 2.61 | .39 | .79 |

1/ Data Resources Inc. Long Term Review, Fall 1979.

2/ 87 percent of the 0-10,000 lb. GVW sales projections. This 87 percent figure was taken from the Rulemaking Support Paper, Light-Duty Truck Fuel Economy Standards Model Years 1982-1985, December 1979, NHTSA, DOT.

3/ Figures used are based on percentages from the Regulatory Analysis of the Light-Duty Diesel Particulate Regulations February 1980, OMSAPC, EPA.

4/ Using 1980 projected sales, imports and captives represented 12.5 percent of total sales.

5/ Total 0-8500 - (Imports/Captives + LDDT).

6/ Using 1980 sales projections data, non-California sales were 90.6 percent of all LDT sales.

7/ Using 1980 sales projections, non-California sales of captives and imports was 74.2 percent of the total.

8/ Using 1980 sales projections, non-California sales of standard size light trucks was 92.9 percent of the total.

diesel-powered truck sales continue to increase. An increase in import and captive truck market shares would seem to suggest a trend toward LDTs with lower GVWRs.

Unexpected events and trends could easily shift sales from the projected values, but these figures represent EPA's best estimate based on available data and the most likely scenario of developments for the next several years.

## D. Other Considerations

### 1. Diesel Engine Penetration

A large unknown with respect to LDTs is their future use of diesel engines. Diesels are attractive in our current fuel-conscious era because of their significant gas-mileage improvements over gasoline-fueled engines, as well as for their high durability and their relative ease of maintenance. Diesels are also relatively low in HC and CO emissions. They do, however, have moderate levels of NOx emission and high levels of particulate emission. Concerns about these latter two factors are preventing current large-scale dieselization of the LDT fleet. Possible adverse health effects of particulate emissions are currently under investigation. However, as Table III-K indicates, manufacturers have already increased the use of diesel engines in LDTs (along with LDVs and HDVs). The largest increase is seen to be in the lighter LDT category. If the problems of NOx and particulate emissions can be satisfactorily resolved, coming years are likely to bring considerable growth in the use of diesel engines for LDTs. Table III-J shows EPA's estimate of this growth for 1983-1987.5/6/

### 2. Fuel Economy Standards

Another consideration relevant to LDTs is their fuel economy. Gas mileage has become an item of primary concern for buyers of LDVs, and it can be reasonably expected that this will be reflected in LDT sales as well. NHTSA is applying fuel economy standards of increasing stringency to LDTs. Table III-L shows current and proposed standards (the figures for 1983 to 1985 are proposed ranges within which the finalized standards are likely to fall). The limited production line category includes only International Harvester, which was deemed unable to satisfy the standards set for the rest of the industry in 1980 and 1981. It is EPA's belief that decreased vehicle emissions and increased vehicle fuel efficiency are not incompatible goals.

### 3. Emission Standards

Presented in Table II-B are past, present, and proposed Federal and California emissions standards for LDTs. California has adopted standards based on vehicle inertia weight which are stricter than the comparable Federal standards. EPA's final 1983 LDT standards are within the capability of manufacturers applying

Table III-K

U.S. Factory Sales of Diesel Trucks by GVW

| Year | 0-6,000 lb | 6,001-10,000 lb |
|---|---|---|
| 1978 | 35,019 | 990 |
| 1977 | 2,392 | 1,128 |
| 1976 | - | 1,596 |
| 1975 | - | 1 |
| 1974 | - | - |

Source: MVMA Motor Vehicle Facts and Figures, 1979, p. 14.

Table III-L

Fleet Average Fuel Economy Standards

| | 4 x 2 | | 4 x 4 | | |
|---|---|---|---|---|---|
| Model Year | Captive Imports | Other | Captive Imports | Other | Limited Production |
| 1979 | - | 17.2 | - | 15.8 | - |
| 1980 | 16.0 | 16.0 | 14.0 | 14.0 | 14.0 |
| 1981 | 16.7 | 16.7 | 15.0 | 15.0 | 14.5 |
| 1982 | 18.0 | | | 16.0 | |
| 1983 (proposed) | 18.0-20.0 | | | 15.6-18.0 | |
| 1984 (proposed) | 18.8-21.4 | | | 16.1-19.3 | |
| 1985 (proposed) | 19.7-22.4 | | | 16.2-19.9 | |

Source: Rulemaking Support Paper, Light Truck Fuel Economy Standards, Model Years 1982-1985; NHTSA, DOT; December, 1979.

state-of-the-art technology. It is expected that manufacturers will make use of much of the technology developed initially for the LDV class. This includes such methods and devices as: exhaust gas recirculation, turbocharging, catalytic converters, air injection, and electronic controls. New devices such as trap-oxidizers for particulates, and high-technology engines are currently being researched and developed.7/

4. High-Altitude Standards

High-altitude areas are defined to be those elevations greater than 4,000 feet (1,219 meters) above sea level. Outside of California, there are 112 U.S. counties located substantially above 4,000 feet in elevation. In 1977, LDT sales in high-altitude areas comprised approximately 5.5 percent of national LDT sales.

Vehicles which, after being designed and adjusted for use at low altitudes, are operated under high-altitude conditions experience a degradation in emissions performance. In particular, emissions of hydrocarbons and carbon monoxide are significantly higher for maladjusted vehicles at high altitudes than at low altitudes. For this reason, and since air pollution in a number of high-altitude areas (primarily urban) is a serious problem, EPA has considered and proposed measures affecting vehicles destined for sale and/or use at high altitudes.

The Clean Air Act Amendments of 1977 require that, beginning in 1984, all vehicles be able to comply with emission standards at all altitudes. EPA has proposed that for the 1982 and 1983 model year, vehicles be able to meet the standards applicable to the altitude at which they are sold and be modifiable to meet the standards at either high- or low-altitude. The proposed high-altitude standards which 1982 and 1983 model year LDTs would be required to meet when tested at a reference altitude of 5,400 feet (1,650 meters) are: 2.0 g/mile HC and 26 g/mile CO in 1982, and 1.0 g/mile HC and 14 g/mile CO in 1983. The NOx standards would be equivalent to those applicable at low-altitude. In addition, EPA has proposed that manufacturers be required to provide adjustment instructions for improving high-altitude emissions performance for 1968 and later model year light-duty vehicles and trucks.8/9/

## References


1/ Federal Register, Gaseous Emission Regulations for 1983 and Later Model Year Light-Duty Trucks; EPA; Thursday, July 12, 1979.

2/ Rulemaking Support Paper: Light Truck Fuel Economy Standards, Model Years 1982-1985; Office of Automotive Fuel Economy Standards, NHTSA, DOT; December, 1979.

3/ Ward's Automotive Yearbook, 1979, p. 135.

4/ Preliminary Regulatory Analysis: Light Truck Fuel Economy Standards, Model Years 1982-1985, NHTSA, DOT, December, 1979.

5/ Neil M. Szigethy, "Will Diesels Dominate?" Fleet Specialist; May/June, 1979, pp. 31-39.

6/ Regulatory Analysis: Light-Duty Diesel Particulate Regulations; ECTD, OMSAPC, EPA.

7/ Draft Regulatory Analysis: Proposed Emission Regulations for 1983 and Later Model Year Light-Duty Trucks; ECTD, OMSAPC, EPA; June 28, 1979.

8/ Draft Regulatory Analysis: Environmental and Economic Impact Statement for the Proposed 1982 and 1983 Model Year High-Altitude Motor Vehicle Emission Standards; SDSB, ECTD, OMSPAC, OANR, EPA.

9/ Federal Register, Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines, Submission of Altitude Performance Adjustments; EPA; Thursday, January 24, 1980.

# CHAPTER IV

# ENVIRONMENTAL IMPACT

## A. Background

The Clean Air Act as amended in 1970 contained many provisions aimed at removing harmful pollutants from the air we breathe. Among other things, the 1970 Act called for the establishment of National Ambient Air Quality Standards. These levels were to be set such that there would be no danger to public health and welfare. To date, ambient air quality standards have been set for seven pollutants: particulate matter, sulfur dioxide ($SO_2$), carbon monoxide (CO), nitrogen dioxide ($NO_2$), ozone (of which hydrocarbons (HC) is the main precursor), hydrocarbon (HC), and lead (Pb). Mobile sources are major contributors to the emissions of all of these pollutants except $SO_2$. This regulation package concerns the establishment of standards for HC and CO from light-duty trucks.

Both HC (in its role as an ozone precursor) and CO emissions have been related to adverse health effects. Detailed information on the health affects of HC and CO will not be discussed in depth in this Regulatory Analysis since such information is well documented elsewhere.1/ Briefly, HC emissions react with sunlight to form ozone and other photochemical oxidants. Ozone is a pulmonary irritant that affects the respiratory mucous membranes, other lung tissues, and respiratory functions. CO when inhaled replaces oxygen in the blood. The presence of CO adversely affects the carrying and delivering capacity of oxygen by the blood.

Although significant improvements have been made in air quality since 1970, a review of air quality monitoring data makes it clear that additional reductions in HC and CO emissions will be necessary if ambient air quality goals set by Congress in the Clean Air Act are to be achieved. On March 3, 1978, EPA published in the Federal Register a listing on a State-by-State, pollutant-by-pollutant basis, of the attainment status of every area of the Nation (43 FR 8962). This information, compiled by the respective States and reviewed by EPA, was the most accurate picture available of the nation's air quality status as of the adoption of the Clean Air Act Amendments. These data indicated that of 3215 counties or county equivalents covered by those designations, 607 (19 percent) were classified as nonattainment for photochemical oxidant, and 190 (6 percent) were classified as nonattainment for carbon monoxide. Nonattainment status indicates that the given area fails to meet the primary national ambient air quality standard (NAAQS) for the pollutant under consideration based upon either direct air quality monitoring or indirect estimates for areas lacking monitoring data. Current non-attainment data is available to indicate the changes which have occurred since 1977. As of July, 1979, the non-attainment designations include 586 (18 percent) counties for ozone and 164 (5 percent) for carbon monoxide.

Since the U.S. population is not uniformly distributed, but rather is concentrated in urbanized areas, the above geographically based figures are not representative of the proportions of population actually exposed to excessive ambient pollutant concentrations. Indeed, it is the very fact of urbanization which has led to many of our air pollution problems. For example, the nonattainment areas for ozone include 103 out of a total of 105 urban areas in the U.S. with populations greater than 200,000 (the exceptions being Honolulu, Hawaii, and Spokane, Washington). The 103 areas represent an exposure of over 100 million people.

Clearly, there is a great need to reduce pollutant (or pollutant precursor in the case of ozone) emissions in the urban areas of the U.S. So long as large numbers of people continue to be exposed to concentrations in excess of the NAAQS, further emission reductions must be sought.

Mobile sources have been recognized for some time as major sources of hydrocarbons (ozone precursors) and carbon monoxide. Light-duty vehicles in particular have been the focus of considerable control work since the late 1960's. However, as light-duty vehicle emissions grow smaller, other source categories such as light-duty trucks grow in proportional significance. The wisdom of controlling light duty truck emissions is evident when these emissions are placed in the context of other sources of these same pollutants.

In order to properly assess mobile source emissions and their control, it is best to look at urban areas where historically the NAAQS contraventions have occurred. In this way a truer perspective of the air quality impact of mobile sources can be obtained. It is in these urban areas that improvements are most needed. The selection of the areas to analyze will be discussed in detail below in Section 2. The HC analysis will be done on an Air Quality Control Region (AQCR) basis. CO, on the other hand, will be analyzed on a county basis. This is due to the more localized nature of CO problems. Fifty seven AQCRs have been selected for HC, and 50 counties for CO. Hydrocarbons analyzed include only non-methane hydrocarbons since the methane fraction is non-reactive.

Figures IV-A and IV-B present breakdowns of non-methane hydrocarbon (NMHC) and CO emissions into various source categories for the selected regions. These figures give the 1976 emission levels along with projected levels out to 1999. The data presented in these figures represent what is considered the base case. That is, it projects future light-duty truck emissions as if no new regulations beyond those already in existence were promulgated. For other source categories, known future control programs are included. For example, heavy-duty trucks are projected based upon the 1984 implementation of the regulations finalized in the January 21, 1980 Federal Register (45FR 4136).2/ The base case also assumes the successful implementation of I/M programs (since the analysis is of non-complying regions).

Figure IV - A

Annual Non-Methane Hydorcarbon
Emissions for 57 Urban Regions

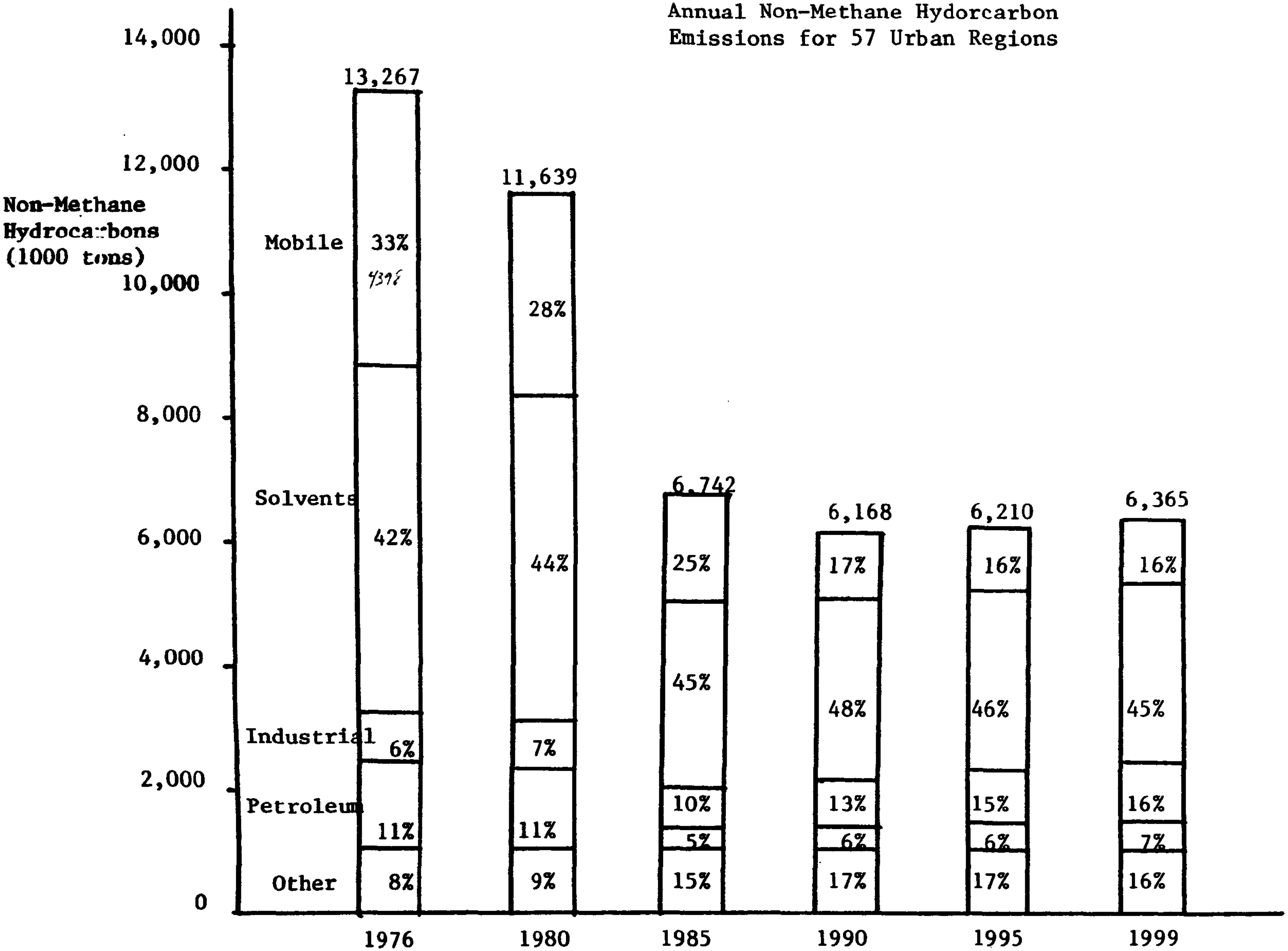
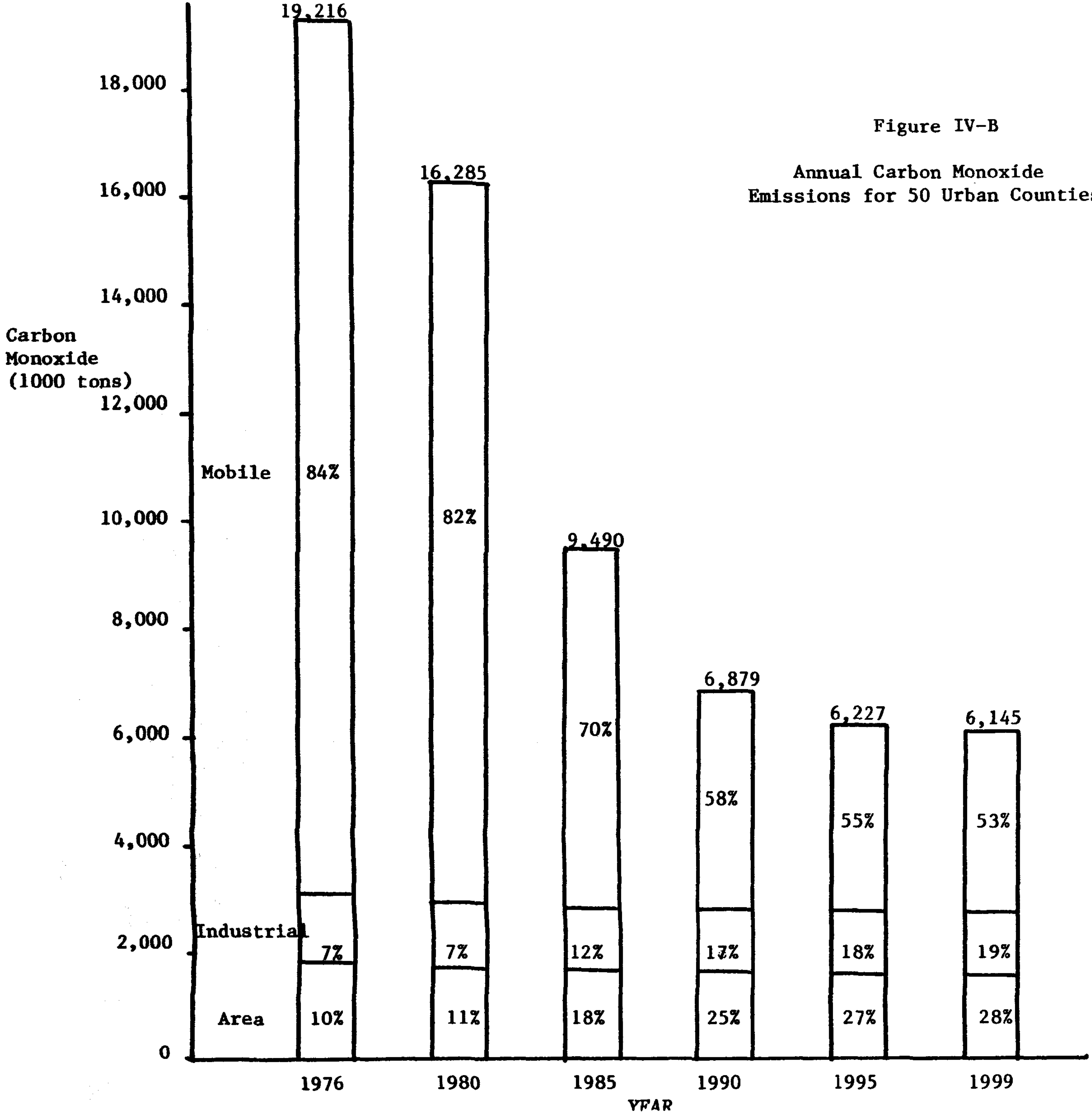


Figure IV-B

Annual Carbon Monoxide
Emissions for 50 Urban Counties



For non-methane hydrocarbons, mobile sources currently represent approximately 33 percent of the urban emissions (Fig. IV-A). With the regulations already in effect this percentage is expected to decline to 16 percent by 1995.

Mobile source carbon monoxide emissions currently represent over 80 percent of the urban emissions (Figure IV-B). This amount is expected to decline to 53 percent by 1999. No significant change in stationary source emissions is expected for CO. However, since CO problems are often attributed to high localized concentrations during periods of high traffic density, stationary sources have minimal impact on CO air quality problems.

Light-duty vehicles (passenger cars) contribute the major portion of mobile source NMHC and CO emissions. The 1976 emission levels from light-duty vehicle and other mobile sources, and projections of the future urban emissions are given in Figures IV-C and IV-D. Again, these projections are for the base case of no new light-duty truck regulations. The figures give a general overview of the contribution to air pollution that each class of vehicles is expected to make through 1995, and of the distribution of the burden of control of emissions from all mobile sources. From these figures it can be seen that emissions from light-duty trucks will grow in proportion to emissions from heavy-duty trucks and light-duty vehicles. This apparent inequitable distribution of the burden for reducing mobile source emissions can be in part accounted for by the past need to concentrate control efforts on light-duty vehicles where potential gains were the highest.

It is evident from the figures that for both NMHC and CO, light-duty trucks represent a growing proportion of emissions. For hydrocarbons, light-duty trucks go from 14 percent of the total in 1976 to 22 percent in 1999. For carbon monoxide the figures are 13 percent in 1976 and 29 percent in 1999. Thus, control of light-duty trucks is extremely important in any overall strategy for reducing emissions sufficient to meet ambient air quality standards. The remainder of this chapter will address the environmental impact which would result from imposition of the light-duty truck emission control strategies considered as part of this rulemaking.

## B. Primary Impact

### 1. Emission Factors

Considerable work has been done within EPA in an attempt to determine accurate emission factors for mobile sources. This work depends heavily on in-use vehicle testing under EPA's Emission Factor Program. To answer the question of how well vehicles perform in actual use, EPA has administered a series of exhaust emission surveillance programs. Test fleets of consumer-owned

Figure IV-C

Annual Mobile Source
Non-Methane Hydrocarbon
Emissions for 57 Urban Regions

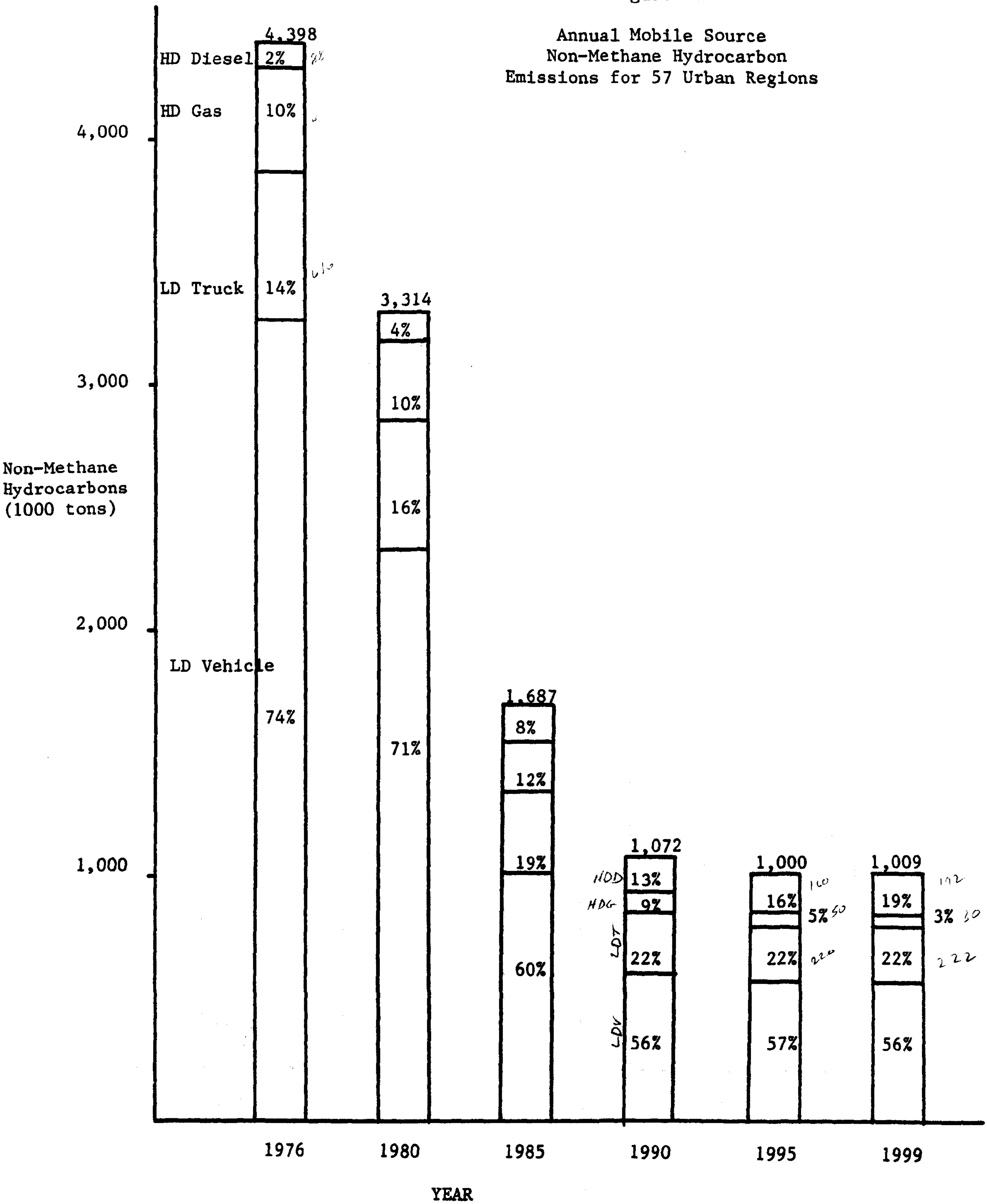
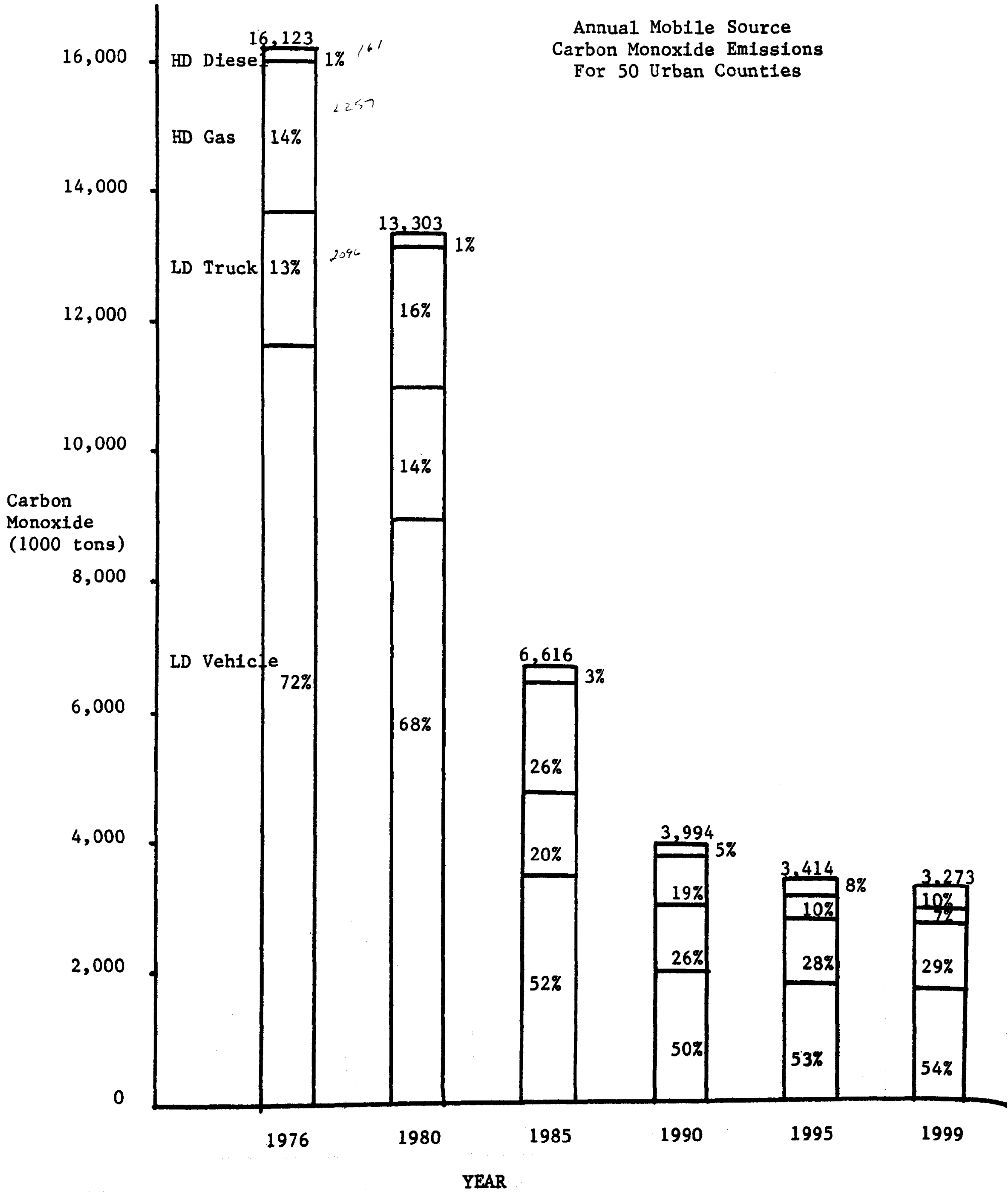


Figure IV-D

Annual Mobile Source
Carbon Monoxide Emissions
For 50 Urban Counties



vehicles within various major cities are selected by model year, make, engine size, transmission, and carburetor in such proportion as to be representative of both the normal production of each model year and the contribution of that model year to total vehicle miles traveled. These programs have focused principally on light-duty vehicles and light-duty trucks.

The data collected in these programs are analyzed to provide mean emissions by model-year vehicle in each calendar year, change in emissions with the accumulation of mileage, change in emissions with the accumulation of age, percentage of vehicles complying with standards, and effect on emissions of vehicle parameters (engine displacment, vehicle weight, etc.). These surveillance data, along with prototype vehicle test data, assembly line test data, and technical judgment, form the basis for the existing and projected mobile source emission factors. 3/

For this regulatory analysis, changes have been made to the emission factors for heavy-duty and light-duty trucks. The emission factors found in the mobile source emission factors document for heavy-duty vehicles are based upon steady-state data gathered on the 9-mode and 13-mode test procedures. In the course of developing the recently finalized heavy-duty engine regulations, EPA has accumulated substantial data on the transient emissions of heavy-duty engines. Both the CAPE-21 data gathering program and resultant transient test procedure were designed to accurately characterize in-use operation and therefore in-use emission. Therefore, the available transient test data has been used to revise the heavy-duty truck emission factors which are currently being used. The emission factors for future heavy-duty engines have also been revised to reflect accurately the final standards and the implementation of Selective Enforcement Auditing with a 10 percent acceptable quality level. Refer to Appendix A of the Regulatory Analysis accompanying the heavy-duty engine rulemaking for details of the methodology and the calculations.4/

The light-duty truck emission factors need revision from those presented in the emission factors document to reflect the implementation of parameter adjustment regulations in 1981 and 1982 and to accurately reflect the impact of the final light-duty truck regulations of this rulemaking. Revised emission factors for pre-1983 light-duty trucks are those presented in "MOBILE 1 Modifications for the LDT Regulation Analysis." The factors contain corrections for 1981 and 1982 light-duty trucks to account for the implementation of parameter adjustment regulations in those model year vehicles. Related adjustment of the computation methodology for I/M credits for light-duty trucks to prevent double counting was also done. This was accomplished by the relatively simple mechanism of limiting the overall I/M plus parameter adjustment credit to values characteristic of currently estimated benefits of an I/M program applied to current (non-parameter adjustment) vehicles. The limits used are 25 percent for HC and 35 percent for CO. For 1983 and later light-duty trucks, emission factors have been derived in Chapter VII using the methodology developed for the heavy-duty rulemaking.

Light-duty trucks currently are powered almost exclusively by gasoline-fueled engines. Only three diesel engine families are currently certified for light-duty trucks. However, this is expected to increase substantially in future years. For example, EPA has projected dieselization of light-duty vehicles to reach 20 percent by 1991.5/ Based upon the similarity of usage between light-duty trucks and light-duty vehicles, the same estimated diesel fractions will be used for light-duty trucks. In order to correctly assess the emissions impact of light-duty trucks, this diesel fraction must be accounted for, since diesel engines have different emission rates than gasoline-fueled engines. In the analysis of air quality impacts, the gasoline-fueled engine emission rates and diesel engine emission rates will be combined according to their respective sales fractions to give a single emission rate. The reason for such combination is that the baseline emission inventory used for the EKMA and Modified Linear Rollback models (see discussion below in section 2 and 3) does not contain separate categories for gasoline-fueled and diesel light-duty trucks.

Estimates of diesel light-duty truck emission rates which will be used in this analysis are based upon rather limited data. Table G-2 of Issue G - Technological Feasibility, of the Summary and Analysis of Comments, contains 1980 diesel light-duty truck certification data. Also presented in that table are results for the light-duty vehicle version of the GM light-duty truck engine. Because of 1980 light-duty vehicle standards, the light-duty vehicle version of the engine incorporates redesigned injectors and EGR which result in lower emission rates. The average results for the families presented in that table are shown below:

| Manufacturer | Engine Family (cubic inch displacement) | Average Emissions | | |
|---|---|---|---|---|
| | | HC | CO | NOx |
| GM LDT | 09J9Z (350) | .76 | 2.0 | 2.0 |
| GM LDV (Oldsmobile) | 03J9ZG (350) | .27 | 1.15 | 1.6 |
| IHC | SD-33T (198) | .42 | 1.9 | 1.5 |
| VW | DP (90) | .32 | .90 | 1.1 |

In computing light-duty truck emission rates, the GM light-duty truck emission rates will be replaced by those of the light-duty vehicle for 1983 and beyond. Such improvements will be necessary to meet the light-duty truck standards.

The engine families do not represent equal sales fractions for 1980. Therefore, the question of sales weighting arises. Currently the GM diesel represents some 76 percent of the diesel sales. However, as more manufacturers introduce more diesel model light-duty trucks, that share will surely drop. Since the VW and IHC engines probably represent typical small and medium sized engine emissions, and the GM a large engine, we will weight each equally. Deterioration factor data for these engines is insufficient to establish whether the diesel deterioration rates will be somewhat lower than those for gasoline-fueled engines as might be expected. Therefore, the more conservative assumption that they are not will be used. Deterioration factors of 1.4 for HC and 1.3 for CO over 100,000 miles have been derived for gasoline-fueled light-duty trucks and will be applied to the diesel vehicles as well.

Using the starting emission rates found by averaging the GM, IHC, and VW engines shown above (and substituting the Oldsmobile data for 1983 and beyond), along with the deterioration factors as just described, the light-duty truck diesel emission rates become:

<u>Prior to 1983</u>

$$HC = 0.5 + 0.02(M/10{,}000)$$
$$CO = 1.6 + 0.05(M/10{,}000)$$

<u>1983 and Beyond</u>

$$HC = 0.34 + 0.01(M/10{,}000)$$
$$CO = 1.3 + 0.04(M/10{,}000)$$

Here M corresponds to accumulated vehicle mileage. The HC and CO deterioration factors have been expressed as equivalent additive values.

The general form of all the emission factors for mobile sources is an equation with some starting new vehicle emission rate plus a mileage dependent deterioration rate. This means that to determine the emissions from a given vehicle one must know the accumulated mileage. To determine the average emission rate for the fleet made up by a given class of vehicles (for example, light-duty trucks), it is necessary to account for the fact that the on-the-road fleet consists of a mix of vehicles of varying ages and model years. The appropriate emission rate is applied to each fraction of the fleet and the fractions are summed into a composite.

When vehicles meeting a new emission standard are introduced into the on-the-road fleet, they at first represent only a small fraction of the whole fleet. As time passes, the newer technology vehicles come to represent a larger and larger share of the entire fleet. This means that the composite emission rate for the entire fleet will show a gradual change in response to new standards, rather than a sudden change.

2. Lifetime Emissions

One way to examine the effect of the rulemaking action is to compare the emissions of vehicles built to meet the requirements of the rulemaking with the emissions of earlier vehicles. Using the emission factor equations, the total lifetime emissions of a given model year vehicle may be estimated. This will be done for 1969 (the "baseline" model year for deriviation of the standard), 1982 (representing vehicles built the year prior to the new standards), and 1983 (year of implementation for this rulemaking) model year vehicles. The calculations will use average vehicle lifetimes of 120,000 miles for light-duty trucks.6/ Lifetime per-vehicle average emissions are given in Table IV-A.

The impact of the new standards on vehicles produced for 1983 (or later) is clearly evident in this data. Compared to emissions from 1982 vehicles, 1983 vehicles are reduced 76 percent for HC and 82 percent for CO in the case of gasoline-fueled vehicles. For diesel engines HC is reduced 37 percent and CO is reduced 20 percent between 1982 and 1983 vehicles.

With reference to the 1969 baseline year, gasoline-fueled light-duty truck HC emissions are reduced 89 percent and CO emissions are reduced 91 percent in 1983 vehicles.

3. Reduction in Urban Emissions From Light-Duty Trucks

We have seen that as new light-duty trucks are put into use and older ones retired, the emissions of the average light-duty truck on the road will decrease. The resulting composite emission factors can be used to project changes in annual emissions from the entire fleet. The same can be done for other mobile source categories as well. To make the projections, the changes in composite emission rates are used along with estimated growth rates in total vehicle miles traveled to modify the baseline emission inventory for future years. Projections are also made of changes in stationary source emission rates depending on present and anticipated stationary source control programs.7/

For hydrocarbons, the exhaust emissions themselves are an indirect rather than a direct problem. That is, the principal harmful effect of HC emissions stems from the photo-chemical reactions leading to ozone formation. The reaction process can take several hours, by which time the pollutants involved are transported and dispersed over broad areas. Therefore, the hydrocarbon emissions have been analyzed on an Air Quality Control Region (AQCR) basis. The AQCR's selected were those non-California, non-high-altitude regions violating the ozone standard (or estimated to be violating where actual sampling data is missing) in a 1975-1977 base period. California regions were excluded since California has its own emission standards. High altitude regions were excluded because the emissions data used in the analysis is

Table IV-A

Lifetime Emissions for Light-Duty Trucks (Tons)

| Class + Pollutant | Model Year 1969 | 1982 | 1983 |
|---|---|---|---|
| Gasoline fueled | | | |
| HC | 0.86 | 0.38 | 0.09 |
| CO | 9.9 | 5.0 | 0.9 |
| Diesel | | | |
| HC | N/A | 0.08 | 0.05 |
| CO | N/A | 0.25 | 0.20 |

not considered representative of high altitude conditions. A separate detailed analysis would have to be done to assess the impact of these regulations on high-altitude areas. This selection process led to a set consisting of 57 AQCRs to be analyzed for hydrocarbons. In addition, because methane emissions are non-reactive and do not contribute to ozone formation, the emission inventories compiled for analysis will be based upon non-methane hydrocarbons (NMHC).

Carbon monoxide emissions, in contrast to hydrocarbons, frequently create localized problems of high concentrations. These are often associated with urban core areas experiencing high traffic densities. It is desirable, therefore, to analyze CO on a more localized basis than AQCRs. This has been done by using a county based inventory. As for HC, only non-California non-high-altitude areas were selected. In addition, regions in Alaska have been excluded. A significant part of the CO problem in Alaskan regions appears to be related to high CO emissions from vehicle operated at low temperatures. The emission factors used in this analysis are not representative for consistent low temperature operation. The result is 50 counties exceeding the CO standard for a 1975-1977 base period.

Following the selection of areas to be analyzed, an emission inventory for each region was compiled. The most recent year for which complete information could be obtained was 1976. This data then forms the basis for future projections. Compilation of the baseline and projection for future years is an involved process entailing a number of assumptions. These are discussed in detail in supporting documents.7/8/ Two assumptions are important to highlight here. The first is the assumption that light-duty vehicle and light-duty truck I/M programs will be implemented in all the areas analyzed by 1982. Since all the areas chosen are areas exceeding the HC and CO standards, such programs are expected.

The second assumption concerns projected growth rates for various source categories in future years. For non-methane hydrocarbons, rollback projections were made for a range of growth rates. The high and low end of these ranges differ by one or two percent. For this analysis we will use the growth rates of the low growth option. For mobile sources these rates appear most consistent with what appears likely because of energy costs and related matters. The high growth assumptions would increase the absolute levels of emissions and decrease the absolute levels of air quality benefits projected by the models somewhat. They would, however, make little difference in the relative change from the base case to the control case. The maximum air quality benefits would peak in 1995 rather than in 1999 if the high growth case were chosen. For heavy-duty vehicles, other specific adjustments in growth rates are also required. Annual vehicle miles traveled (VMT) are expected to decline for gasoline-fueled engines by about 2 percent per year, while diesel VMTs will increase by about 5 percent per year. These rates reflect increased use of diesel engines in the heavy-duty industry, largely because of energy considerations.4/

Projections for both emission data and air quality data are made on an AQCR by AQCR basis (or county by county for CO). However, the underlying assumptions on emission factors are not region specific. Rather, they represent typical nationwide values. Because of this, only average results for all regions will be used for analysis.

Figure IV-E and IV-F provide a comparison of the projected mobile source emissions for the base case of no new light-duty truck regulations with the projected emissions for the final regulations. They cover the years from 1990-1999. By 1990, light-duty trucks would account for 22 percent of mobile source NMHC and 26 percent of mobile source CO emissions. The substantial reductions in light-duty truck emissions expected are clearly indicated. For HC, in 1999 the reduction reaches 55 percent. For CO, in 1999 the reduction is 62 percent. These percentages are measured in comparison to the base-case emissions for the same year, 1999.

Expressed as a percentage of all mobile source emissions, the impact of the final rulemaking is as follows. Hydrocarbons are reduced 12 percent in 1995 and 13 percent in 1999. Carbon monoxide is reduced 17 percent in 1995 and 21 percent in 1999.

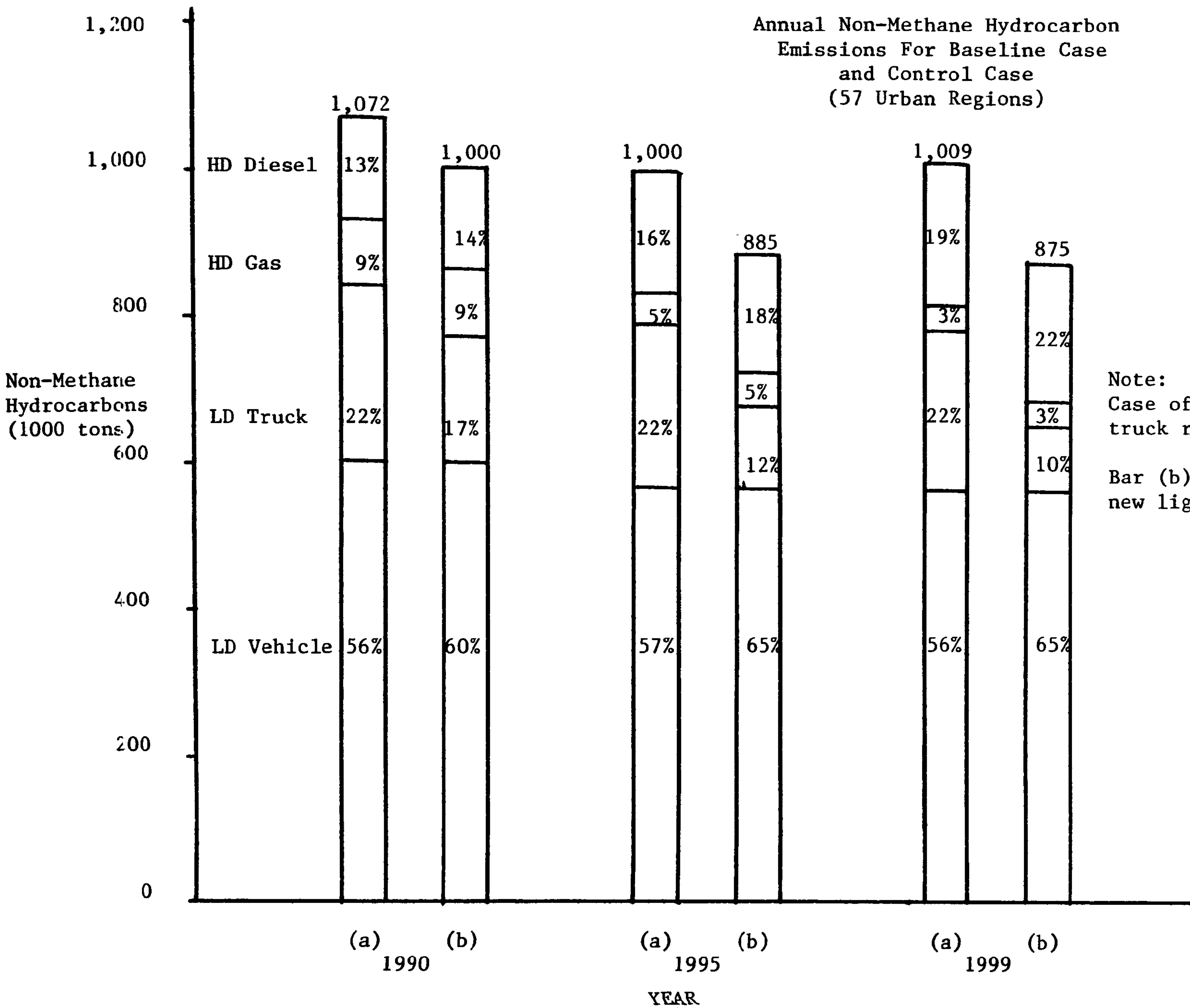
4. Ambient Air Quality Impact of Regulation

Using the emission rates previously discussed, an analysis was done of the air quality impact in each of the selected regions.8/ The Modified Rollback method was used for oxidant and CO to project future air quality improvements for each region. In addition, the Empirical Kinetic Modeling Approach (EKMA) was also used for oxidant. The EKMA procedure has been developed by EPA in an attempt to provide an improved analysis of the relationship between oxidant and precursor emissions while avoiding the complexity of photochemical dispersion models.9/ There is uncertainty over the applicability of EKMA, so that both EKMA and rollback were used to provide a range of possible air quality impacts.

In preparing the air quality projections, baseline emission rates for various source categories were taken from the National Emissions Data System (NEDS), and projections for future control strategies plus growth rates were made. In combination with the mobile source projections, this data allowed an evalutation of air quality improvements to be expected. With both Modified Rollback and the EKMA approach, the relative changes from strategy to strategy are more reliable than predictions of absolute levels of air quality. Therefore, the results will be expressed as percentage gains over baseline between various strategies. In addition, although the individual regions used in the analysis can be identified, the results are not considered accurate enough to be used for

Figure IV-E

Annual Non-Methane Hydrocarbon Emissions For Baseline Case and Control Case (57 Urban Regions)

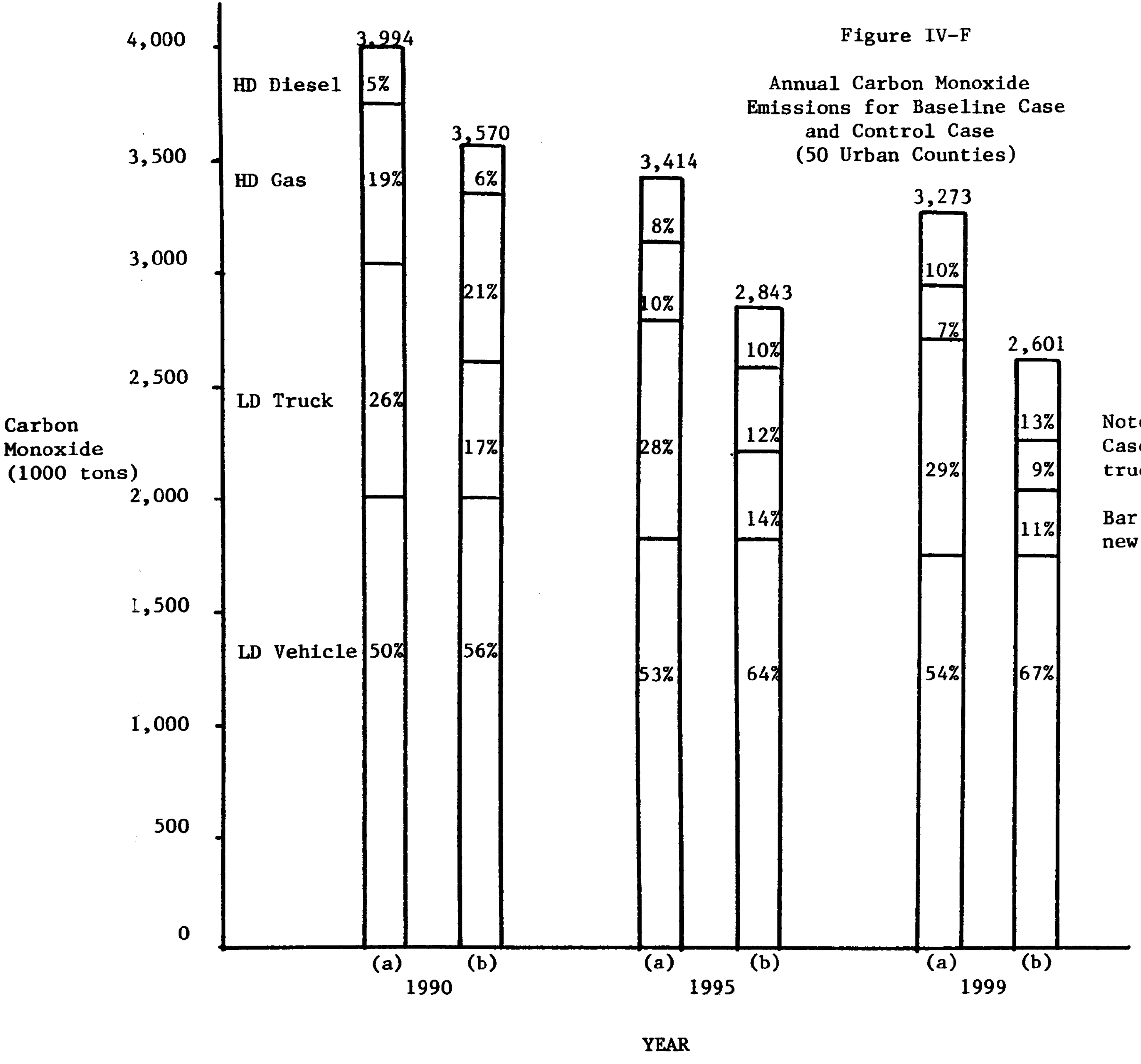



Note: Bar (a) = Baseline Case of no new light-duty truck regulations.

Bar (b) = Control case with new light-duty truck regulations.

Figure IV-F

Annual Carbon Monoxide
Emissions for Baseline Case
and Control Case
(50 Urban Counties)




Note: Bar (a) = Baseline Case of no new light-duty truck regulations.

Bar (b) = Control case with new light-duty truck regulations.

a region by region review of the regulations. Rather, averages over all areas analyzed will be used. The average air quality improvements are given in Table IV-B.

The modified linear rollback and EKMA models differ by a factor of nearly 2 to 1 for ozone reductions. However, they each indicate similar percentage gains from implementing the new standards. For the 1990-1999 period, improvements of 1 percent to 2 percent in ozone are projected to result from implementing the light-duty truck regulations.

Table IV-B indicates that carbon monoxide will be improved 3 percent in both 1990 and 1995, and 4 percent in 1999.

The significance of a percentage gain in air quality in terms of progress toward attainment of standards depends upon the original levels. For example, a 2 percent improvement in air quality may be sufficient to bring a region that is already close to the standard into compliance, whereas in a region experiencing very high levels (relative to the standard) that 2 percent would represent a totally inadequate reduction. In a region already meeting the standards, such a further gain would increase the margin for compliance. The question could then be posed: "How many areas originally exceeding air quality standards are brought into compliance by implementing the new emission standards?" In Table IV-C the air quality improvements are analyzed in this fashion.

Considering the ozone results first, the difference in absolute reductions predicted by modified rollback versus EKMA noted in Table IV-B are again apparent. While modified rollback indicates that 96-98 percent of the regions originally violating the ozone standard will come into compliance in the 1990's, EKMA puts that percentage at 72 percent. Therefore, as noted earlier, caution must be used in interpreting results from either model in absolute terms. For example, the indication from modified rollback that nearly all violating regions will meet the ambient ozone standard by 1999 should not be considered reliable. Rather, the relative change attributable to implementation of the new regulations is the item of maximum accuracy. The table indicates that implementation of the light-duty truck regulations will result in approximately a 0 percent (EKMA) to 2 percent (rollback) reduction in the number of violating regions.

The cautions noted for ozone are equally important in interpreting the CO results in Table IV-C. Only rollback applies to this case, and that model indicates that with either strategy, all regions analyzed will attain the CO standard by 1990. However, it has already been noted that it is not within the ability of this model to accurately predict absolute air quality levels. Therefore, the indication of all regions meeting the standard is inconclusive. As an illustration of the accuracy required to accept the absolute projections, in the final rollback projections for 1999 only 94 percent of the regions are in compliance with the standard

Table IV-B

Average Air Quality Percent Reductions
From 1976 Base Year

Ozone
(Modified Linear Rollback/EKMA)

| Strategy | 1980 | 1985 | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| Base Case | 13/7 | 49/25 | 54/31 | 54/31 | 53/31 |
| Implement LDT Regs | 13/7 | 49/25 | 55/32 | 55/33 | 55/32 |

Carbon Monoxide

| Strategy | 1980 | 1985 | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| Base Case | 16 | 54 | 68 | 72 | 72 |
| Implement LDT | 16 | 55 | 71 | 75 | 76 |

Table IV-C

Percentage of Regions Originally Violating
Air Quality Standards Brought Into Compliance

Ozone
(Modified Linear Rollback/EKMA)

| Strategy | 1980 | 1985 | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| Base Case | 35/14 | 96/56 | 98/72 | 98/72 | 96/72 |
| Implement LDT Regs | 35/14 | 96/56 | 98/72 | 98/72 | 98/72 |

Carbon Monoxide

| Strategy | 1980 | 1985 | 1990 | 1995 | 1999 |
|---|---|---|---|---|---|
| Base Case | 2 | 90 | 100 | 100 | 100 |
| Implement LDT | 2 | 92 | 100 | 100 | 100 |

by a margin of greater than 20 percent for the base case. For the control case, that result changes by 4 percent to a value of 98 percent. Inaccuracies on the order of 20 percent or greater are more than possible in the present air quality analysis, and would markedly change the absolute levels of predictions. However, such inaccuracy would probably be relatively constant from strategy to strategy and lead to consistent relative effects. Unfortunately, since changes in air quality produced by the new regulations do not become significant prior to 1990, no clear conclusions can be drawn about the effect these regulations will have on attainment status. However, as noted, based upon the number of regions within 20 percent of the standard, implementing the light-duty truck regulations produces a 4 percent improvement.

## C. Potential Secondary Environmental Impacts

### 1. Sulfuric Acid Emissions

A recent EPA report10/ provides an in-depth review of the current status of sulfate emissions from mobile sources. On a nationwide basis, mobile sources represent less than 2 percent of the total man-made sulfur oxides. However, with the introduction of the catalyst/air pump technology to control HC and CO emissions from mobile sources, there exists the potential for a significant source of mobile related sulfate emissions in the form of sulfuric acid aerosol. While of negligible magnitude on a regional basis, mobile source sulfuric acid emissions could produce a significant localized urban sulfate concentration in urban street canyons, or congested urban freeway situations. Moreover, mobile source sulfates differ from stationary source sulfates in that they are emitted in the form of a fine sulfuric acid mist and the particles tend to remain near ground level.

The increase in sulfate emissions due to the use of oxidation catalyst/air pump control systems on passenger cars and light-duty trucks has been of considerable concern to EPA. In pre-model year 1975 non-catalyst systems, most of the fuel sulfur leaves the vehicle after combustion as $SO_2$. In oxidation catalyst/air pump systems used on recent model year automobiles and light-duty trucks, a small amount (less than 10 percent10/) of the sulfur is converted by the catalyst to $SO_3$. The $SO_3$ combines with water in the exhaust to form sulfuric acid aerosol.

Extensive efforts have been made within government and industry to improve the information about mobile source sulfate emission factors, sulfate air quality modeling techniques and sulfate health effects as a function of exposure level. In addition, technology assessment work is proceeding to identify how sulfates are formed in catalyst/air pump systems, and to develop other low sulfate producing catalytic control systems such as the three-way catalyst. According to current data, the extent of sulfate emissions is much less than early concerns had anticipated. Major adverse health and welfare effects from mobile source sulfates are unlikely.10/ Table

IV-D indicates sulfuric acid emission rates for several mobile source categories.

Implementing the new light-duty truck standards is not expected to increase present mobile source sulfate emission or to present a future problem. Catalyst systems are already in use on light-duty trucks. Insofar as the 1983 standards might lead to some increased use of three-way system there could be a decrease in sulfate emissions.

### 2. Water Pollution, Noise Control, Energy Consumption

Complying with the light-duty truck regulations is expected to have negligible impact on water pollution, or on the ability of the light-duty truck manufacturers to meet present and future noise emission regulations. Implementing these regulations can be done with no fuel economy penalty. In fact, the analysis of fuel economy impact done in the Summary and Analysis of Comments indicates that there should be a net gain in fuel economy between 1982 and 1983. For futher discussion of fuel economy, the reader is referred to Issue L of the Summary and Analysis of Comments.

## D. Irreversible and Irretrievable Committment of Resources

A small additional committment of platinum and palladium will be required over and above that needed for current light-duty trucks which already employ catalysts. This increase will result from the need to improve catalyst durability and meet lower emission standards. The incremental demand in 1985 would be approximately 38,600 troy ounces of plantinum and 16,200 troy ounces of palladium. These figures are based upon vehicle sales, catalyst loadings and catalyst sizes developed in Chapter V and the Summary and Analysis of Comments (Issue F - Economic Impact). In the event that recycling of catalyst noble metals becomes economical in future years, this incremental demand could be offset or eliminated.

## E. Relationship of Short-Term Uses of the Environment to Maintenance and Enhancement of Long-Term Productivity

More stringent control of light-duty truck emissions than that currently imposed will result in substantial decreases in hydrocarbon and carbon monoxide emissions from this source. This reduction will be beneficial and aid in the long-term attainment and maintenance of acceptable air quality.

Table IV-D

Approximate Mobile Source
Sulfuric Acid Emission Rates 10/

| Source Category | $H_2SO_4$ Conversion Rate (%) | $H_2SO_4$ (mg/mile) |
|---|---|---|
| Non-catalyst car | 1 | 1 |
| Oxidation catalyst car | 10 | 10-15 |
| 3-way catalyst car | 5 | 4 |
| Light-duty diesel car | 2 | 9 |
| Heavy-duty diesel truck | 2 | 50 |
| Aircraft gas turbine | 0.03 | N/A |

## References

1/ For a current review of this data, as well as citations to other reports on health effects of HC and CO, see "Health Effects of Exposure to Low Levels of Regulated Air Pollutants - A Critical Review," Benjamin A. Ferris, Jr., M.D., Journal of the Air Pollution Control Association, Vol. 28, No. 5, May 1978.

2/ For details on assumed future strategies for other source categories see "Data Assumptions and Methodology for Assessing the Air Quality Impact of Proposed Emission Standards for Heavy-Duty Vehicles," EPA Air Management Technology Branch, Office of Air Quality Planning and Standards, November 1979.

3/ A complete presentation of mobile source emission factors, including future use projections, can be found in EPA-400/9-78-005, "Mobile Source Emission Factors - Final Document," March 1978.

4/ "Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and Later Model Year Heavy-Duty Engines," EPA Office of Mobile Source Air Pollution Control, December 1979.

5/ "Summary and Analysis of Comments on the Notice of Proposed Rulemaking for the Control of Light-Duty Diesel Particulate Emissions from 1981 and Later Model Year Vehicles," EPA Ofice of Mobile Source Air Pollution Control, October 1979. Table I-5.

6/ "Average Lifetime Periods for Light-Duty Trucks and Heavy-Duty Vehicles," EPA Report SDSB 79-24, G. Passavant, November 1979.

7/ "Data Assumptions and Methodology for Assessing the Air Quality Impact of Proposed Emission Standards for Heavy-Duty Vehicles," EPA Air Management Technology Branch, Office of Air Quality Planning and Standards, November 1979.

8/ "Air Quality Impact of Final LDT Emission Standards - Summary of Results," EPA, April 1980.

9/ "Uses, Limitations and Technical Basis of Procedures for Quantifying Relationships Between Photochemical Oxidants and Precursors," EPA-450/2-77-021a, US EPA, Research Triangle Park, NC, November 1977.

10/ "Emissions of Sulfur-Bearing Compounds From Motor Vehicles and Aircraft Engines," Report to the United States Congress, EPA-600/9-78-028, August 1978.

# CHAPTER V

## ECONOMIC IMPACT

This chapter examines the costs associated with the 1983 LDT emission standards and related control strategy being finalized in this rulemaking. Costs of this rulemaking lie in three major areas: development and testing, certification, and emission control hardware. A few LDTs may experience a change in operating costs as a result of these regulations.

The vehicle manufacturers must bear the initial costs of development, certification, and emission control hardware. These costs will be added to the truck selling price, marked up, and then passed on to the ultimate purchaser.

Due to the complex nature of the LDT emission standards program and the current dynamic nature of the LDT market a few words of explanation are necessary.

Vehicles sold in California must certify to a different set of emission standards than those sold in the remaining 49 states. (See Chapter III). For this reason, this analysis will exclude California sales from any analysis or costs. California sales of LDTs are 8-10 percent of the total LDT market.1/ EPA has used a figure of 9.4 percent of all imports and captives.2/ Using these figures and some data received from NHTSA in their recent LDT fuel economy standards proposal EPA has developed sales projections for the years 1983-1987. Table V-A gives both 50 states and Federal only sales projection for the analysis period.

The light-duty truck market of the 1980's is very difficult to project. Rising fuel prices and fuel economy pressures in general have halted the sales boom of the late 1970's and led the market into a very dynamic state. Increased dieselization and the effects of fuel economy and exhaust emission standards will lead to substantial changes in the characteristics of the market over what is present in 1980.

At least four areas should be addressed to explain the forces acting on the market: dieselization, imports, new engine lines, and fleet wide engine downsizing.

Although light-duty diesel trucks (LDDT) are only about 1.5 2/ percent of the current light-duty truck sales, both EPA and the manufacturers expect this percentage to increase substantially in the 1980's. In the light-duty diesel particulate rulemaking action, EPA addressed this changing market share and arrived at the following figures for LDDTs: 1983(8.9 percent), 1984(9.5 percent), 1985(11.4 percent), 1986(13.8 percent), 1987(16.5 percent). This analysis used these percentages in the sales projections discussed previously.

Table V-A

LDT Sales Projections (millions)

All States

| | 0-10,000 GVW | 0-8,500 GVW | Domestic LDT | Import/ Captive LDT | LDDT |
|---|---|---|---|---|---|
| 1983 | 3.60 | 3.13 | 2.46 | 0.39 | 0.28 |
| 1984 | 3.97 | 3.45 | 2.69 | 0.43 | 0.33 |
| 1985 | 4.25 | 3.70 | 2.82 | 0.46 | 0.42 |
| 1986 | 4.42 | 3.85 | 2.84 | 0.48 | 0.53 |
| 1987 | 4.58 | 3.99 | 2.83 | 0.50 | 0.66 |

49 States (Excludes California)

| | 0-8,500 GVW | Domestic LDT | Import/ Captive LDT | LDDT |
|---|---|---|---|---|
| 1983 | 2.84 | 2.29 | 0.29 | 0.26 |
| 1984 | 3.13 | 2.50 | 0.32 | 0.31 |
| 1985 | 3.35 | 2.62 | 0.34 | 0.39 |
| 1986 | 3.49 | 2.64 | 0.36 | 0.49 |
| 1987 | 3.62 | 12.68 | 0.37 | 0.61 |
| | 16.42 | 12.68 | 1.68 | 2.06 |

See Chapter III for more detail.

The market share of imports and captive imports has increased greatly in the last year. However, beginning in 1980 captive imports are no longer used to determine compliance with fuel economy standards, which may lead the corporate importers to slowly replace their captive imports with their own smaller light trucks. As a result of this possible action, the foreign manufacturers of these captive imports may choose to open their own retail outlets and sell under their own names instead of as captives. This situation remains so uncertain that EPA will assume that whether the light-duty trucks from Isuzu, Mitsubishi, and Toyo Kogyo are sold as captive imports or pure imports, their market shares remain relatively stable.

EPA expects that most, if not all, of the domestic manufacturers will be introducing new smaller light-duty trucks in the 1980's. NHTSA's rulemaking support paper outlines some of these plans.3/ These new truck families will be used as replacements for some fraction of the sales of the larger, less fuel efficient engines. The anticipated introduction of these new truck families further indicates the dynamic nature of the light-duty truck market.

Finally, in addition to the introduction of new truck lines with smaller engines, EPA expects that domestic manufacturers will adjust their sales mixes such that they sell fewer of their large CID engines and more of the smaller more fuel efficient engines. The 1980 sales projection data submitted by the manufacturers breaks neatly into three specific cylinder/CID groups (see Table below). However, EPA expects that in the mid-eighties a large shift will occur in these percentages. The current and future market splits are shown below:

Sales Splits

| Number of Cylinders | Engine CID Range | 1980 Market Percentage | EPA Market Projection (1983-1987) |
|---|---|---|---|
| 4 | 0-200 | 11% | 15% |
| 6 | 200-300 | 19 | 45 |
| 8 | 300-400 | 70 | 40 |

It is clear that the light-duty truck fleet sold in the mid-eighties will have considerably different sales mix characteristics than that certified for 1980. However, neglecting the changes in sales mix, the emission control hardware changes which would be necessary to the 1980 LDT fleet are representative of those incremental changes which would be necessary on the new sales mix of four, six, and eight cylinder engines sold in the mid-eighties. This relevancy of the 1980 fleet will be used to later predict the emission control hardware cost.

## A. Cost to Truck Manufacturers

### 1. Development and Testing

EPA expects that manufacturers will incur development costs related to redesigning their emission control related hardware for the full useful life. It is difficult to estimate the actual development and testing costs each manufacturer or vendor will incur.

However, it is quite likely that the bulk of this redesign and development cost will be borne in improving catalyst, EGR, air injection, and electronic engine controls (EEC). As a means of estimating this hardware redesign and development cost EPA will conservatively use the same amount of research and development investment that went into the initial components, but inflated to 1980 dollars. For catalysts ($5.11), EGR ($1.37), air injection ($1.23) and electronic engine controls (EEC) ($1.23).4/ These figures sum to $8.94, but EPA will conservatively assume $10 to cover any minor changes in material which might increase component durability or optimization costs which might be desirable to improve efficiency or decrease cost.

To allocate this development cost, EPA has relied on manufacturer's comments to the 1979 LDT standards. Based on the manufacturers comments, the development and testing costs will be allocated over a five year period with the bulk of the cost being incurred in the first three years. Using this methodology and a development cost of $10 per truck sold, the costs are apportioned according to the following schedule:

| | |
|---|---|
| Start of 1981: | $55M |
| Start of 1982: | 44M |
| Start of 1983: | 33M |
| Start of 1984: | 22M |
| Start of 1985: | 11M |
| | 165m |

EPA expects that the 1983 standards will require more development work than the 1979 standards primarily because of the increased useful life period and the 10 percent AQL. For the 1979 standards an R&D cost of $90 million was estimated. EPA believes the $165 million in development costs in this analysis is ample to cover any redesign, development testing, or emission control system optimization efforts undertaken.

### 2. Emission Control System Costs

#### a. Gasoline-Powered LDTs

EPA expects the manufacturers to continue the use of oxidation catalyst/air injection/EGR systems to achieve compliance with the 1983 emission standards. In addition, EPA expects that manufacturers will use a form of electronic engine controls (EEC).

Specifically, EPA expects manufacturers will use EEC to control spark timing and to modulate EGR when necessary. Controlling spark timing during cold start will aid in the reduction of HC and CO emissions by minimizing catalyst light-off time and then permitting optional spark timing during other driving modes. Some families may choose to replace their current EGR system with a modulated EGR system to achieve any small NOx reductions which might be required. The emission levels of the current LDT fleet indicate that not all LDTs will require EEC and/or modulated EGR to reduce emissions, however, this analysis has conservatively assumed that all manufacturers use EEC.5/

To determine the hardware related costs of complying with the 1983 emission standards and control strategy, EPA studied the emission levels and emission control strategies used on all engine families in the 1980 LDT fleet.5/ Using the results of this analysis EPA has estimated the costs of the hardware necessary for each engine family to achieve 4,000-mile emission levels below the expected average target levels.

These hardware costs generally fall into three major areas: catalytic converter upgrades, air injection system upgrades, and electronic engine controls (EEC).

The primary changes in catalytic converters are in the areas of converter volume and noble metal loading. These changes will increase catalyst efficiency and durability.

Air injection systems on about eight engine families will have to be upgraded as a result of the more stringent emission standards. Of the eight families affected, four will have to replace pulse air systems with mechanical air pumps, three will have to add a mechanical air pump where none is presently used, and one will have to add a pulse air system. The improved air injection systems in these 8 engine families will be necessary to insure increased oxidation of HC and CO during all driving modes.

EPA has assumed that all LDTs use EEC in 1983 to control spark timing and modulate EGR. The EEC system will entail an electronic control unit plus simple sensors for spark control and EGR modulation. This is a very conservative approach since not all LDTs will require EEC with spark control and modulated EGR.5/ Fuel economy pressures may force the manufacturers to use EEC however.

The results of EPA's engine family by engine family analysis are shown in Tables V-B, V-C and V-D for eight, six, and four cylinder engines respectively. These tables show the expected hardware cost increase for each family, but the family names have been deleted to protect the confidentiality of the manufacturers sales projections which have been used in the sales-weighting process. The use of the current manufacturers sales projections allows for the maintenance of the same relative market shares throughout the period. The summary and analysis of comments

Table V-B

Emission Control Hardware Cost: 8 Cylinder
1980 Dollars

| Family | Percent of 8 Cylinder Sales | Air Pump Upgrade Costs | Catalytic Converter Upgrade Costs | Electronic Engine Control Systems | Total |
|---|---|---|---|---|---|
| 1 | 0.87 | $0 | $23 | $60 | $83 |
| 2 | 3.67 | 0 | 23 | 60 | 83 |
| 3 | 5.78 | 0 | 25 | 60 | 85 |
| 4 | 8.16 | 0 | 23 | 60 | 83 |
| 5 | 4.31 | 0 | 25 | 60 | 85 |
| 6 | 1.40 | 0 | -20 | 60 | 40 |
| 7 | 18.73 | 0 | 10 | 60 | 70 |
| 8 | 0.83 | 0 | 0 | 60 | 60 |
| 9 | 13.76 | 0 | 10 | 60 | 70 |
| 10 | 2.36 | 0 | 0 | 60 | 60 |
| 11 | 15.35 | 0 | 16 | 60 | 76 |
| 12 | 18.27 | 27 | 0 | 60 | 87 |
| 13 | 5.06 | 27 | 0 | 60 | 87 |
| 14 | 0.69 | 0 | 16 | 60 | 76 |
| 15 | 0.77 | 0 | 16 | 60 | 76 |

Sales-Weight Cost per LDT: $77.41

Table V-C

Emission Control Hardware Cost: 6 Cylinder
1980 Dollars

| Family | Percent of 6 Cylinder Sales | Air Pump Upgrade Costs | Catalytic Converter Upgrade Costs | Electronic Engine Control Systems | Total |
|---|---|---|---|---|---|
| 1 | 12.64 | $0 | $13 | $60 | $73 |
| 2 | 7.41 | 0 | 13 | 60 | 73 |
| 3 | 13.45 | 0 | 25 | 60 | 85 |
| 4 | 41.24 | 0 | 2 | 60 | 62 |
| 5 | 23.86 | 23 | 16 | 60 | 99 |
| 6 | 1.38 | 0 | 46 | 60 | 106 |

Sales-Weight Cost per LDT: $76.72

Table V-D

Emission Control Hardware Cost: 4 Cylinder
1980 Dollars

| Family | Percent of 4 Cylinder Sales | Air Pump Upgrade Costs | Catalytic Converter Upgrade Costs | Electronic Engine Control Systems | Total |
|---|---|---|---|---|---|
| 1 | 8.55 | $0 | $0 | $60 | $60 |
| 2 | 1.49 | 0 | 13 | 60 | 73 |
| 3 | 16.14 | 0 | 79* | 60 | 139 |
| 4 | 0.30 | 0 | 0 | 60 | 60 |
| 5 | 5.49 | 4 | 0 | 60 | 65 |
| 6 | 3.67 | 0 | 0 | 60 | 60 |
| 7 | 22.98 | 23 | 33 | 60 | 116 |
| 8 | 0.57 | 27 | 0 | 60 | 87 |
| 9 | 9.71 | 23 | 0 | 60 | 83 |
| 10 | 7.48 | 23 | 0 | 60 | 83 |
| 11 | 2.98 | 0 | 0 | 60 | 60 |
| 12 | 18.22 | 0 | 122* | 60 | 182 |
| 13 | 2.41 | 0 | 65 | 0 | 65 |

Sales-Weight Cost per LDT: $112.50

* Includes $24 in stainless steel exhaust and unleaded fuel restrictor costs necessary due to the first time use of catalytic converter technology.

document supporting this rulemaking outlines the actual compliance steps anticipated in each case.

The costs for these hardware changes was estimated using the data and methodology in a cost estimation report prepared under contract for EPA.4/ This report was used to estimate costs for catalytic converter upgrades, air injection systems, and EEC (ECU plus sensors). For the few families which require modulated EGR, EPA has estimated that it would have approximately the same cost as the current EGR system which it is replacing so no significant increase in first cost would occur. This methodology was altered by allowing for the effects of inflation and using more realistic profit and overhead margins at the corporate and dealer level. The inflation rate used was 8 percent per annum, which is slightly greater than the new car CPI values for 1978 and 1979 (6.2 percent and 7.4 percent respectively).6/ The overhead and profit margin used is the same as in the recent heavy-duty engine rulemaking action (11.4 percent overhead, 17.6 percent profit).7/ Also, 1980 noble metal prices for platinum and palladum were used.

b. Light-Duty Diesel Trucks (LDDT)

In 1980 three manufacturers certified light-duty diesel trucks: General Motors, International Harvester and Volkswagen. Of the three truck families, only the General Motors family did not meet all of the 4,000-mile target emission levels.

In its light-duty diesel particulate rulemaking action, EPA estimated a cost of $30 per engine for this engine family to reduce its gaseous emissions. This would involve the addition of EGR, injector redesign and possibly some other minor engine modifications. By 1983, all of the necessary changes will have been made on GM's light-duty diesel passenger car fleet. Therefore, the only substantial change in GM's LDDT fleet will be to incorporate the changes into this engine family.

Light-duty diesel trucks will also have to comply with the new diesel crankcase control requirements. Presently, only one family, that from International Harvester, does not have a closed crankcase. EPA has determined that the cost to close the crankcase is about $6 per engine when a simple cyclonic separator is employed.8/

As stated previously, EPA expects that sales of LDDT will increase substantially during the mid-eighties. The 1980 projected sales of about 1.5 percent of the market is expected to rise to an average of 12 percent of the market during the period 1983-1987. EPA has reason to believe that other manufacturers will be introducing LDDT lines to gain a portion of this increasing market.

It is reasonable that the new light-duty truck engines introduced in the mid-eighties will have emission characteristics similar to the three families now produced. Some of them will be inherently very clean and have no emission problem, but some others will have problems with HC and NOx. As a means of estimating this market, EPA will use the same basic split as is present today, thus meaning that one-third of the engines will require gaseous emission reductions and one-third will require closing of the crankcase. Under this scenario, a per engine cost of twelve dollars is anticipated (.33($30 + $6)).

c. Fleetwide Emission Control Hardware Costs

Having now computed the hardware cost for gasoline and diesel light-duty trucks to meet the emission target levels, it only remains for these costs to be spread over the entire LDT fleet.

These costs will be allocated according to the scenario developed in the first few pages of this chapter. That is, for gasoline-powered LDTs EPA expects 15 percent 4 cylinder (less than 200 CID), 40 percent 6 cylinder (200-300 CID) and 45 percent 8 cylinder (greater than 300 CID). EPA is anticipating that light-duty diesel trucks will average twelve percent of the market over the period 1983-1987. Using this scenario, the per truck emission control hardware cost can be determined as shown below.

Hardware Cost =.12($12)+.88(.45($77)+.40($77)+.15($113)) = $74

If the fleet wide sales mix were to remain at current levels (11% 4 cylinder, 19% 6 cylinder, 70% 8 cylinder) this cost would be $80.

3. Certification Costs

Certification is the process in which EPA determines whether a manufacturer's light-duty trucks conform to applicable regulations. The manufacturers must prove to EPA its trucks are designed and will be built such that they are capable of complying with the emission standards over their full useful life. The certification process begins by a manufacturer submitting a certification application to EPA. Subsequently, two steps occur.

The first step involves the determination of preliminary deterioration factors for the regulated pollutants. The light-duty truck manufacturer may determine these preliminary deterioration factors in any manner it deems necessary to insure that the factors it submits to EPA for certification purposes are accurate and representative of the deterioration expected over the full useful life. Manufacturers must state that their procedures follow sound engineering practices and specifically account for the deterioration of EGR, air injection, and catalyst systems as well as other critical deterioration processes which the manufacturer may identify. In addition, when applicable, the manufacturer must state that the allowable maintenance intervals were followed in determining the preliminary deterioration factors. The manufacturers would submit preliminary deterioration factors, based on the revised useful life definition, in each case where current certification procedures require testing of a durability vehicle. Beyond these requirements EPA would not approve or disapprove the durability test procedures used by the manufacturers.

Step two involves emission data vehicles. Although the number of emission data vehicles per family is not fixed, a reasonable range is 2-8 with the 1980 average being approximately 4 per engine family. These vehicles would be operated for 4,000 miles before the emission test. The preliminary deterioration factor would be multiplied times the 4,000-mile emission test results to predict whether the emission data vehicles would meet the standards for their full useful life. If the emission data vehicles are predicted to pass the standards over the full useful life, then the engine family is granted certification.

As can be seen in the discussion above, each engine family will incur costs in two distinct areas: preliminary deterioration factor assessment and emission data vehicles.

To determine their preliminary deterioration factors EPA expects the manufacturers will use a procedure similar to that used now. However, due to the new useful life definition EPA expects that manufacturers will run their durability vehicles for 100,000 miles as opposed to the current 50,000 miles. As a general rule manufacturers run from one to two durability vehicles per family.

The calculation of the industry's cost for finding these preliminary deterioration factors under this assumption is shown in Table V-E. The unit costs are based on EPA estimates of what manufacturers have spent on testing durability data vehicles in the past.9/ The estimates were made in 1975, but have been adjusted for inflation and the impact of the longer testing period. The twenty-eight emission tests allow for testing at 5,000-mile intervals during the expected 100,000 miles of test operation and eight tests associated with maintenance. Based on the current number of engine family control system combinations EPA expects there will be about 50 combinations certified by all manufacturers in 1983. Total industry costs of determining preliminary deterioration factors are estimated at $31 million.

The testing of emission-data vehicles will not be affected by regulations, except that carry-over of emission test results from previous model years will be disrupted. EPA's method for estimating the cost impact of this disruption is to assume that no emission-data carry over is possible in the first effected year. This overestimates the incremental impact in the first year, since 100 percent carry over would not have been possible in any case. But the disruption also has an incremental impact in the second and following years. EPA reasonably assumes that the various errors cancel each other.

The calculation of the costs of testing emission-data vehicles is shown in Table V-F. Again, unit costs are derived from EPA

Table V-E

Certification Costs Associated with Determining
Preliminary Deterioration Factors
1980 Dollars

I. Cost per Engine Family - Emission Control System Combination

| | |
|---|---|
| Prototype Vehicle | \$ 35K |
| Mileage Accumulation to 100,000 miles Maintenance and Overhead | \$263K |
| Twenty-Eight Emission Tests at \$400 per test | \$ 12K |
| | \$310K |

II. Total Cost Industry Wide

Assuming fifty engine-system combinations will be tested and two vehicles per engine family.

100 x \$310K = \$31.0M Total Cost

Table V-F

Certification Costs Associated with
Emission Data Vehicle Testing

I. Cost per Emission Data Vehicle

| | |
|---|---|
| Prototype Vehicle | $13.8K |
| Mileage Accumulation to 4,000 miles, Maintenance, and Overhead | $ 8.8K |
| Two Emission Tests at $400 per test | $ 0.8K |
| | $23.4K |

II. Total Cost Industry Wide

Assuming 200 emission data vehicles from 50 families:

200 x $23.4K = $4.68M Total Cost

estimates made in 1975. EPA also estimates that 200 emission-data vehicles will require testing, an average of four per engine family-control system combination. (The ratio of emission-data vehicles to combinations is not fixed by regulation, so there is some variability in it from combination to combination and from year to year.) Emission-data costs total about $4.68 million.

The total certification cost ($35.68M) may be overestimated by as much as 20 percent if California does not adopt the revised durability testing procedure. To be conservative EPA has included the cost for recertification of the California families even though actual California sales have been excluded from the other costs and benefits.

4. Selective Enforcement Auditing Costs (SEA)

In addition to the revised emission standards for 1983, EPA is implementing changes in the LDT sampling system and acceptable quality level. The costs associated with the SEA program can be divided into two main categories: sampling system changes and 10 percent acceptable quality level costs (AQL).

a. Sampling Plan Changes

The incremental costs of changing from a batch sampling plan to a sequential sampling plan are negligible. There may be a small cost decrease due to a slight decrease in the average number of engines in an audit (at a 40 percent AQL).

b. 10 Percent AQL Costs

Incremental costs associated with going from a 40 to a 10 percent AQL lie in three areas: formal SEA testing costs, self audit testing costs, and costs associated with meeting the lower target levels.

Under the sequential sampling system the average number of vehicles tested at a 40 percent AQL is sixteen (assumes 40 percent non-compliance). However at a 10 percent AQL the average sample number is thirteen (assuming 10 percent non-compliance).10/ So there would be a formal SEA testing cost decrease of at the very least $1,200 per audit (assuming no vehicle break-in period). This cost is small compared to others discussed in this chapter, so it will conservatively be neglected.

Although EPA solicited manufacturers comment on any incremental increases in self auditing which may be required, only Chrysler responded in the affirmative. They estimated a one time cost of $1.7 million for equipment and $300,000 a year for testing. Since Chrysler did respond in the affirmative their costs will be included. Perhaps the reason for the lack of response from the manufacturers is because they are already very close to achieving the compliance levels necessary for the 10 percent AQL.11/ California audit data shows non-compliance levels of 5.1 percent for HC, 6.2 percent for CO, and 9.4 percent for NOx.

With the change to the emission standards and the useful life definition it is difficult to determine precisely the incremental hardware cost of going from a 40 percent AQL to a 10 percent AQL.

On a fleetwide basis, EPA expects the same hardware to be used regardless of the AQL. Gasoline-powered LDTs will still use air injection, EGR, oxidation catalysts, and electronic engine controls. As outlined in the summary and analysis of comments document, EPA expects that one engine family will have to add mechanical air pumps instead of a pulse air system at a fleetwide per vehicle cost of about $1 per LDT. In addition, the more stringent HC and CO targets will probably force an incremental increase in noble metal loading of not more than 0.1 grams of platinum on average. On a fleetwide basis these costs are only about $2 per truck. For diesel LDTs, the implementation of the 10 percent AQL will force GM to add EGR to their 350 CID diesel at a cost estimated at $15 per truck. Using the fleet projections discussed earlier and taking engines of this type to be one-third of the light-duty diesel truck sales in the mid-eighties, the per vehicle cost on a fleetwide basis is about $.60 per engine. All of the hardware costs discussed in this paragraph have already been included in the emission control hardware costs in section A. Incremental hardware costs of the 10 percent AQL are estimated at $4 per LDT. These costs are relatively small primarily because the change in emission targets is relatively small and the degree of conformity during production is already at the levels required for a 10 percent AQL.

5. Total Costs to Manufacturers

The four main costs to manufacturers (development and testing, certification, emission control hardware, and SEA related expenditures) are summarized in Table V-G. All costs are in 1980 dollars. The total cost shown in Table V-G, $1.418 billion dollars (undiscounted) provides sufficient funds for the manufacturers to deal with all aspects of this regulatory strategy.

B. Costs to Users of Light-Duty Trucks

1. Increases in First Costs

The added cost to manufacturers for development and testing, certification, SEA, and emission control system hardware will be passed on to purchasers of light-duty trucks. The amount a manufacturer must increase the price to recover its expenses depends on the timing of the costs and of the revenues from sales and on the cost of capital to the manufacturer. Table V-G showed the manner in which the manufacturers costs are distributed over the period 1981-1987. The cost of capital used is 10 percent, and EPA has

Table V-G

Total Costs to Manufacturers for Trucks
Produced During 1983-1987
1980 Dollars

| Year | Development Cost 1/ | Certification Cost 1/ | SEA Costs 1/ | Emission Control Hardware 2/ | Total |
|---|---|---|---|---|---|
| 1981 | $55M | $0 | $ 0 | $ 0 | $ 55M |
| 1982 | 44M | 35.7M | 1.7M | 0 | 81.4M |
| 1983 | 33M | 0 | 0.30M | 210M | 243.3M |
| 1984 | 22M | 0 | 0.30M | 232M | 254.3M |
| 1985 | 11M | 0 | 0.30M | 248M | 259.3M |
| 1986 | 0 | 0 | 0.30M | 258M | 258.3M |
| 1987 | 0 | 0 | 0.30M | 267M | 267.3M |
| Totals | $165M | $35.7M | $3.2M | $1215M | $1418.9M (undiscounted) |

1/ Fixed cost.
2/ Each year's costs are approximately 1/3 fixed cost (tooling, overhead, etc.) and 2/3 variable cost (material, labor, profit, etc.).

allowed the recovery of all fixed investment within five model years. The expected average, sales-weighted first price increase for 1983-1987 vehicles is $95 and is comprised of $17 for R&D, $4 for certification and SEA testing and $74 for emission control hardware. The range of this first price increase varies from $61 to $203 for gasoline-powered LDTs and reflects the differences in emission control hardware costs. For LDDTs the first price increase ranges from $21 to $51.

2. Maintenance Costs

For the vast majority of the engine families and trucks produced in the mid-eighties EPA is expecting no change in operating costs. However, two light-duty truck families will be using catalyst technology for the first time in 1983 and thus will have decreased operating costs associated with fewer exhaust system replacements and fewer spark plug replacements. The use of unleaded gasoline combined with material improvements in the exhaust system will reduce maintenance costs associated with exhaust system replacement. EPA estimates that approximately one entire exhaust system replacement will be saved over the vehicle lifetime. Spark plug life will be increased substantially over the current intervals as a result of the use of unleaded fuel.

To estimate these cost savings, exhaust system and spark plug replacement costs, the current and future spark plug replacement costs, the current and future spark plug replacement intervals, and a mileage accumulation rate for light-duty trucks must be known.

EPA ascertained exhaust system and spark plug replacement costs using parts plus labor replacement cost estimates received from several retail dealers. For a set of four spark plugs estimates ranged from $6.80 to $7.68. EPA used the lowest point in these estimates, approximately $6.80 per set. Exhaust system replacement costs ranged from $150 to $210 for parts and labor. Since at least one complete exhaust system will not have to be replaced, EPA will conservatively use the lowest cost of this range or $150 per replacement.

The current spark plug intervals for these two families are both 15,000 miles.2/ The new maintenance interval is 30,000 miles. For exhaust systems EPA has estimated that with the use of unleaded gasoline only one replacement late in the sixth year would be required and a second replacement could be eliminated. (see Table V-H).

Although the financial savings will not be computed or accounted for in this analysis, one other potential savings does exist. With the change from leaded to unleaded fuel accompanying the use of catalyst technology, blowby emissions of lead into the crankcase will also be eliminated. This in turn, should allow an increase in the oil change interval, and thus savings to the owner over the vehicle life.

Table V-H

Exhaust System and Spark Plug Savings

| Year 1/ | Average Annual Mileage 2/ | Cumulative Mileage 2/ | Number of Spark Plug Replacements Based on Intervals 15,000 miles | 30,000 miles | Exhaust System Replacement With and Without Unleaded Gasoline Without | With |
|---|---|---|---|---|---|---|
| 1 | 7,950 | 7,950 | 0 | 0 | - | - |
| 2 | 15,450 | 23,400 | 1 | 0 | - | - |
| 3 | 14,500 | 37,900 | 1 | 1 | - | - |
| 4 | 13,550 | 51,450 | 1 | 0 | 1 | - |
| 5 | 12,650 | 64,100 | 1 | 1 | - | - |
| 6 | 11,700 | 75,800 | 1 | 0 | - | 1 |
| 7 | 10,800 | 86,600 | 0 | 0 | - | - |
| 8 | 9,850 | 96,450 | 1 | 1 | 1 | - |
| 9 | 8,950 | 105,400 | 1 | 0 | - | - |
| 10 | 8,050 | 113,450 | 0 | 0 | - | - |
| 11 | 7,150 | 120,600 | 1 | 1 | - | - |
| 12 | 1,400 | 122,000 | 0 | 0 | - | - |
| | | | 8 | 4 | 2 | 1 |

1/ Year of light-duty truck usage.
2/ Average Lifetime Periods for Light-Duty Trucks and Heavy-Duty Vechiles, US EPA, OMSAPC, ECTD, SDSB 79-24 Glenn W. Passavant, November 1979.

Finally, to compute the discounted values of these savings, the average mileage accumulation rate for light-duty trucks (<6000 lbs. GVWR) must be known. This was taken from an EPA technical report and is shown in Table V-H together with the exhaust system and spark plug computations.

Using the data in Table V-H and the standard 10 percent discount rate, the average spark plug and muffler savings is estimated at $115 (discounted) per vehicle effected.

Since sales from these two engine families are only about four percent of the total,2/ the average savings per LDT is only $4.61 (discounted).

3. Fuel Economy and Fuel Costs

One means of meeting the target emission levels is what EPA would call the "quick fix technology" approach. This would involve the use of the same basic emission control hardware as is currently used; and achieving emissions reductions through engine or emission control system calibrations and start catalysts. This is the type of technology which some manufacturers used to meet the 1980 California emission standards. If this "quick fix technology" is used, then a 3 to 4 percent fuel economy penalty is possible.12/

However, EPA has no reason to believe that this fuel economy penalty need occur. If the manufacturers use the electronic engine controls and upgraded catalyst/air injection systems described in the summary and analysis of comments and costed in this chapter, the necessary emission reductions should be achievable with no fuel economy penalty. If a manufacturer has trouble meeting the target emission levels without a fuel economy penalty, then the option of using a 3-way catalyst system is available. This 3-way system would cost about $96 more per LDT than the emission control system outlined previously for an 8 cylinder engine.5/ EPA's assessment of the fuel economy impact of these regulations is reinforced by NHTSA's analysis for their proposed light-duty truck fuel economy standards for model years 1982-1985, which shows a fleetwide fuel economy gain from MY 1982 to MY 1983.13/

The two LDT families which will be using catalyst technology for the first time will also require more expensive unleaded fuel for the first time. A long term unleaded-leaded price differential of three cents per gallon is anticipated.14/

Using a sales-weighted average fuel economy of 21.6 miles per gallon for these two engine families,2/ a lifetime period of 122,000 miles15/, and an unleaded fuel differential of three cents per gallon, lifetime fuel costs will be increased by $114 (discounted) for each of these light-duty trucks, on a per LDT basis this cost is only $4.56 (discounted).

4. Total Costs to Users

To summarize, users of light-duty trucks can as a result of these regulations expect to pay an average of $95 more for 1983 model year trucks than for comparable models purchased in 1982, in 1980 dollars. Operating costs will not increase for the average vehicle. The purchasers of light-duty truck models which will require unleaded fuel for the first time can expect their increased costs for unleaded fuel to be offset by saving in maintenance expenses for spark plugs and the exhaust system.

C. Aggregate Costs

The aggregate costs to the nation of complying with the 1983 Federal LDT emission regulations consist of the sum of increased costs for development, new or upgraded emission control hardware, certification costs and selective enforcement auditing at a 10 percent AQL. Two truck models will also require unleaded gasoline for the first time, but this expenditure should be offset by savings in maintenance costs related to spark plugs and the exhaust system. All of these costs will be calculated for a five-year period of compliance.

The five-year costs of compliance are dependent on the number of light-duty trucks sold during the period. The accuracy and validity of projecting vehicle sales as far into the future as 1987 is problematic, so cost estimates based on such projections are subject to some qualification. However, because the largest portion of the costs in this analysis are variable costs (hardware) and not fixed costs (certification, R&D) the accuracy of the sales projections is not as important as might be the case in some other rulemaking actions. Future sales of LDT for this rulemaking action were discussed previously, and are shown in Table V-A.

The various costs associated with this rulemaking action will occur in different periods. In order to make all costs comparable, the present value at the start of 1983 of the aggregate costs has been calculated, based on a discount rate of 10 percent. Use of a discount rate emphasizes that because of the time value of money, a cost incurred now is worth more to the nation than a cost incurred in the future.

The calculation of the present value in 1983 of the aggregate costs, with the assumptions required for the calculation is shown in Table V-I. The aggregate cost of complying with the new regulations for the five-year period is equivalent to a lump sum investment of about $1.29 billion (1983 dollars) made at the start of 1983. Expressed in other terms, the aggregate cost of compliance is equivalent to an investment of $95 per LDT made at the start of the year the LDT is produced.

It is estimated that LDTs over 6,000 lbs. GVWR comprise 45 percent of the LDT group.16/ In accordance with the Clean Air Act,

Table V-I

Present Value in 1983 of the Aggregate Cost of Compliance for the 1983-1987 Model Years

| Year 1/ | Cost 2/ | Present Value in 1983 3/ |
|---|---|---|
| 1981 | $ 70,950K | $ 85,850K |
| 1982 | 104,980K | 115,478K |
| 1983 | 253,117K | 253,117K |
| 1984 | 260,387K | 236,715K |
| 1985 | 262,477K | 216,923K |
| 1986 | 258,647K | 194,325K |
| 1987 | 268,267K | 183,230K |

Undiscounted Aggregate Cost: $1,478,825K

1983 Present Value of Aggregate Costs: $1,285,638K

1/ Costs are assumed to occur at the start of each year.

| Cost | Year |
|---|---|
| Redesign and development | Estimated at $165 million and allotted over the five year period (1981-1985) according to the formula: Cost (millions) = 21846 - 11(year). |
| Certification | 1982 - Preliminary deterioration factor assessment and emission data vehicles. |
| Emission control system | Same as model year. |
| SEA | 1982 (hardware), 1983-1987 (testing). |

2/ 1980 dollars, includes profit and overhead.

3/ 10 percent discount rate.

Table V-J

Aggregate Costs of Compliance for
Vehicles Produced During 1983-1987
(Discounted at 10% to January 1, 1983)

| | |
|---|---|
| Redesign and Development | $ 228,382K |
| Certification | 50,630K |
| SEA Testing (self audit) | 4,026K |
| Manufacturing of Hardware | $1,002,600K |
| Total Discounted Cost | $1,285,638K |

Table V-K

Undiscounted Costs of Compliance Per Vehicle for Vehicles Produced During 1983-1987

| | |
|---|---|
| Redesign and Development | $12.96 |
| Certification | 2.80 |
| SEA Testing (self audit) | .25 |
| Manufacturing of Hardware (sales-weighted) | 74.00 |
| Undiscounted Cost per Vehicle | $90.01 |

Table V-L

Discounted Costs of Compliance Per Vehicle for Vehicles Produced During 1983-1987

| | |
|---|---|
| Redesign and Development | $16.87 |
| Certification | 3.74 |
| SEA Testing (self audit) | .30 |
| Manufacturing of Hardware (sales-weighted) | 74.00 |
| Discounted Cost per Vehicle and First Price Increase | $94.91 |

any vehicle over 6,000 lbs. GVWR is a heavy-duty vehicle and must meet the heavy-duty engine emission standards. Using the appropriate portions of the fixed, and variable costs the expenditure for meeting the reductions required by statutes is about $580 million dollars (discounted).

For ease of reference, the components of the cost of compliance and the different ways of expressing it are summarized in Tables V-J, V-K, and V-L.

D. Sensitivity of the First Price Increase to Changes in Key Analysis Parameters

In any analysis of this type large changes in any key projections or assumptions may lead to significant changes in the economic impact of the regulations to the ultimate consumer. This economic impact may take the form of either changes in the first price incrase or operating cost changes.

EPA has identified six major areas to use in this sensitivity analysis: hardware cost, discount rate, sales projections, fleet sales mix projections, fixed cost expenditure rate, and changes in operating costs.

1. Hardware Cost

EPA's estimated hardware costs could be in error if, for example, noble metals increase or decrease drastically or 3-way catalyst systems are required on a percentage of the eight cylinder sales.

Four cases will be analyzed:

1) 25 percent increase in noble metal prices
2) 25 percent decrease in noble metal prices
3) 20 percent of eight cylinder engines require 3-way systems
4) 40 percent of eight cylinder engines require 3-way systems

Using the noble metal costs and hardware cost methodology used previously, the table below gives the impact of these changes on the hardware cost and the anticipated first price increase of $95:

| Case | Incremental Change in First Price Increase |
|---|---|
| 25% increase in noble metal prices | +$1.68 |
| 25% decrease in noble metal prices | -$1.68 |
| 20% of 8 cylinder use 3-way | +$7.48 |
| 40% of 8 cylinder use 3-way | +$15.02 |

2. Discount Rate

In the current times of sluggish motor vehicle sales and unstable economic conditions some manufacturers may choose to finance their capital requirements through the capital markets. Current costs of capital (prime rate) have varied between ten and twenty percent in the past two to three years. To gauge the impact of changes in the prime rate on the first price increase, two additional discount rates will be tested: 12.5 percent and 15 percent. The results are shown below:

| Discount Rate | Incremental Change in First Price Increase |
|---|---|
| 12.5% | +$1.33 |
| 15% | +$2.70 |

3. Sales Projections

As it is with any other product, the cost per item is dependent on the number of units sold and thus, the first price increase is dependent on the number of light-duty trucks sold.

To determine the sensitivity of the first price increase to total sales, fleets of fifteen percent larger and smaller than that used in this analysis will be tested. With all other inputs the same as in the base case, the sensitivity of the first price increase to total sales is shown below.

| Discount Rate | Incremental Change in First Price Increase |
|---|---|
| +15% | -$2.71 |
| -15% | +$2.71 |

4. Fleet Sales Mix Projections

Due to market pressures, fuel economy pressures, and emission standards, EPA is expecting a shift in the market from its present mix of LDDT and 4, 6, and 8 cylinder gasoline-powered trucks.

At least two different areas of this sales mix should be investigated: dieselization and engine sizing mix changes.

An average dieselization percentage of 12 percent is expected through the period 1983-1987. To test the sensitivity to dieselization, values of 6 percent and 18 percent will be used. To gauge the sensitivity of the analysis to the engine size mix, three additional scenarios will be tested: 8 cylinder dominant, 6 cylinder dominant, and 4 cylinder dominant. The results of this analysis are shown below:

| Fleet Change | Incremental Change in First Price Increase |
|---|---|
| 6% Increase in Dieselization | -$4.04 |
| 6% Decrease in Dieselization | +$4.04 |
| 8 cylinder dominant (70% 8 cylinder, 20% 6 cylinder, 10% 4 cylinder) | -$1.63 |
| 6 cylinder dominant (30% 8 cylinder, 55% 6 cylinder, 15% 4 cylinder) | ±$0 |
| 4 cylinder dominant (35% 8 cylinder, 35% 6 cylinder, 30% 4 cylinder) | +$4.70 |

5. Fixed Cost Expenditures

Manufacturers may choose to expend the expected fixed costs at a different rate than was used in this analysis (Table V-G). The year in which the fixed costs are incurred is important in determining the effect of fixed costs on the first price increase due primarily to the compound effects of discounting and overhead/profit.

This analysis will examine two cases: 1) all fixed costs are incurred before production begins and 2) all fixed costs are incurred before the anticipated 1985 NOx regulations. For this analysis, certification and SEA expenditures will be incurred as shown in Table V-G, but the R&D expenses will be spread evenly over the term allowed. For case one above this is a two year period and for case two a four year period. The results of this analysis are shown below.

| Expenditure Rate | Incremental Change in First Price Increase |
|---|---|
| 2 years (evenly 1981 and 1982) | +$1.28 |
| 4 years (evenly 1981 through 1984) | -$0.28 |

6. Changes in Operating Costs

The emission control technology described in this chapter and in the technological feasibility discussion is expected to provide compliance with emission standards with no fuel economy penalty and possibly a slight fuel economy improvement.

If the EEC/catalyst/air pump system were to yield a fuel economy loss or gain this would have a substantial impact on the total economic burden of this regulation.

To estimate the potential impact of a slight change in fuel economy, EPA has analyzed the impact of a one percent gain or loss in fuel economy from the 1980 CAFE levels of 16 mpg for 2 wheel drive and 14 mpg for 4 wheel drive trucks. The results of this analysis are shown below: 24/

| Fuel Economy Change | Incremental Cost Change per Vehicle |
|---|---|
| +1% | -$83 |
| -1% | +$83 |

In addition, the possibility remains that some manufacturers may choose to meet the emission standards using larger, more heavily loaded catalysts, increased air injection and engine modifications, instead of EEC systems. EPA's fuel economy analysis in the summary and analysis of comments concluded that a 3 to 4 percent fuel economy loss would be possible if the pure catalyst system was used. However, the pure catalyst system is about $30 cheaper than the EEC system. Using the same methodology as referenced previously and the $30 decrease in first price yields the cost changes shown below:

| Pure Catalyst System/ Fuel Economy Change | Incremental Cost Change Per Vehicle |
|---|---|
| -3% | +$219 |
| -4% | +$302 |

Figure V-A summarizes the cost and cost effectiveness for both the EEC and pure catalyst control system for a range of fuel economy changes.

As can be seen in Table V-M which summarizes this analysis, the greatest sensitivity is related to changes in operating costs. EPA fully expects that fuel economy pressures will force the manufacturers to use the EEC based system rather than a pure catalyst system. Thus, any fuel economy penalty will be averted. The greatest sensitivity of the remaining parameters is related to hardware costs. This is as expected since the hardware related costs account for 78 percent of the expected first price increase (see Table V-L). Even the most dramatic departure from the scenario analyzed would yield only a 16 percent increase in the first price increase. From the benefits shown later in Chapter VII, the average first price increase would have to be well in excess of $145 before cost effectiveness would become a concern.

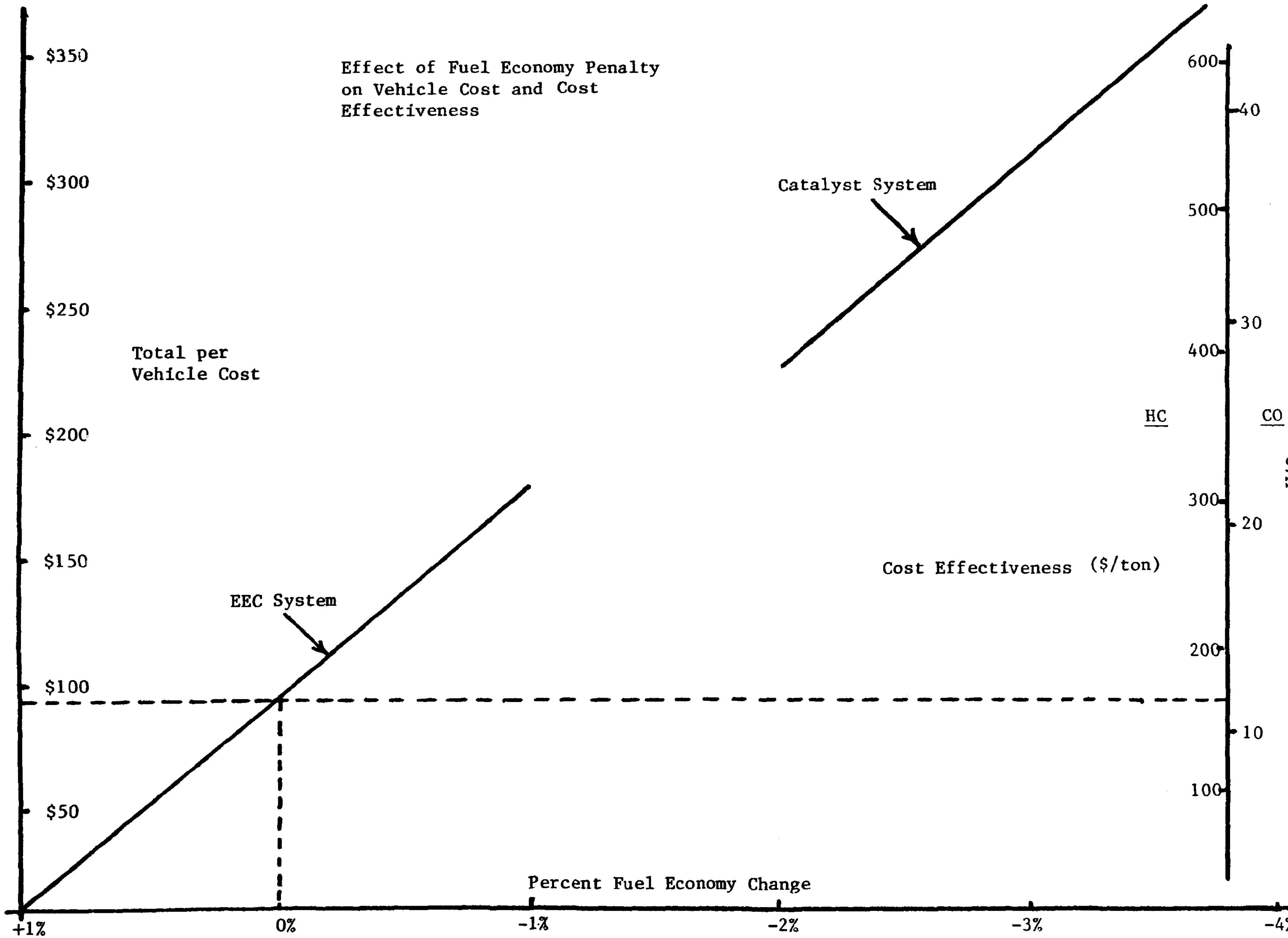
## E. Socio-Economic Impact

### 1. Impacts on Manufacturers

#### a. Capital Expenditures

The promulgation of the 1983 LDT emission regulations will

Figure V-A



Effect of Fuel Economy Penalty on Vehicle Cost and Cost Effectiveness
Total per Vehicle Cost
$350
$300
$250
$200
$150
$100
$50
Catalyst System
EEC System
HC
CO
600
500
400
300
200
100
40
30
20
10
Cost Effectiveness ($/ton)
Percent Fuel Economy Change
+1%
0%
-1%
-2%
-3%
-4%

Table V-M

Economic Impact Sensitivity

| Case Tested | Absolute Change in the Average First Price Increase Expected ($95) |
|---|---|
| 25% increase in noble metal prices | +$ 2 |
| 25% decrease in noble metal prices | -$ 2 |
| 20% of 8 cylinders use 3-Ways | +$ 7 |
| 40% of 8 cylinders use 3-Ways | +$15 |
| 12.5% discount rate | +$ 1 |
| 15% discount rate | +$ 3 |
| Sales 15% greater | -$ 3 |
| Sales 15% less | +$ 3 |
| 18% dieselization | -$ 4 |
| 6% dieselization | +$ 4 |
| 8 cylinder dominant | -$ 2 |
| 6 cylinder dominant | ±$ 0 |
| 4 cylinder dominant | +$ 5 |
| Fixed costs (2 years) | +$ 1 |
| Fixed costs (4 years) | ±$ 0 |
| +1% fuel economy (EEC) | -$83* |
| -1% fuel economy (EEC) | +$83* |
| -3% fuel economy (pure catalyst) | +$219** |
| -4% fuel economy (pure catalyst) | +$302** |

Note: All values rounded to the nearest dollar.

* Operating cost change only.

** Operating cost as offset by $30 saving on first price increase.

cause the manufacturers of these vehicles to spend about $200 million for development and certification and an additional average of $243 million a year (over the first five years) for production of emission control systems over and above those required to meet current standards. These costs will be paid ultimately by individuals who buy light-duty trucks, but the manufacturers will be required to bear the initial cost burden for this work. This regulation, therefore, will require manufacturers to generate additional capital between promulgation of the final rule and 1983, either internally or on the capital markets, sufficient to meet each year's costs.

Table V-G showed the manufacturers costs by category and year. Costs are first incurred in 1981 as redesign and development begins, but the first opportunity to recover costs via price increases will be in 1983.

Manufacturers should have little trouble financing the required investment. If the total pre-1984 development, and certification costs plus the 1983 emission control hardware costs are distributed among the manufacturers in proportion to their shares of the LDT market,2/ the required investment by each manufacturer is as follows:17/

| Manufacturer | Required Investment |
|---|---|
| AMC | 29.7M |
| Chrysler18/ | 62.5M |
| Ford | 122.0M |
| General Motors | 122.3M |
| IHC | 4.6M |
| Isuzu | 6.7M |
| Mitsubishi | 3.7M |
| Nissan | 9.4M |
| Suzuki | .2M |
| Toyota | 7.0M |
| Toyo Kogyo | 9.7M |
| Volkswagen | 1.9M |

These investments are small when compared to the total capital requirements of the manufacturers in this period. For example, Ford would have to invest about 8.3 percent of its 1978 corporate profits and General Motors would have to invest only 3.7 percent of its 1978 corporate profits. Chrysler's investment will have to be funded from limited loan guarantees. However, in all cases, most if not all of the investment will be recovered through the first price increase.

b. Effects on the Demand for LDTs

Changing the prices of light-duty trucks may, of course, impact sales. An average first cost increase of $95 means a selling price rise of about 1-2 percent. This increase is less than the usual annual increase of 5 to 7 percent.6/

EPA knows of no specific estimates of the price elasticity of demand for LDTs. The short term elasticity of demand for LDVs and LDTs has been estimated at -0.70.19/ Lacking any other estimates, this short term elasticity of demand has been assumed as valid for LDTs. In a report by EPA's Office of Noise Abatement Control, a long-term elasticity of demand of -0.32 was cited for all trucks and buses.20/ Considering that LDTs comprise the vast majority of vehicles in this group, and the long-term elasticity of demand for heavy-duty vehicles is near -0.7, using the -0.32 as the long-term elasticity demand for light-duty trucks, is a reasonable estimation. One method of estimating the sales decrease is the Ford Econometric Model.21/ This model accounts for first cost increases, changes in fuel economy, and increases costs of operation and maintenance. Using some of the data presented in this chapter and making some simple assumptions as to LDT average retail price and fuel economy, the model predicts that LDT sales should decrease about 0.5 percent in the short term and about 0.2 percent in the long term as a result of these regulations. Sales by some smaller manufacturers of LDTs may decline more than those of larger manufacturers due to their smaller sales volume over which the development, certification and tooling costs can be amortized. The small decrease in total industry sales, due to these regulations, will be more than overcome by normal sales growth and thus can be expected to have no noticeable effect on any single manufacturer's sales.

It is unlikely that the sales mix between LDTs, HDVs, and LDVs will be significantly affected. Only commercial concerns would consider switching from an LDT to an HDV for delivery or other purposes, but the greater selling price and operating costs of heavy-duty vehicles would greatly deter this switching. Some vehicle owner's who drive LDTs for pleasure may choose to switch to LDVs, or lower GVWR LDTs, as a result of this action.

Since commercial LDTs are used primarily for intracity delivery, no switch to shipping freight by rail or air is feasible.

It is not expected that the promulgation of the regulations will have any long term impact on employment or productivity in the light-duty truck industry, since industry wide sales will be affected little.

### 2. Impact on Users

Users of light-duty trucks will be affected by the higher vehicle costs. The expected average, sales-weighted first cost increase of $95 should not substantially impact the owner's ability to pay for new LDTs. These regulations will increase costs only .08 cents per mile over the useful life, an insignificant fraction of current costs.

### 3. Effects of Energy Use

EPA expects compliance with these regulations to be based upon continued use of catalyst plus air pump system and the addition of the newly developed electronic engine controls. These regulations will have no negative fuel impact and will not inhibit manufacturers' ability to comply with fuel economy standards for LDTs. (See fuel economy issue in the Summary and Analysis of Comments).

4. Inflationary Effects - Consumer Price Index

The consumer price index (CPI) is one of the primary indications for changes in the general price level. It is estimated that light-duty trucks contribute about 0.5 percent to the CPI determination.22/ Combining this percent contribution with the average estimated price increase of about 1.5 percent will give only a .0075 percent increase in the CPI. Needless to say this increase is negligible compared to other elements of the CPI. Therefore, EPA concludes that these emission regulations will have no significant price level impact. Further, since the public will receive air quality and related health improvements in exchange for the higher LDT prices, the rise in the CPI that will occur cannot properly be termed inflation.

5. Balance of Trade Effects

The increase in the precious metal loadings of catalytic converters may cause an increase in the imports of platinum and palladium. Before one can quantify this impact, an engine family by engine family analysis of the increases noble metal loadings is necessary. This is found in the Economic Impact issue of the Summary and Analysis of Comments document supporting the rulemaking. This data must then be sales weighted, considering only domestically produced engines.

Accomplishing this analysis yields a per LDT increase of .338 grams of platinum and .091 grams of palladium. The current value of these increased metal imports is about $3.90 per domestic LDT. Using the sales projections in Table V-A this comes to an increase in imports of about $9.9 million dollars per year. Assuming increases in domestic imports of platinum and palladium neglects the real possibility that recycled precious metals from used catalysts may be commerically available by the mid-eighties.

Another major balance of trade impact is related to the first price increase in imported LDTs. Based on the hardware costs in Table V-D (most imports are 4 cylinder) an average first price increase of $134 can be expected for imported LDTs. The expected first price increase for imported LDTs is larger than average due to the first time use of catalytic converter technology on a high percentage of imported LDTs. If one assumes a constant market share for imported LDTs this yields a loss in the balance of trade by an average of about $45 million dollars per year.

6. Local and Regional Effects

The domestic light-duty truck manufacturers operate about 22

Table V-N

Light Truck Assembly Plants
in the United States

General Motors:

Fremont, California
Lakewood, Georgia
Baltimore, Maryland
Detroit, Michigan
Flint, Michigan
Pontiac, Michigan
St. Louis, Missouri
Lordstown, Ohio
Janesville, Wisconsin

Ford:

San Jose, California
Louisville, Kentucky
Wayne, Michigan
Twin Cities, Minnesota
Kansas City, Missouri
Lorain, Ohio
Norfolk, Virginia

Chrysler:

Warren, Michigan
St. Louis, Missouri

American Motors:

Toledo, Ohio
South Bend, Indiana

International Harvester:

Fort Wayne, Indiana

Volkswagen:

Westmoreland, Pennsylvania

plants in assembling their products. Their locations for each manufacturer, are shown in Table V-N.23/ A total of twelve states are included.

General Motors operates nine assembly plants to produce light-duty trucks and vans. Some of these plants are also used to assemble passenger cars. General Motors has plants located in seven states with three in Michigan. Ford operates seven assembly plants spread over seven states. Chrysler and AMC currently operate two each, IHC and Volkswagen operate one each.

It is reasonable that any slight decrease in employment which might be related to these regulations would be spread evenly across the twenty-two plants affected. If production were to drop 0.2 percent as a result of these regulations, spreading that drop evenly over the twenty-two plants would yield a drop of only 0.2 percent at each plant. This is a relatively incalculable impact considering other factors affecting production, and thus only a very insignificant drop in employment might result.

Offsetting this slight drop would be the jobs created or sustained by the research and development effort anticpated. This impact would be strongest at the large volume manufacturers (GM, Ford, Chrysler) and at the vendors which produce emission related components.

In any event, the expected annual sales increases and the effects of the dynamic condition of the LDT market will render the employment impact of these regulations negligible.

As a result, EPA concludes that no locality or region will suffer noticeable or disproportionate economic impact, positive or negative, as a result of these regulations, and all areas will benefit by the improvements in air quality these regulations will bring.

References


1/ See Chapter III.

2/ Based on data gathered from EPA's Certification Division.

3/ Rulemaking Support Paper, Light Truck Fuel Economy Standards Model Years 1982-1985, U.S. DOT, NHTSA, December, 1979.

4/ Cost Estimations for Emission Control Related Components/ Systems and Cost Methodology Description, Leroy H. Lindgren, Rath and Strong Inc, March 1978, EPA-460/3-78-002.

5/ See Issue F, Economic Impact, in the Summary and Analysis of Comments supporting this rulemaking action.

6/ Based on Bureau of Labor Statistics data.

7/ Summary and Analysis of Comments to the NPRM: 1983 and Later Model Year Heavy-Duty Engines, U.S. EPA, OMSAPC, December 1979.

8/ The six dollar cost is based on discussion with a Mercedes-Benz retail dealer and represents an approximate replacement cost for the closed crankcase system on their light-duty diesel engines plus profit.

9/ EPA memo, Light-Duty Vehicle Certification Costs, D. Hardin, Jr. to E. Brune, D. Kimball, and J. Marzen, March 13, 1975.

10/ Analytical Development of Sampling Plans for SEA, Sylvia Leaver, EPA Office of Enforcment, MSED, December, 1978.

11/ Analysis of California Two Percent Audit Data, March 1980, available in the Public Docket.

12/ See Issue L Fuel Economy in the Summary of Analysis of Comments supporting this rulemaking action.

13/ Preliminary Regulatory Analysis of Light Truck Fuel Economy Standards Model Years 1982-85, DOT, NHTSA, Office of Program and Rulemaking Analysis December 1979, Table III-12.

14/ Fuel Additive Issues and Petroleum Product Supply Effects, February 1980, Sobotka and Company, Inc., pp. 20, 21, prepared for EPA under contract 68-01-4939.

References (cont'd.)

15/ Average Lifetime Periods for Light-Duty Trucks and Heavy-Duty Vehicles U.S. EPA, OMSPAC, SDSB 79-24, Glenn W. Passavant, November 1979.

16/ Environmental Impact Statement - Emission Standards for Light-Duty Trucks, U.S. EPA, OMSPAC, ECTD, November 1976.

17/ Required investment includes a portion of the fixed costs and the 1983 hardware cost. The portion for each manufacturer is based on it's portion of the total projected sales.

18/ Chrysler's cost includes its SEA hardware cost and 1983 SEA testing costs.

19/ "Economic Analysis of Selective Enforcement Auditing Regulations", U.S. EPA, Thomas J. Alexander, December 22, 1975.

20/ "Background Document for Medium and Heavy Truck Noise Emission Regulations", Appendix C, EPA Office of Noise Abatement Control, March 1976, EPA-550/9-76-008.

21/ Econometric model of new car sales presented by Ford Motor Company in submission to the 1977 Suspension Hearing panel, interoffice memo of January 27, 1976, J.V. Deaver to D.A. Jensen.

22/ Preliminary Impact Assessment of the Non-Passenger Automobile Fuel Economy Standards for Model Years 1980 and 1981, DOT, NHTSA, Planning and Evaluation Office of Program Analysis, November 29, 1977.

23/ Automotive News Market Databook Issue, April 1980 and Wards Automotive Yearbook, 1979.

24/ This analysis used a fuel price of $1.30 per gallon and a discount rate of 5 percent for the price of fuel over the useful life periods and mileage accumulation rates shown in reference 15 above for LLDT and HLDT. In addition, this anlaysis used LLDT as 55 percent of the market and HLDT as 45 percent of the market. Based on historical sales data LLDTs are 95 percent 2WD and 5 percent 4WD. HLDTs are 47 percent 2WD and 53 percent 4 WD.

# CHAPTER VI

# ALTERNATIVE ACTIONS

## A. Introduction

As EPA has proceeded with the development of a final rulemaking based upon analysis of comments received in response to the July 1979 proposal, alternatives and options in essentially all aspects of the rulemaking have been evaluated. Most of the comments received from manufacturers either explicitly or implicitly involved alternatives to items which EPA had proposed. That is, EPA was requested to evaluate eliminating, modifying or replacing elements of the rulemaking proposal in a wide variety of ways based upon what manufacturers perceived as defects in the proposal, or more desirable alternatives. Some of the alternatives raised during the comment period had already been analyzed by EPA, while some had not.

In the Summary and Analysis of Comments detailed analysis of all identified alternatives are developed. This document is available in the public docket (OMSAPC-79-2) and the material it contains will not be repeated in this chapter beyond the level of a brief review of major alternatives considered. In addition to the Summary and Analysis of Comments, Chapter VII (Cost Effectiveness) of this Regulatory Analysis considers the emission benefits and costs associated with each basic element of the rulemaking and determines the resulting cost effectiveness.

The alternative evaluated by EPA will be considered in three areas: 1) Alterantive standards, 2) Alternative to specific elements of the rulemaking, 3) Alternative timing for implementation.

## B. Alternative Standards

There were two options available to EPA with regard to the establishment of the standards. The first concerned the stringency of the standards. The second involved dividing the light-duty truck class into subcategories and establishing separate standards for each subcategory.

Concerning the stringency level of the standards, the proposed levels of 0.8g/mile HC and 10g/mile CO are being finalized. This is being done in spite of the fact that revisions to the light-duty truck baseline made since the proposal indicate that the statutory 90 percent reduction standards could be lower (0.6 HC, 8 CO).1/ Rather than adopt more stringent standards, EPA has retained the original standards, as proposed. This has been done primarily for the sake of promptly completing this rulemaking. The 0.8 and 10g/mile standards do produce substantial benefits at an economical cost. They also represent levels very close to the statutory 90 percent reduction levels (88 percent for HC and 87 percent for CO). Therefore, they are being finalized for the 1983 model year. Revised standards for HC and CO may however be considered as part of future rulemaking.

EPA also has the option of adopting standards less stringent than those proposed. This is not being done because of the substantial environmental benefits of the statutory reductions and the ready feasibility of attaining those reductions.

In addition to the actual level of the standards, EPA described at the time of the NPRM an option involving subdivision of the current light-duty truck class into subcategories and establishing graduated standards. As described in the draft Regulatory Analysis accompanying the NPRM, this alternate could have advantages. By such an approach, the smaller and lighter light-duty trucks could be controlled to more stringent levels and a greater overall emission reduction would result. On the other hand, such an approach could have a detrimental effect on fuel economy if it were to discourage downsizing of vehicles. This could happen if a manufacturer found himself facing more stringent emission standards as a result of his desire to downsize.

As was the case with lower numerical levels for standards, it would be outside the range of this rulemaking to change the class limits at this time. At the time of the proposal, EPA indicated its belief that retention of a single light-duty truck class was the best option. However, EPA intends to continue its study of this option. If at some future time the balance should shift toward a subdivided light-duty truck class, then that approach would appear in an EPA proposal.

## C. Alternatives to Specific Elements of the Rulemaking

Since essentially all aspects of the proposal were questioned during the comment period, EPA has analyzed all of these in the course of developing the final rulemaking. Alternatives relating to the rulemaking include redefinition of useful life, in-use durability testing, allowable maintenance regulations, a 10 percent acceptable quality level for assembly line testing, and diesel crankcase control. For each, there is an appropriate portion of the Summary and Analysis of Comments which can be consulted. In addition, the cost effectiveness of each element is estimated in Chapter VII of this Regulatory Analysis. It is important to realize that Chapter VII is actually an analysis of alternative rulemaking packages. Each cost versus benefit ratio is derived from a comparison of the final rulemaking with a rulemaking package not having the item being evaluated. Thus, each constitutes a unique combination package, and each combination represents an alternative approach to the rulemaking.

For the case of in-use durability testing, this review process indicated that the proposal should not be promulgated at the present time. For each of the remaining elements, the basic approach originally proposed by EPA remains the best alternative. However, modifications have been made in several of them to improve their practicability or clarity.

## D. Alternative Timing for Implementation

The last major area where alternatives were considered is that of the first model year for which the final rule should be applied. EPA had proposed the regulation for 1983. Many comments were received indicating that in the context of such aspects of the proposal as redefined useful life, allowable maintenance restrictions and a 10 percent AQL, manufacturers were doubtful that compliance could be attained by 1983. In addition, legal issues concerning provisions of the 1977 Clean Air Act Amendments and their relation to any minimum mandated lead time were strongly raised.

The timing for introduction of new regulations can have very important consequences. From the manufacturers point of view it affects the rate at which resources must be expended to attain compliance, and possibly the very ability to comply. Environmentally, timing defines the point at which desired emission reductions will begin to be realized. In considering these consequences, an appropriate balance must be struck.

EPA has carefully considered the comments concerning lead time. An analysis can be found in the Summary and Analysis of Comments. In brief, the conclusion reached is that model year 1983 is a readily attainable compliance deadline, and that there are no legal barriers to EPA's promulgation of that deadline. Therefore EPA has decided to promulgate the final rules for the 1983 model year.

## References

1/ See the Summary and Analysis of Comments, Issue K-Numerical Standards/Standards Deviation.

# CHAPTER VII

# COST EFFECTIVENESS

## A. Methodology

Cost effectiveness is a measure of what might be termed the economic efficiency of some action directed toward achieving some goal. Expressed as cost per unit of benefit achieved, cost effectiveness can be used to compare various alternative methods of achieving the same goal. In the context of improving air quality, the goal is to reduce emissions of harmful pollutants, and cost effectiveness is expressed in terms of the dollar cost per ton of pollutant controlled.

To evaluate cost effectiveness, two pieces of information on the alternative being evaluated are needed. These are the cost of the alternative and the benefits to be gained. Costs to be used in this chapter will be total identified costs expressed on a per engine basis, including both costs to the manufacturer and costs to the operator (all discounted to January 1 of the model year in which the vehicle is produced). These costs will be allocated equally among the pollutants being controlled. The benefits will be computed as total lifetime emission reductions per vehicle.

In this chapter, the rulemaking provisions will be subjected to two distinct analyses. The first will be an incremental analysis of each of the major components of the package. The second will be an analysis of the package as an integrated strategy. The purpose of these two approaches are different, and the reader is cautioned against misinterpretations of the incremental analysis. In the incremental approach, the effect on costs and benefits of removing individual components will be examined. To varying degrees, both costs and benefits of these components overlap and several components of the package may act together to obtain a given benefit. In such a case, loss of any one part of the package can result in a disproportionate loss of benefits. There are so many overlapping interrelationships that it would be impossible to consider every possible combination of the various components of the package. This analysis will instead look at the single set of options produced by deleting each component one at a time. The total loss of benefits produced by deleting a component will be associated with the cost of that part of the package. Therefore, if one were to simply sum incremental costs or incremental benefits as an attempt at obtaining total costs or benefits, significant amounts of double counting would occur. Such a procedure would be invalid. The integrated cost effectiveness analysis must be used to evaluate overall costs or benefits.

## B. Background

In the draft Regulatory Analysis which accompanied the proposed regulations, a cost effectiveness analysis of the proposal was carried out. That analysis considered the overall cost effectiveness of the entire proposal as an integrated compliance strategy. In the preamble to the NPRM it was noted that "(i)t is not possible to present the individual cost-effectiveness values of each element (e.g., change in durability testing, change in AQL, etc.) of this proposal due to insufficient data. Moreover, the individual elements are interrelated which makes it difficult to isolate the benefits for each element. Removing one element might seriously jeopardize the effectiveness of the other elements," (44FR 40793 July 12, 1979). For these two reasons, cost-effectiveness values for individual elements were not presented.

During the course of the comment period on the proposed regulations, EPA has endeavored to develop more data and establish methods for estimating changes in emissions which could be associated with changes in the various components of the package. This effort has been sufficiently successful to allow estimated cost effectiveness analyses for the main components of the rulemaking to be undertaken.

The problem of interrelated benefits still exists, however. It is important to bear in mind that the benefits and costs in this analysis will overlap, and that summing them all would result in double counting. For example, consider the case of extended catalyst lifetimes required under the allowable maintenance provisions and the revised useful life definition. The benefit of increasing catalyst lifetimes is significant. However, if the useful life remained at 50,000 miles, the intent of the allowable maintenance provision for catalyst change intervals would be lost. Therefore, incremental analysis of the allowable maintenance interval and revised useful life will each separately be looking at partly the same benefit in emission reductions.

Allowing the benefits to overlap in this fashion may appear to give too much credit to individual elements of the package. This is not true, since in each case the benefit considered will be the best estimate of what the package would actually gain or lose if that element were retained or removed. The purpose of an incremental analysis is to answer that question for each element. Although it would be desirable, it is not the chief purpose of an incremental analysis to evaluate the benefits of the total package. The benefit attributed to the overall integrated package will be determined separately.

## C. Summary

Using all data now available (both that generated by EPA and that submitted to EPA during the public comment period on the proposed regulations), an analysis of the cost effectiveness of each major element of the regulation package and of the overall package as a unit has been done. This analysis developed benefits expressed as tons of pollutant removed (either HC or CO) over the average lifetime of an individual vehicle along with total costs for the same lifetime (discounted to year of sale).

Overall benefits and costs used as a starting reference the existing regulations applicable to 1982 model year light-duty trucks. That is, both overall benefits and overall costs were developed as changes in relation to the case of the existing regulations continuing in effect. Benefits and costs for the individual elements of the package, on the other hand, were evaluated in terms of changes to the final package. The loss in benefits that would occur if each element were removed from the package was evaluated in comparison with the cost reduction that would be produced by that same change. Figure VII-A summarizes the benefits developed. Costs, benefits, and cost effectiveness are tabulated in Table VII-A. Cost-effectiveness figures for other mobile source control strategies are provided in Table VII-B for comparison purposes.

D. Overall Rulemaking

Lifetime emissions for vehicles built to conform to this rulemaking are given in Table IV-A. Also in that table are lifetime emission rates for model year 1982 light-duty trucks. The difference between these two is the benefit to be realized by implementing the rulemaking. That is,

(MY '82 lifetime emission) - (MY '83 lifetime emission) = net benefit

Using the data from Table IV-A, we have:

Benefit for HC = 0.38 - 0.09 = 0.29 tons per vehicle

Benefit for CO = 5.0 - 0.9 = 4.1 tons per vehicle

The cost analysis of Chapter V determined costs attributable to various aspects of the regulation package. These cost, given in Table V-L, are reproduced below:

| Item | Discounted Cost per Engine |
|---|---|
| Redesign and Development | $16.87 |
| Certification | 3.74 |
| SEA Testing (self auditing) | 0.30 |
| Hardware | 74.00 |
| Total cost per engine | $94.91 |

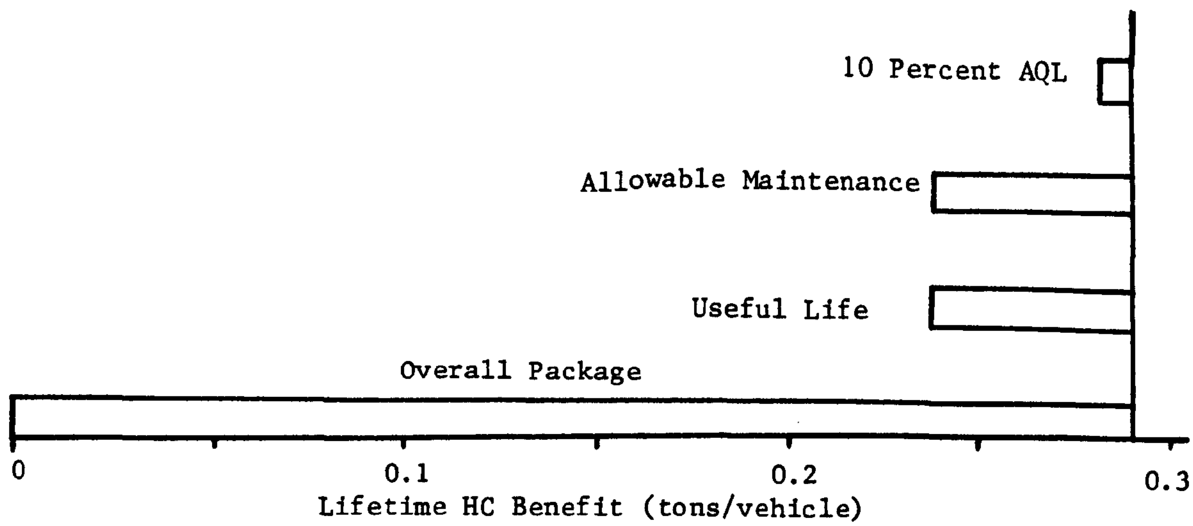
The total cost per engine, when split equally between HC and CO, and combined with the per vehicle benefits will give the cost-effectiveness values shown in Table VII-A.

E. Redefinition of Useful Life

In section D above, the lifetime emissions per vehicle

Figure VII-A

Incremental Lifetime Benefits



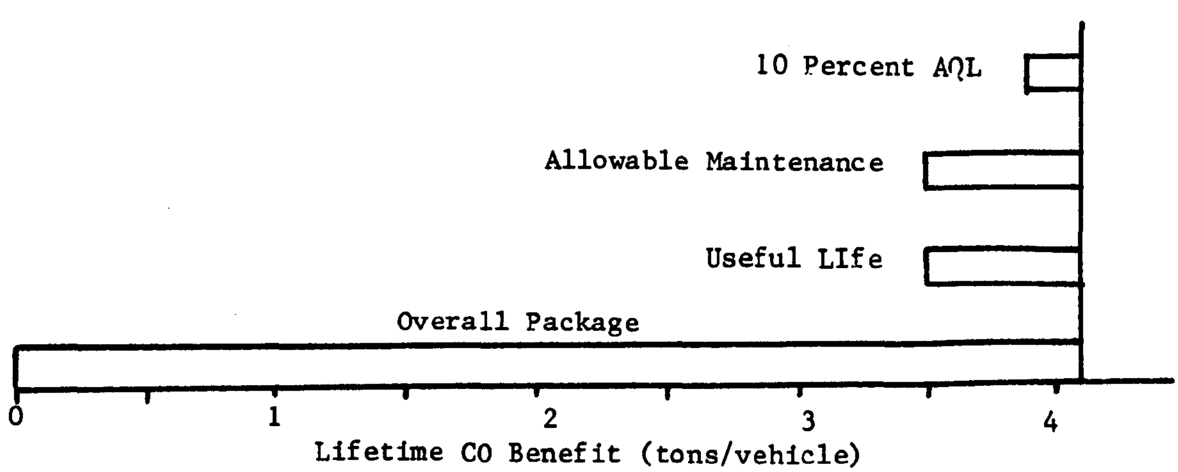



Table VII-A

Incremental Lifetime Cost Effectiveness

| Option | Cost (dollars) | Benefit (tons) HC | CO | Cost Effectiveness ($/ton) HC | CO |
|---|---|---|---|---|---|
| Useful life | 11 | 0.05 | 0.6 | 110 | 9 |
| Allowable maintenance | 11 | 0.05 | 0.6 | 110 | 9 |
| 10 percent AQL* | 3.70 | 0.006 | 0.2 | 205 | 6 |
| Overall package | 95 | 0.29 | 4.1 | 164 | 12 |
| I/M | 37 | 0.05 | 0.6 | 370 | 31 |

* Note: The ten percent AQL includes a NOx benefit of 0.04 tons. Cost is therefore dividied three ways. The cost effectiveness for NOx is $31 per ton.

Table VII-B

Cost Effectiveness ($/Ton) Comparison
With Other Emission Control Strategies

| Control Program | Baseline Emission a/ | Emissions After Control Program Initiated a/ | Cost Effectiveness ($/Ton) | | |
|---|---|---|---|---|---|
| | | | HC | CO | NOx |
| LDV Statutory Standards b/ | HC = 1.5 | HC = 0.41 | 470 | 41 | 2300 |
| | CO = 15 | CO = 3.4 | | | |
| | NOx = 3.1 | NOx = 0.4 | | | |
| LDT Interim Standards c/ | 1) HC = 2.0 | HC = 1.7 | 200 | 21 | 73 |
| | CO = 20 | CO = 18 | | | |
| | NOx = 3.1 d/ | NOx = 2.3 | | | |
| | 2) HC = 4.3 | | | | |
| | CO = 44 | | | | |
| | NOx = 5.2 e/ | | | | |
| I/M for Existing LDVs f/ | -- | -- | 78 | 7.7 | 2763 |
| Motorcycle Standards 1978/1979 g/ | HC = 9 | HC = 8-22.5 h/ | 364 | Neg. | -- |
| | CO = 34.67 | CO = 27.4 | | | |
| 1980 + | HC = 8-22.5 | HC = 8 | 365 | Neg. | -- |
| | CO = 27.4 | CO = 19.3 | | | |
| 1984 HDE Regs i/ | HC = 1.5 | HC = 1.3 | 238 | 8 | (gas) |
| | CO = 25 | CO = 15.5 | 253 | - | (diesel) |
| | HC + NOx = 10 | NOx = 10.7 | | | |

a/ Emission Levels in grams/mile, except for HD which are g/BHP-hr.

b/ Report: Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976.

c/ "Environmental Impact Statement - Emission Standards for Light-Duty Trucks," November 29, 1976.

d/ Trucks 0 - 6,000 lbs. GVWR.

e/ Trucks 6,001 - 8,500 lbs. GVWR.

f/ "Cost Effectiveness Estimated for Mobile Source Emission Control," Vector Research, Inc. for EPA, January 1978.

g/ "Environmental and Economic Impact Statement - Exhaust and Crankcase Regulations for the 1978 and Later Model Year Motorcycles."

h/ Sliding Scale Based on Engine Displacement (cubic centimeters).

i/ "Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and Later Model Years Heavy-Duty Engines," EPA Office of Mobile Source Air Pollution Control, December 1979.

were calculated to be 0.29 tons of HC and 4.1 tons of CO. These numbers, as has been noted, presumed that all other aspects of the rulemaking were intact. The basic assumption made in that regard was that the combined package would result in in-use emissions which closely match the performance of certification vehicles. The only exception was due to the failure of a small percentage (8.5 percent of total) of catalysts on a random basis near the end of the vehicle useful life.

The evaluation of the new useful life definition will proceed by estimating the loss of benefits and reduction in costs that would occur if this element were removed from the package while all other elements remained intact. This method will make it possible to evaluate the impact of not implementing useful life on the overall package while at the same time estimating the cost effectiveness of this element.

1. Benefits

The extension of the useful life definition to the average full lifetime rather than something approximating half of the full life as is done in current practice has the effect of requiring that vehicles will be able to meet emission standards throughout their average life. This will require new vehicle emission rates to be lower so as to not exceed the standards after accounting for emissions deterioration over approximately twice the mileage interval of current practice. Full life useful-life will also require the use of control systems which are sufficiently durable to last the vehicle's lifetime. This makes the useful life change a key to the effectiveness of the allowable maintenance provisions. In addition, since performance of emission related maintenance will be a condition for maintaining warranty coverage, it is likely that high mileage vehicles will be better cared for than is currently the case.

The increased level of maintenance will have an associated degree of emission benefits. However, a method for quantifying those benefits is lacking. The remaining two aspects of full life useful-life - lower initial emission rates and more durable components - do provide a basis for estimating the benefits of this element of the rulemaking. If full life useful life were dropped in favor of the current 50,000-mile useful life then both of these areas would suffer. Emission target levels would increase and system durability would not have to be proven beyond 50,000 miles. The latter fact would have its major emission impact in relation to catalysts. If catalyst durability need only be proven to 50,000 miles then a "50,000 mile catalyst" will be used instead of a "100,000 miles catalyst".

Following the procedure used in section G, these changes can be quantified. The production target levels have been noted as (0.81) x (max. legal level/df) for HC and (0.68) x (max. legal level/df) for CO. The maximum legal level means the highest actual emission rate which would round off to the emission standard. The dfs used for the benefits of the overall package were 1.4 for HC and 1.3 for CO over 100,000 miles. For a useful life reduced to 50,000 miles, these df's become 1.2 for HC and 1.15 for CO. The resulting target levels are:

$$(0.81) \times (0.85/1.2) = 0.57 \text{ g/mi HC}$$

$$(0.68) \times (10.5/1.15) = 6.2 \text{ g/mi CO}$$

These emission levels form the starting point for vehicles whose catalysts remain operational. Because of deterioration, emissions will increase with time corresponding to our df's of 1.2/1.15 for 50,000 miles. Expressed in gram per mile the overall emissions as a function of mileage (M) are:

$$HC = 0.57 + .023(M/10,000) \qquad \text{(VII-1)}$$

$$CO = 6.2 + 0.19(M/10,000) \qquad \text{(VII-2)}$$

In the absence of full useful life, we have noted that catalysts designed for 50,000 miles would be used. However, based upon probability, not all catalysts will have exactly the same lifetime. Nor will all catalysts need to be changed at the same point due to failure. We will treat each catalyst as having a finite lifetime, beyond which emission performance will begin to degrade at a rapid rate. This could result from occasional high-temperature conditions or other operating conditions which will affect system integrity, or randomly occurring factors during catalyst system manufacturer which affect durability of the system as extended mileage accumulates. A distribution generally found appropriate for lifetime phenomena is the Weibull distribution.1/ This distribution has the form:

$$F = 1 - \exp\left[-\left(\frac{M}{\theta}\right)^b\right] \qquad \text{(VII-3)}$$

To specify the function of equation VII-3, we will let the nominal catalyst lifetime (50,000 miles in this case) correspond to a failure rate of 5 percent. This gives the manufacturer a 95 percent confidence in catalysts performing properly for the desired lifetime. We will further use a "Weibull slope" of $b = 3$. Based upon these two factors, the "characteristic value," $\theta$, becomes 134,570 miles. A plot of this function is given in Figure VII-B.

If a catalyst were to fail on an in-use vehicle with extended mileage, it is quite posible that it would not be replaced. Therefore, average emission will increase somewhat near the end of the useful life period. For these catalysts which fail, emission rates characteristics of well maintained non-catalyst engines are desired. Based upon a review of emission factors for light-duty trucks,2/ starting emission rates of 2.56 g/mi HC and 31.5 g/mi CO

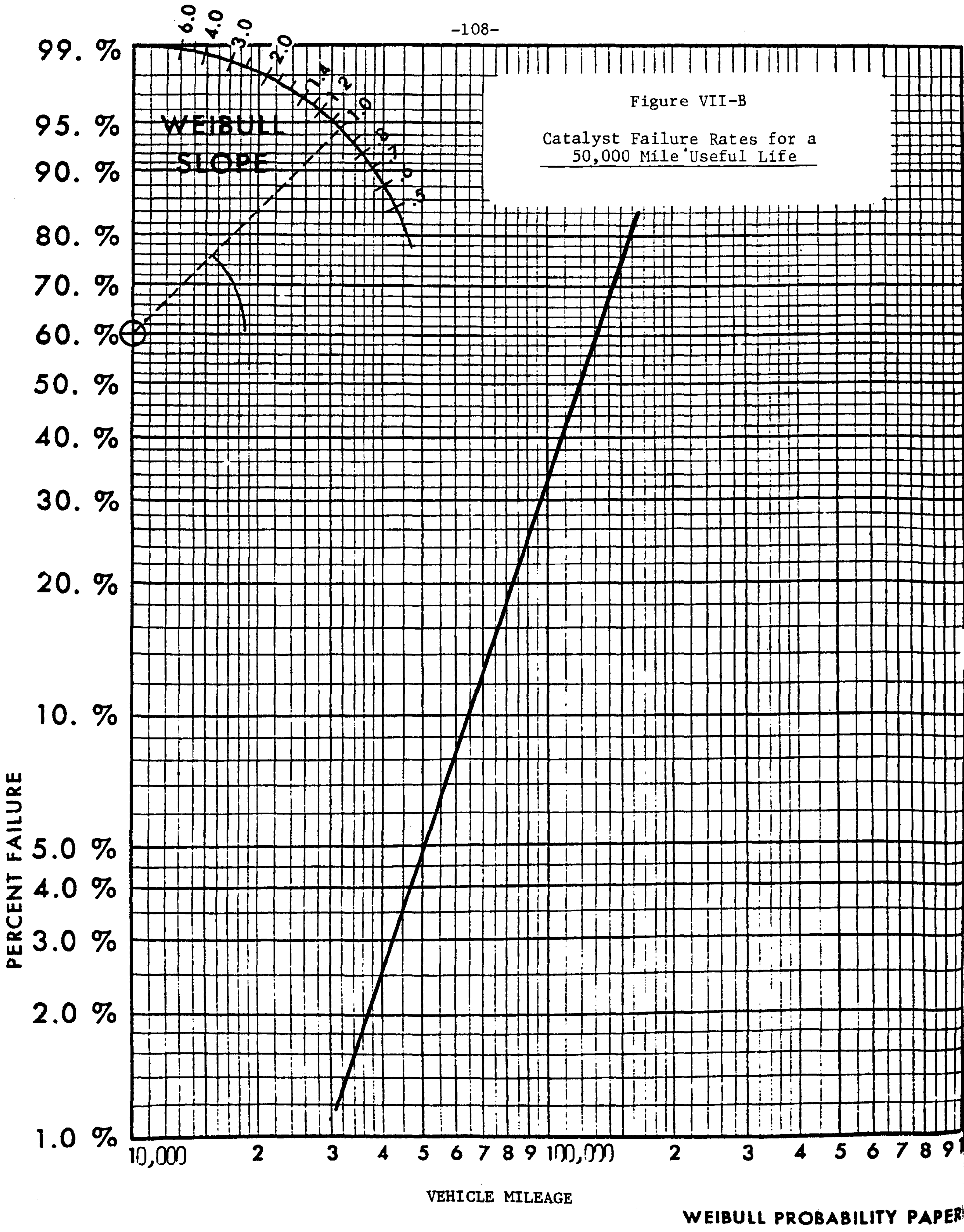


Figure VII-B
Catalyst Failure Rates for a 50,000 Mile Useful Life
WEIBULL SLOPE
6.0
4.0
3.0
2.0
1.4
1.2
1.0
.8
.7
.6
.5
99. %
95. %
90. %
80. %
70. %
60. %
50. %
40. %
30. %
20. %
10. %
5.0 %
4.0 %
3.0 %
2.0 %
1.0 %
PERCENT FAILURE
10,000
2
3
4
5
6
7
8
9
100,000
2
3
4
5
6
7
8
9
VEHICLE MILEAGE
WEIBULL PROBABILITY PAPER

are appropriate. These can be combined with a df characteristic of a well maintained non-catalyst vehicle of 1.1 to give the following emission rates.

$$HC = 2.56 + 0.051(M/10{,}000) \quad \text{(VII-4)}$$

$$CO = 31.5 + 0.63(M/10{,}000) \quad \text{(VII-5)}$$

Combining equations (VII-1) to (VII-5), the overall average emission rates will be:

$$HC = [0.57 + 0.023(M/10{,}000)][1 - F] + [F][2.56 + 0.051(M/10{,}000)]$$

$$HC = 0.57 + 0.023(M/10{,}000) + F[2.0 + 0.028(M/10{,}000)] \quad \text{(VII-6)}$$

$$CO = [6.2 + 0.19(M/10{,}000)][1 - F] + [F][31.5 + 0.63(M/10{,}000)]$$

$$CO = 6.2 + 0.19(M/10{,}000) + F[25 + 0.44(M/10{,}000)] \quad \text{(VII-7)}$$

To illustrate the effect of catalyst decay, equation (VII-6) is plotted in Figure VII-C. Also shown is the result for a 100,000 mile catalyst lifetime.

Over the full useful life of 120,000 miles3/ equations (VII-6) and (VII-7) yield total emission of 0.14 tons of HC and 1.5 tons of CO. The net loss of benefits from eliminating the useful life changes is the difference between these net emissions and those previously determined for the full rulemaking. The result is:

0.14 - 0.09 = .05 tons HC and 1.5 - 0.9 = 0.6 tons CO

Remembering that the benefit of increased maintenance by the vehicle owner has not been quantified, these benefits should be viewed as a lower limit of the potential available.

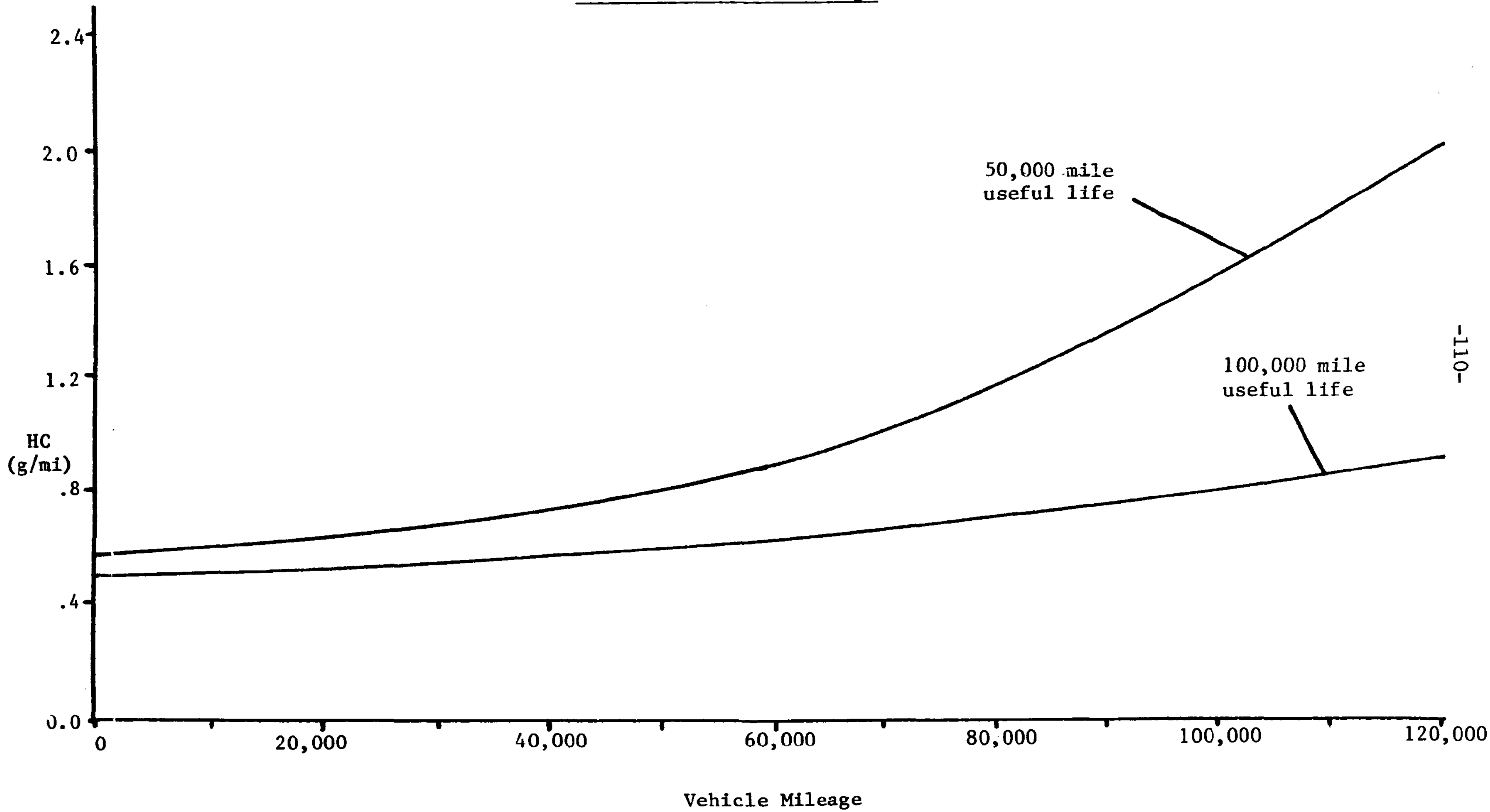
2. Costs

Apportioning the per-engine costs attributable to the change in useful life is a difficult task. The methodology to be used for estimating useful life cost has been developed earlier, in Chapter V. That discussion notes that electronic engine controls and upgraded air injection systems would be required for either case. Costs for catalyst improvements, however, would be different. Approximately 30 percent of catalyst costs (and the related R&D for design) are attributed to the increased useful life. From the data in Chapter V, this can be determined to be \$4.27 for hardware and \$5.06 for R&D.

A second area of cost can be directly tied to the useful life change. This cost is the cost of running extended durability vehicles to determine a full-life deterioration factor. Of the \$3.74 certification costs quoted earlier, \$1.44 is related to the extended useful life. Total cost associated with the useful life

Figure VII-C

1983 Model Year
Fleet Average HC
Emission Rate vs. Mileage



change is therefore, \$4.27 + \$5.06 + \$1.44 = \$10.77.

F. Allowable Maintenance Restrictions

These regulations will affect a wide variety of emission related components. The overall impact will include decreasing the amount of emission maintenance required to maintain proper vehicle emission rates. This will reduce the likelihood of excess in-use emissions due to improper maintenance.

Benefits attributable to many of the maintenance items are difficult to quantify. However, one of these, the catalyst change interval, exerts what is perhaps the major emissions influence and can be estimated. The allowable maintenance regulations will result in a minimum catalyst change interval of 100,000 miles. Depending upon the actual useful life to which various manufacturers will certify, catalyst lifetimes longer than 100,000 miles may be used in some cases. However, we will use 100,000 miles for the analysis. Without the allowable maintenance restrictions, catalyst change intervals corresponding to current vehicle useful lives (50,000 miles) are expected. Based upon the position that catalysts on in-use vehicles are not likely to be changed, even though catalyst changeover would be specified in the maintenance instructions, then the in-use fleet would not perform as expected. Emissions would increase after the 50,000 mile point and with a shorter lifetime higher rates of catalyst failure would occur.

Emission rates for this situation would be essentially the same as those developed for a 50,000 mile useful life in Section E above. Lifetime loss of benefits from dropping the allowable maintenance regulations would thus be the same as those developed for useful life:

0.05 tons HC and 0.6 tons CO.

Costs would also be the same as those estimated for useful life. Results are in Table VII-A.

G. Selective Enforcement Auditing (SEA)

The question to be evaluated with regard to SEA concerns the acceptable quality level (AQL) to be used in that program. This level identifies the maximum failure rate that can occur in audits of production LDTs before there is a significant probability of failing an audit. The light-duty truck SEA programs will use a 10 percent AQL to allow for measurement error and quality control aberrations.

1. Benefits

The benefits will be estimated by evaluating the change in emissions which would result if the AQL were relaxed from 10 percent to 40 percent. In general, changing the AQL results in a change in the mean production level target the manufacturer will aim for. The degree of change can be calculated from statistical considerations and there are various ways that these calculations can be approached, all of which give similar results.4/

a. 10 Percent AQL

Manufacturers base their estimates of production line mean values upon limited testing of pre-production vehicles (typically 3). In order to ensure that an SEA audit will be passed with some desired confidence factor (we will use 90%), their target emission levels will, of necessity, be some point below the required level (because of production variability and the small sample size). This point can be estimated by standard statistical techniques, using the "t" statistic. The following relationships will be used:

$$LMT = \text{low mileage target} = \text{max. legal level}/df \qquad \text{(VII-8)}$$

$$m = \text{maximum desired production mean} = LMT - 1.28s \text{ (at a 10 percent AQL)} \qquad \text{(VII-9)}$$

$$x = \text{target new vehicle emission rate} = m - s\,(t/\sqrt{n}) \qquad \text{(VII-10)}$$

Where,

max. legal level = highest actual emission rate which when rounded off will equal the standard

df = multiplicative deterioration factor

s = standard deviation of emission levels

t = "t" statistic for 90% confidence level and n-1 degrees of freedom

n = sample size

To perform the calculations, estimates of deterioration factors and emission variability (standard deviation) are required. Both of these can be obtained from data available to the staff at this time.

Deterioration factor estimates were given in the NPRM. These were 1.5 for HC and 1.3 for CO over 50,000 miles and were described as "typical of the upper end of the range of factors for current catalyst systems," (44FR 40792 July 12, 1979). Having been used by EPA, these values were frequently echoed back by commenters in evaluating the impact of the proposed regulations. The values were chosen by EPA to illustrate the fact that even with relatively high deterioration factors, the standards were still feasible. It is more appropriate in the present case (when we wish to make a best estimate of the overall impact of the regulations) to choose estimates of average expected deterioration factors rather than upper limits. To do this, the staff has examined 1980 certification data for light-duty trucks. The average deterioration factors for 43 durability vehicles for 1980 are 1.17 HC/1.13 CO/1.01 NOx. (Calculations for NOx will be included throughout this section. The change in AQL affects the production mean levels for NOx even though the standard is unchanged. These changes figure in the costs and feasibility analyses.) To calculate our target values we will use the following 50,000 mile and 100,000 mile df's:

For 50,000 miles : 1.2 HC/1.15 CO/1.02 NOx

For 100,000 miles: 1.4 HC/1.3 CO/1.04 NOx

100,000 miles is used because, as noted elsewhere, manufacturers are expected to either certify to a 100,000 mile lifetime, or have a catalyst change at that point.

The extension to 100,000 miles relies on extending the deterioration rates in a linear fashion from 50,000 miles to 100,000 miles. Data available to the staff indicates that this is appropriate. See for example the data submitted by American Motors on high mileage vehicles, presented in Figures 1-4 of Issue G of the Summary and Analysis of Comments (Technological Feasibility).5/

Data on variability was submitted by several commenters. Variability in the form of s/x ratios was submitted by GM, IH, and AM. Ford submitted variability measured as s/LMT. Although the form of the Ford data is somewhat different, Ford indicated in its submission that current engine emissions levels are such that x is approximately equal to or somewhat less than LMT. Therefore, the Ford s/LMT data can be used as an estimate of s/x. Variability expressed as s/x is desired by the staff because of its judgement that this measurement (known as the coefficient of variation) will remain a relatively constant ratio as emission levels (x) go up or down.6/

The variability data submitted by commenters showed a wide range of values. The Ford data was relatively low (.08 HC/.16 CO/.22 NOx) compared to the other submissions (generally in excess of 0.30). Attempts to resolve the discrepancies led to the conclusion that the GM, IH, and AM data was not properly calculated for our purposes. These firms had combined all sampling results within a given engine family to compute means and standard deviations. Doing this combines data on several different configurations possibly existing within the same family. Since the emission values of each configuration would tend to cluster at different values, the variability calculated when the results were lumped together could be substantially higher than the variability existing within any individual configuration. SEA audits are done on a configuration level, and it is the variability characteristic of configurations which is needed. Therefore, the GM, IH, and AM data cannot be used.

Fortunately, the Ford data was computed on a configuration specific basis, which probably accounts for the lower values supplied by Ford. Based on the Ford values, we will use estimated variability of 0.10 HC/0.20 CO/0.25 NOx.

The information on deterioration and variability can be used with equations (VII-8), (VII-9), and (VII-10) to calculate emission target values for a 10 percent AQL. The usual pre-production sample size is 3 vehicles. Calculations will also be done for sample sizes of 5 and 7. Estimates of the production mean/LMT ratios will be made first, and then deterioration factors will be incorporated to generate target production means.

We have:

$$x = m - s\ (t/\sqrt{n})$$

$$m = LMT - 1.28s$$

$$s/x = 0.10,\ 0.20 \text{ or } 0.25$$

Combining these we get, depending on the s/x ratio used:

| | | |
|---|---|---|
| $x = LMT-0.10x(1.28+t/\sqrt{n})$ | $x = LMT-.20x(1.28+t/\sqrt{n})$ | $x = LMT-.25x(1.28+t/\sqrt{n})$ |
| $x(1.128+0.10t/\sqrt{n}) = LMT$ | $x(1.256+.20t/\sqrt{n}) = LMT$ | $x(1.32+.25t/\sqrt{n}) = LMT$ |
| $x/LMT = 1/(1.128+.10t/\sqrt{n})$ | $x/LMT = 1/(1.256+.20t/\sqrt{n})$ | $x/LMT = 1/(1.32+.25t/\sqrt{n})$ |

For sample size n = 3,5,7, the results are as follows:

| n | t | x/LMT (s/x = 0.10) | x/LMT (s/x = 0.20) | x/LMT (s/x = 0.25) |
|---|---|---|---|---|
| 3 | 1.886 | .81 | 0.68 | 0.63 |
| 5 | 1.533 | .84 | 0.72 | 0.67 |
| 7 | 1.440 | .85 | 0.73 | 0.69 |

The above tabulation indicates some of the flexibility inherent in production target levels. For example, if a manufacturer's variability for CO were 0.25 instead of 0.20, increasing the sample size from 3 to 5 vehicles would allow the same target values to be maintained.

The values of "t" used are those for a 90 percent confidence level. Some manufacturers felt that a confidence level as high as 97 percent was needed for each individual parameter in order to maintain an overall confidence of 90 percent for all three pollutants. This argument was based upon the assumption that the pollutant levels are independent of each other, which is not true. HC and CO are strongly related. The analysis of feasibility contained in the Summary and Analysis of Comments indicates that most of the emission reductions required to meet the final regulations will be needed for CO and NOx. Meeting the CO targets will all but guarantee the HC levels. Some increased confidence level might be desired to cover meeting both CO and NOx. However, this increased confidence can be obtained at the same target levels by increasing vehicle sample size. For example, going from 3 to 5 engines would increase the level of confidence to 95 percent or better.

Using equation (VII-8) along with the x/LMT ratios and deterioration factors derived above, target emission rates can be computed as follows:

$(0.85/1.4)0.81 = 0.49$ HC

$(10.5/1.3)0.68 = 5.5$ CO

$(2.35/1.04)0.63 = 1.4$ NOx

Allowing the emissions to increase according to the desired df's will yield the following:

$\text{HC} = 0.49 + 0.02(M/10{,}000)$

$\text{CO} = 5.5 + 0.16(M/10{,}000)$

$\text{NOx} = 1.4 + 0.0056(M/10{,}000)$

Following the discussion of section E, the effect of catalyst failures can be incorporated. NOx emissions are largely unaffected by catalyst failure. Using equations (VII-4) and (VII-5) combined with the above equations, the average emission rates for the 10 percent AQL case can be expressed as:

$$\text{HC} = 0.49 + 0.02(M/10{,}000) + F[2.07 + 0.031(M/10{,}000)] \quad \text{(VII-11)}$$

$$\text{CO} = 5.5 + 0.16(M/10{,}000) + F[26.0 + 0.47(M/10{,}000)] \quad \text{(VII-12)}$$

$$\text{NOx} = 1.4 + 0.0056(M/10{,}000) \quad \text{(VII-13)}$$

The fraction of failed catalyst will be as specified in equation (VII-5). For a 100,000 mile catalyst, the "characteristic value" $\theta$ is 269,141. Lifetime emissions corresponding to equations (VII-11), (VII-12) and (VII-13) can be calculated as 0.09 tons HC 0.9 tons CO and 0.19 tons NOx over 120,000 miles. These correspond to emission rates for the complete rulemaking package.

b. <u>40 Percent AQL</u>

In order to revise the target emission rates to reflect a 40 percent AQL, we need simply change equation (VII-9) to reflect a 40 percent rather than a 10 percent cutpoint.

$$m = \text{LMT} - 0.25s \quad \text{(40 percent AQL)} \quad \text{(VII-14)}$$

Carrying this result through the calculations as done for the 10 percent AQL case will produce the following, (again for our 3 different variabilities):

$$x/LMT = 1/(1.025 + 0.10t/\sqrt{n}) \qquad (s/x = 0.10)$$

$$x/LMT = 1/(1.05 + 0.20t/\sqrt{n}) \qquad (s/x = 0.20)$$

$$x/LMT = 1/(1.06 + 0.25t/\sqrt{n}) \qquad (s/x = 0.25)$$

For sample sizes of n = 3, 5, 7 the results are as follows:

| n | t | x/LMT (s/x = 0.10) | x/LMT (s/x = 0.20) | x/LMT (s/x = 0.25) |
|---|---|---|---|---|
| 3 | 1.886 | 0.88 | 0.79 | 0.75 |
| 5 | 1.533 | 0.91 | 0.84 | 0.81 |
| 7 | 1.440 | 0.93 | 0.86 | 0.84 |

Using these new ratios along with the applicable deterioration rates, equation (VII-8) will yield the following target emission rates:

(0.85/1.4)0.88 = 0.53 HC

(10.5/1.3)0.79 = 6.4 CO

(2.35/1.04)0.75 = 1.7 NOx

Continuing with the calculations, the 40 percent AQL equivalents to equations (VII-11), (VII-12) and (VII-13) can be expressed as:

**HC = 0.53 + 0.02(M/10,000) + F[2.03 + 0.031(M/10,000)]** **(VII-15)**

**CO = 6.4 + 0.19(M/10,000) + F[25.1 + 0.44(M/10,000)]** **(VII-16)**

**NOx = 1.7 + 0.0068(M/10,000)** **(VII-17)**

Lifetime emissions for equations (VII-15), (VII-16) and (VII-17) corresponding to the 40 percent AQL case are 0.093 tons HC, 1.1 tons CO and 0.23 from NOx. At a 10 percent AQL, the emissions were 0.087 tons HC (expressed to 3 places) 0.9 tons CO and 0.19 tons NOx. Loss of benefits associated with going from a 10 percent AQL to a 40 percent AQL is then 0.093 - 0.087 = 0.006 tons HC, 1.1 - 0.9 = 0.2 tons CO, and 0.23 - 0.19 = 0.04 tons NOx.

The amount of emission reduction attributable to the change of AQL is quite small for light-duty trucks. This is particularly true for the HC reduction of 0.006 tons. These small benefits are simply reflecting the fact that the AQL has a relatively small effect on the target emission rates. Thus, changing the AQL from 10 percent to 40 percent changes the projected targets for HC from

0.49 to 0.53. The reason why the targets show small sensitivity to the AQL is the low amount of emission variability being seen in light-duty trucks. Since vehicle-to-vehicle variations in emissions are small, it only requires a small reduction in the average emission rate to insure that 90 percent of the vehicles pass the standard.

2. Costs

We have just noted that changing the AQL has a relatively small impact on emissions. Consequently, changing the AQL has little impact on the difficulty of meeting the standards or the costs associated. Hardware related costs have been identified in the Summary and Analysis of Comments as $0.92 for air pumps, $0.60 for diesel EGR, and $1.88 for catalyst loading changes. Added to this would be a saving of $0.30 for SEA testing costs, for a total cost of $3.70. Since the AQL change produces a NOx benefit as well as an HC and CO benefit, cost effectiveness in Table VII-A is calculated on the basis of dividing costs among three pollutants.

## H. Inspection and Maintenance (I/M)

The analysis which has been done so far has contained no specific reliance on I/M programs. In the overall rulemaking neither specific benefits nor costs for I/M programs have been included. However, there are ways in which I/M would enhance the effectiveness of the rulemaking and help insure full realization of possible benefits. Therefore, some discussion of I/M in relation to this rulemaking is appropriate even though it is not required by the regulations being promulgated.

In the context of this rulemaking package, I/M can be viewed as an "insurance policy" for many of the benefits. The presence of an I/M program, which EPA expects would be implemented in those areas requiring maximum benefits, will insure against neglect or abuse of emission related systems by the vehicle owner. The two principal areas when this might occur are misfueling with leaded fuel or tampering with emission related hardware.

EPA has estimated that misfueling in light-duty vehicles occurs in up to 8 percent of the vehicles.7/ There are no corresponding estimates for heavy-duty vehicles since catalysts have yet to be used. However, something similar seems possible. The incentive for misfueling is largely an economic one, due to the lower cost of leaded fuel compared to unleaded fuel. In an area having an I/M program, the vehicle owner would be faced with a much more powerful economic incentive against misfueling. This incentive would be the cost of replacing the vehicle catalyst, which would be over $300, should he fail the I/M test. Rather than incur this expense, EPA believes the owner would avoid misfueling his vehicle. Thus, I/M insures against the loss of benefits which might result from misfueling without actually generating the costs associated with catalyst replacement.

A similar situation would occur in relation to tampering. Current engine systems are easy to adjust, and could be adjusted differently for an I/M test than they are for normal operation. For future engines this will not be the case. Engines complying with the parameter adjustment regulations will be difficult to adjust in such a way as to adversly affect emissions. The potential for costly repairs from failure of an I/M test (such as replacing a damaged carburetor) would make the occurrence of such maladjustment unlikely. Other forms of tampering, such as removal of the catalyst or other components, would also be difficult enough to be deterred by the need to pass an annual I/M inspection.

The above scenario allows a rough estimate to be made of the benefits an I/M program might realize. Assumptions are as follows: 8 percent of the vehicles would be misfueled initially, without I/M. Their catalysts would fail to non-catalyst emission levels used earlier for failed catalyst emission rates (equations (VII-4) and (VII-5)). An additional 8 percent of the catalysts will be estimated to have failed by the end of the average useful life period due to occasional misfueling. This is equivalent to 4 percent failed over the whole life in terms of emissions. Tampering will be accounted for by including an additional 5 percent. Catalyst failures would then total to 8 percent + 4 percent + 5 percent = 17 percent. There will be a 17 percent shift in emissions from rates for operating catalysts to rates for failed catalysts. Referring to equations (VII-1), (VII-2) (VII-4), and (VII-5) the change in emission can be expressed as:

$$\text{HC Increase} = 0.17[(2.56 + 0.051(M/10{,}000)) - (0.57 + 0.023(M/10{,}000))]$$

$$\text{CO Increase} = 0.17[(31.5 + 0.63(M/10{,}000)) - (6.2 + 0.19(M/10{,}000))]$$

Lifetime emission benefit of the I/M program using these relations is .05 tons HC and 0.6 tons CO.

Cost for the I/M program consists of a $5 annual inspection fee. On the belief that I/M will deter the problems of misfueling and tampering, no other new costs will be incurred. The fee costs over the vehicle life (12 years), discounted to year of sale, are $37.47. This is used to compute the cost effectiveness found in Table VII-A.

It could be argued that once an I/M program is put in place to deter tampering and misfueling, that some of the benefits derived from other components of the overall regulation (useful life, allowable maintenance) could be secured by I/M. However, it is the intent of the regulatory strategy to force the design of durable emission control systems that are not highly susceptible to malmaintenance. It is less costly for the consumer to pay for these features as part of the new vehicle engine design than to have to secure maintenance or replace parts later on. If the full useful life and allowable maintenance provisions of the regulations were dropped in favor of reliance of an I/M program to obtain the related benefits, the cost of field maintenance and replacement catalysts would then have to be charged to the I/M program. Considering the catalyst situation alone makes this approach much less efficient than the approach of retaining all parts of the regulation package and backing it up with I/M. We have previously estimated the incremental hardware cost of a full life versus a half life system to be $22. The cost of a replacement catalyst considering after-market parts markup is about $330.

## I. Idle Test

The idle standard applies to CO emissions from gasoline fueled engines. Based upon the idle emission data now available to EPA, any emission reduction brought about by the need to certify to an idle standard would be minimal. Costs associated with implementation of the idle test are only the actual cost of running the additional certification test. No new test equipment is required. There is also no impact on other costs (e.g. control hardware). Expressed as a cost per vehicle, the costs are negligible. Because this is so, a cost effectiveness computation would not be meaningful and will not be attempted.

## References

1/ Discussed in many statistical texts. See, for example, "Statistical Design and Analysis of Engineering Experiments," Lipson & Sheth, p. 36.

2/ "Mobile Source Emission Factors - Final Document," EPA-400/9-78-005, March, 1978, TableII-1.

3/ "Average Lifetime Periods for Light-Duty Trucks and Heavy-Duty Vehicles," EPA Report SDSB 79-24, G. Passavant, November 1979.

4/ One alternate procedure for calculating targets can be found in the Regulatory Analysis of the final 1984 Heavy-Duty Engine Gaseous Emission Regulations, Chapter VII, Section 5a.

5/ This data was originally submitted by AM to challenge the extrapolation of df's derived at low mileage to high mileage (what has been characterized as the "lever arm" effect). The data does demonstrate that this procedure can result in major errors for individual vehicles due to the large amount of scatter in the data points. However, for the case at hand here, this is not a problem because over the average of a number of vehicles these errors (due to random scatter) will cancel out. The importance of the data lies in its demonstration of basically linear emission deterioration over 100,000 miles.

6/ See for example the submission by Caterpillar of August 15, 1979 in response to the Heavy-Duty Engine Gaseous Emission NPRM, pp. 10-13.

7/ Memorandum, "Fuel Switching," Benjamin Jackson, EPA Office of Enforcement, August 2, 1979.