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BACKGROUND DOCUMENT
FOR
MEDIUM AND HEAVY TRUCK
NOISE EMISSION REGULATIONS

MARCH 1976

U.S. Environmental Protection Agency
Washington, D.C. 20460

TECHNICAL REPORT DATA

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On March 31, 1976, the Environmental Protection Agency issued a regulation governing noise emissions from medium and heavy trucks. That regulation was issued under Section 6 of the Noise Control Act of 1972.

This document presents and discusses the background data used by the Agency in setting the standards contained in the regulation. Presented here is a comprehensive exposition on the most up-to-date available information on the environmental, technological, and economic aspects of medium and heavy truck noise.

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PREFACE

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Section 1

INTRODUCTION

STATUTORY BASIS FOR ACTION

Through the Noise Control Act of 1972 (86 Stat. 1234), Congress established a national policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." In pursuit of that policy, Congress stated, in Section 2 of the Act, "that, while primary responsibility for control of noise rests with State and local governments, Federal action is essential to deal with major noise sources in commerce, control of which requires national uniformity of treatment. "As part of that essential Federal action, subsection 5(b)(1) requires the Environmental Protection Agency (EPA), after consultation with appropriate Federal agencies, to publish a report or series of reports "identifying products (or classes of products) which in his judgment are major sources of noise." Further, Section 6 of the Act requires the EPA to publish proposed regulations for each product, which is identified or which is part of a product class identified as a major source of noise, where in his judgment noise standards are feasible and fall into various categories of which transportation equipment (including recreational vehicles and related equipment) is one.

Pursuant to subsection 5(b)(1), the Administrator has published a report which identifies new medium and heavy trucks as a major source of noise [1]. As required by Section 6, EPA shall prescribe regulations on the noise emissions from new medium and heavy trucks which are "requisite to protect the public health and welfare, taking into account the magnitude and conditions of use of new medium and heavy trucks, the degree of noise reduction achievable through the application of the best available technology, and the cost of compliance."

In October 1974, EPA published proposed regulations on new medium and heavy trucks [2]. Interested parties were given opportunities to participate in the final regulations by submitting comments on the proposed regulations. Comments were made in the form of written responses in Docket ONAC 74-1 and in Public Hearings held on 19–20 February 1975 in Arlington, Virginia and on 27 February 1975 in San Francisco, California. Discussions of the public comments are continued in Appendix A.

After the effective date of a regulation on noise emissions from a new product, Section 6 of the Noise Control Act requires that no State or political subdivision thereof may adopt or enforce any law or regulation which sets a limit of noise emissions from such new product, or components of such new product, which is not identical to the standard prescribed by the Federal Regulation. Subsection 6(e)(2), however, provides that nothing in Section 6 precludes or denies the right of any State or political subdivision thereof to establish and enforce controls on environmental noise through the licensing, regulation or restriction of the use, operation or movement of any product or combination of products.

The noise controls which are reserved to State and local authority by subsection 6(e)(2) include, but are not limited to the following:

1. Controls on the manner of operation of products
2. Controls on the time in which products may be operated
3. Controls on the places in which products may be operated
4. Controls on the number of products which may be operated together
5. Controls on noise emissions from the property on which products are used
6. Controls on the licensing of products
7. Controls on environmental noise levels

To assist EPA in enforcing regulations on noise emissions from new products, State and local authorities are encouraged to enact regulations on new products offered for sale which are identical to Federal regulations.

OUTLINE AND SUMMARY OF BACKGROUND DOCUMENT

Background information used by EPA in developing regulations limiting the noise emissions from new medium and heavy trucks is presented in this document. An outline and summary is given below.

Section 2 – The Truck Industry. General information on medium and heavy truck, their manufacturers and users are contained in this section.

Section 3 – Baseline New Truck Noise Levels. The method of measurement of noise emissions from medium and heavy trucks used in obtaining most of the data on the new truck noise levels presented in this document is discussed in Section 3. Noise levels for existing new medium and heavy trucks is presented. A summary of current State and local regulations on new medium and heavy trucks is given.

Section 4 – Health and Welfare. This section discusses the benefits to be derived from the various regulatory options. It discusses the concepts of fractional noise impact, the procedures for computing the reduction in average traffic noise levels and equivalent number of people impacted by urban traffic noise. Annoyance resulting from an individual truck passby is also presented.

Section 5 – Technology. This section provides information on the noise control technology required to bring trucks into compliance with not-to-exceed regulatory levels of 83, 80, 78 and 75 dBA. A discussion of the noise reduction achievable through the application of the best available technology is provided in Section 5.3. Criterion for determining the levels to which trucks can be quieted are set forth and are evaluated with respect to the lead time necessary to produce complaint vehicles.

Section 6 – Cost of Compliance. This section provides estimates of the costs to bring medium gasoline, heavy gasoline, medium diesel and heavy diesel trucks into compliance with not-to-exceed regulatory levels of 83, 80, 78 and 75 dBA. Estimates of changes in fuel and maintenance cost caused by noise control treatments are also presented.

Section 7 – Economic Analysis. This section examines the impact of different regulatory options on the reduction in truck sales, employment and supplies of quiet engines and noise treatment hardware. The economic impact on the trucking industry, consumer prices and different sectors of the national economy are also considered.

Section 8 – Enforcement. This section discussed Assembly Process Testing as the primary method of assuring that the new trucks will conform to the regulation. The various enforcement actions open to EPA are also stated, should they be needed when a manufacturer is found to be producing noncompliant vehicles.

Section 9 – Environmental Effects. For this section, the effects of truck noise regulations on air and water pollution, solid waste disposal, energy and natural resource consumption and land use are considered.

Appendix A – The Docket Analysis. Appendix A examines in detail all of the written public comments submitted to Docket ONAC 74-1 and presented in Public Hearings in Arlington, Virginia and San Francisco, California. Public comments are summarized and organized according to contributor. Analyses of comments on issues in the following areas are given.

- Benefits to public health and welfare
- Noise control technology
- Costs of compliance
- Costs versus benefits
- Economic impact

- Test procedure
- Enforcement
- Classification

Action taken in response to public comment on each issue is discussed.

Appendix B – Predictions of traffic population mixes used in estimating benefits to public health and welfare are presented and discussed.

Appendix C – The elasticity of demand for medium and heavy trucks is considered.

Appendix D – The estimated costs of compliance are given in terms of 1975 dollars.

Appendix E – The computer model used to determine total costs for different regulatory options is discussed. Computer printouts for all options considered by the Agency are presented.

Appendix F – The net operating income is defined.

Appendix G – The method for computing the economic impact on a specific sector of the trucking industry is discussed.

Appendix H – Estimates of the costs of testing are presented.

Appendix I – Summary of Fan Clutch Field Tests.

REFERENCES

[1] ENVIRONMENTAL PROTECTION AGENCY. Identification of products as major sources of noise. *Federal Register* 39: 121, 22297–222999 (June 21, 1974).

[2] ENVIRONMENTAL PROTECTION AGENCY. Transportation equipment noise emission controls, proposed standards for medium and heavy duty trucks. *Federal Register* 39: 210 (Part II), 38338–38362 (October 30, 1974).

Section 2

THE TRUCK INDUSTRY

Of the major means by which goods are transported, Table 2-1 implies that trucks are not the least expensive; yet, because of convenience, trucks account for over 80 percent of the total dollars spent on moving domestic freight.

The cost per ton-mile (approximately 17 cents) is considerably more expensive than the cost (approximately 1.5 cents per ton-mile) for shipping by rail, the next largest carrier of goods. However, as can be inferred from Table 2-1, trucks on the average carry more goods over shorter distances, and provide a flexibility that cannot be achieved by other modes of transportation.

Over the period 1967 to 1972, total new truck sales increased 1.3 times as fast as the gross national product; new heavy truck sales increased more than 2.5 times as fast [1]. The trend over the past several years has been for more goods to be moved by truck. It is expected that this trend will continue and that each year there will be more trucks on the nation's freeways, highways, and city and residential streets.

Table 2-1
Domestic Freight Tranportation Market, 1970

Mode Transportation	Tons		Ton-Miles		Revenue Dollars	
	Millions	Percent	Millions	Percent	Millions	Percent
Truck......	$1,684	34.2	$412,000	18.7	$69,084	81.3
Rail	1,572	32.1	771,000	34.8	11,869	14.0
Water*.....	867	17.6	595,000	26.9	1,902	2.3
Pipeline	790	16.1	431,000	19.5	1,396	1.6
Air........	3	0.0	3,400	0.1	720	.8
Total	$4,916	100.0	$2,212,000	100.0	$84,971	100.0

*Includes Domestic Deepsea, Great Lakes and Inland Waterways.
Source: Transportation Facts and Trends, TAA Quarterly Supplement, April 1973.

GENERAL DESCRIPTION OF MEDIUM AND HEAVY TRUCKS

Medium and heavy trucks are defined as trucks with a gross vehicle weight ratings (GVWR) greater than 10,000 pounds. There is a wide range of types of medium and heavy trucks. At one extreme of the vehicle characteristics are gasoline-powered 2-axle single vehicles with 4 tires and GVWR of less than 13,000 pounds. At the other extreme there are 11-axle combination vehicles with 42 tires, turbocharged diesel engines and a gross combination weight rating in excess of 130,000 pounds.

Medium and heavy trucks can be described in terms of the following attributes: the GVWR, the major use, the number of axles, the type and size of engine, and the style of the cab.

Designation in terms of GVWR for medium and heavy trucks has been defined by the Motor Vehicle Manufacturers Association [2] and is shown in Table 2-2.

Table 2-2
Truck Designation by GVWR (Pounds)

GVWR Category	GVWR Group	Range of GVWR
Medium trucks	1	10,001 - 14,000
(10,001-26,000 lbs)	2	14,001 - 16,000
	3	16,001 - 19,500
	4	19,501 - 26,000
Heavy trucks	5	26,001 - 33,000
(over 26,000 lbs)	6	over 33,000

There are three types of truck designs which reflect the major uses for medium and heavy trucks. A ruggedly built cab-chassis unit for mounting dump beds, concrete mixers, etc., is often referred to as a construction truck while a light cab-chassis unit for mounting van bodies, etc., is designated as a delivery truck. A truck-tractor for pulling trailers is called a line-haul truck.

The number of axles by which engine power is transmitted to the road surface can also be used for truck designation. For trucks with two axles, one of which drives the truck (as in an automobile), the designation is 2 x 4; i.e., two out of the four wheels (dual tires count as one wheel) are driving. Similarly, a tandem axle, truck-tractor is designated as a 4 x 6 and an all-wheel drive truck is a 4 x 4 or a 6 x 6.

In terms of engine type, trucks can be designated simply as having either a gasoline engine or a diesel engine. The horsepower rating of the engine can also be used for truck classification purposes.

Trucks can also be designated by the style of the truck cab. The two main styles of cabs are the conventional cab (sometimes termed a "fixed" cab) style and the cab-over engine (COE) style. In a conventional cab, the driver sits behind the engine. Conventional cab styles may be either "short" (Fig. 2-1) or "long" (Fig. 2-2), depending on the length of the hood. In the COE style, the driver is positioned above and to the side of the engine. The COE style may be either "low" (Fig. 2-3) or "high" (Fig. 2-4), depending on the distance of the deck, or floor, of the cab above the ground.

DISTRIBUTION OF TRUCKS BY CATEGORIES

A statistical analysis of the census data on the characteristics and uses of the truck population in the United States, which was collected and made available to EPA by the Bureau of the Census, provides an estimate of the total truck population in the United States in 1972. The total truck population with GVWR in excess of 10,000 pounds in 1972 was estimated to be 3,533,000 trucks. The distribution of these trucks by GVWR category and type of engine is shown in Table 2-3 [1].

Table 2-3
Total Truck Population, 1972

GVWR Category	Gasoline Engine		Diesel Engine		Total Trucks
	Number	Percent	Number	Percent	
Medium . .	2,335,000	98	41,000	2	2,376,000
Heavy. . . .	509,000	44	648,000	56	1,157,000
Total	2,844,000	80	689,000	20	3,533,000

Table 2-4, a breakdown for diesel engine trucks by GVWR for selected years between 1966 and 1972, shows a trend toward fewer medium trucks being powered by diesel engines and a trend toward increased use of diesel engines for heavy trucks, particularly the larger GVWR group 6 trucks.

The distribution of new truck production in 1972, according to GVWR category and group as well as type of engine, is shown in Table 2-5 [1]. Over 90 percent of the new trucks produced are used in domestic truck transportation.

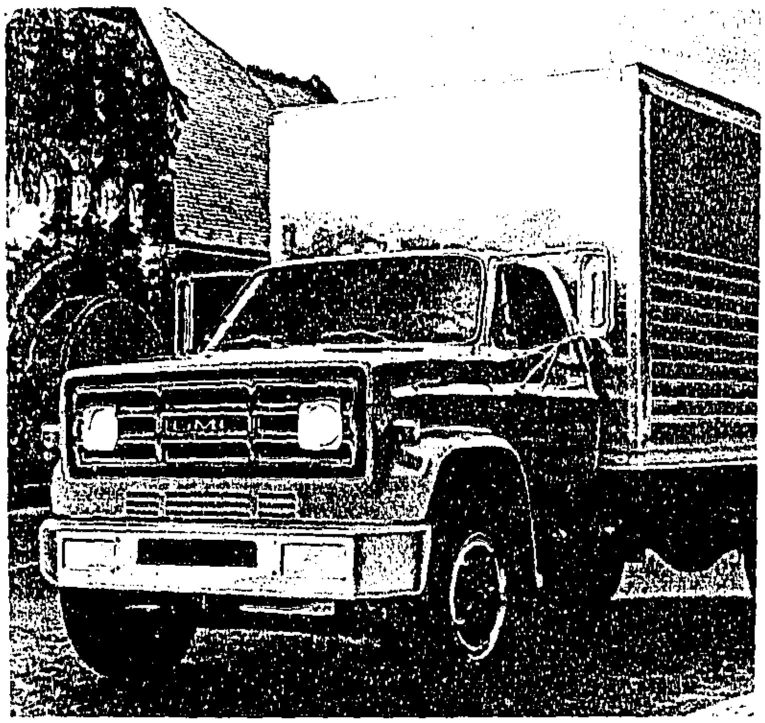

Figure 2-1. Truck With Short Conventional Cab

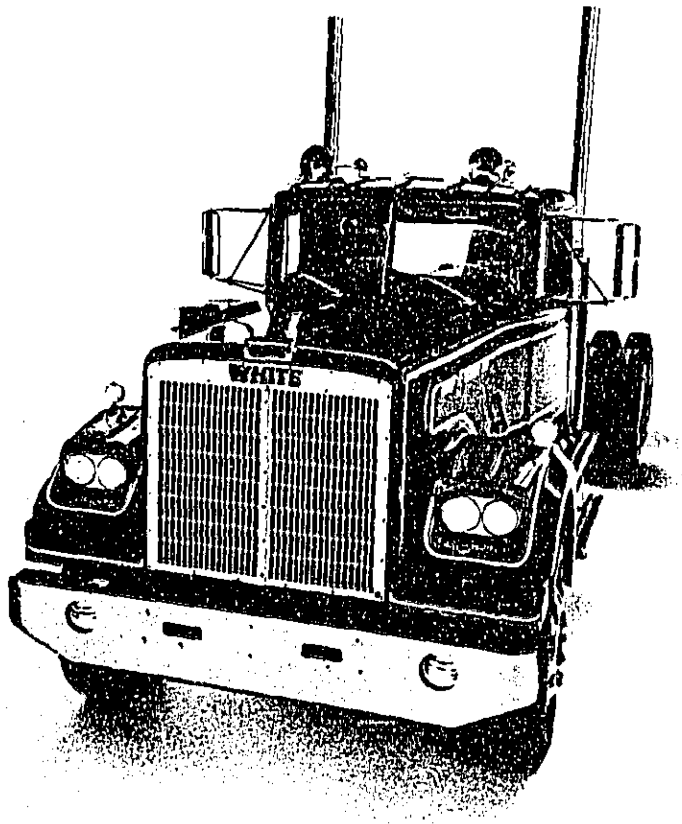

Figure 2-2. Truck With Long Conventinal Cab

Figure 2-3. Truck With Low Deck Cab-Over-Engine

Figure 2-4. Truck with High Deck Cab-Over Engine

Table 2-4
Percent of Diesel Trucks to Total Trucks by Categories
for Selected Years, 1966-1972

Year	Medium Trucks					Heavy Trucks		
	GVWR Group				Total	GVWR Group		Total
	1	2	3	4		5	6	
1966	0%	0%	1%	3%	4%	5%	19%	24%
1968	0	0	0	2	3	4	21	25
1970	0	0	0	3	3	4	28	32
1972	0	0	0	1	1	3	30	33

Source: MVMA 1973 Motor Truck Facts.

Table 2-5
New Truck Production, 1972

GVWR Category	Gasoline Engine		Diesel Engine		Total Trucks
	Number	Percent	Number	Percent	
Medium	227,263	98	5,045	2	232,308
Heavy	41,994	23	138,044	77	180,038
Total	269,257	65	143,089	35	412,346
GVWR Group:					
1	44,221	100	0	0	44,221
2	9,397	98	215	2	9,612
3	26,330	100	31	0	26,371
4	147,315	97	4,789	3	152,104
5	25,364	65	13,563	35	38,927
6	16,630	12	124,481	88	141,111
Total	269,257	65	143,089	35	412,346

TRUCK MANUFACTURERS

The number of new trucks produced by the major truck manufacturers in 1972 are shown in Table 2-6 [1]. Four truck manufacturers, General Motors (including its Chevrolet Division), Ford, International Harvester and Dodge, produce almost 98 percent of all medium trucks and approximately 60 percent of the heavy trucks.

The financial characteristics of the parent companies of the major truck manufacturers is shown in Table 2 7 [1]. Of these parent companies, the five that are considered large, have sales and assets in excess of $1 billion; two have sales or assets between $500 million and $1 billion; and four smaller companies have less than $100 million in sales and assets.

Table 2-6
Number of New Trucks by Manufacturer, 1972

Truck Manufacturer	Medium Trucks			Heavy Trucks		
	Gasoline	Diesel	Total	Gasoline	Diesel	Total
Chevrolet	53,722	135	53,857	1,602	3,696	5,298
Diamond Reo	37	--	37	1,044	3,207	4,251
Dodge	45,042	278	45,320	3,623	1,480	5,103
FWD	4	8	12	301	606	907
Ford	63,544	3,010	66,554	13,952	18,824	32,776
GMC	25,568	446	26,014	8,126	16,017	24,143
IHC	39,064	1,165	40,229	12,230	29,311	41,541
Mack	0	0	0	25	26,331	26,356
White	0	0	3	753	21,854	22,607
Others	282	0	282	338	16,718	17,056
Total	227,263	5,045	232,308	41,994	138,044	180,038

Table 2-7
Financial Characteristics of Truck Manufacturer's
Parent Company, 1972 ($ Millions)

Parent Company of Truck Manufacturer	Sales	Net Income	Assets	Net Worth	Comments
General Motors Corporation	$30,435	$2,163	$18,273	$11,683	Truck producing divisions are Chevrolet and GMC.
Ford Motor Company	20,194	870	11,634	5,961	For year ended 10/31/72.
Chrysler Corporation	9,759	221	5,497	2,489	Truck producing subsidiary is Dodge Trucks, Inc.
International Harvester Company	3,527	87	2,574	1,198	
The Signal Company (Mack)	1,481	41	1,328	653	Truck producing subsidiary is Mack. Including Brockway, a Division of Mack, had consolidated sales of $713 million and net income of $35 million.
White Motor Corporation	943	9	573	222	Truck producing divisions are Autocar, White, Freightliner and Western Star. Total truck sales of these groups were $611 million with earnings of $27 million in 1972.
Pacaar, Inc.	595	30	268	170	Truck producing subsidiaries are Kenworth and Peterbilt. On and off-highway trucks produced by Peterbilt, Kenworth and Dart represents about 75% of sales.
Diamond Reo Trucks, Inc.	83	7	30	5	
Hendrickson Manufacturing Co.	44	Not Available	23	15	Sales include trucks, special truck equipment, and truck modifications.
FWD Corporation	28	0.4	25	6	Sales primarily trucks, year end 9/30/72. FWD is a subsidiary of Ocwen Corporation, and investment company.
Oshkosh Truck Corporation	22	0.3	14	7	Sales primarily trucks.

MOTOR TRUCK USERS

A listing of the major users of trucks to move goods is given in Table 2-8 [3]. As shown, the agricultural industry is the largest user of medium trucks and for-hire industry is the largest user of heavy trucks.

Table 2-8
Distribution of Trucks by Major Users, 1972

Major User of Trucks	Medium	Heavy	Total
Agriculture	32.5%	10.3%	26.3%
Wholesale and retail trade	19.8	18.3	19.4
Construction	11.1	19.1	13.4
For-hire	6.3	30.6	13.4
Services	9.5	2.5	7.5
Personal transportation	9.0	1.0	6.7
Manufacturing	3.6	8.5	5.0
Utilities	3.4	1.9	2.9
Forestry and lumbering	1.7	3.6	2.3
Mining	.6	1.9	1.0
All other	3.0	2.3	2.1

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[1] KEARNEY, INC, A.T. A study to determine the economic impact of noise emission standard in the medium and heavy truck industry (EPA Contract No. 68-01-154), A.T. Kearney, Inc. (1974)

[2] MOTOR VEHICLE MANUFACTURERS ASSOCIATION, INC., 1973, Motor Truck Facts (1973).

[3] U.S. BUREAU OF CENSUS, Truck inventory and use survey, 1972, census of transportation, Washington, D.C. (1972).

Section 3

BASELINE NEW TRUCK NOISE LEVELS

The baseline noise levels for different truck categories as well as the test procedure used to determine the noise levels are presented in this section.

TEST PROCEDURE USED

The most widely used test in the United States for measuring noise levels for medium and heavy trucks is the Society of Automotive Engineers (SAE) Standard J366b test entitled "Exterior Sound Level for Heavy Trucks and Buses." In April 1973, the test was revised, making it an SAE Standard (J366b) rather than an SAE J366a Recommended Practice. The majority of the truck noise level data in this document was measured using the SAE J366a recommended practice test procedure. No significant changes in the test procedure were made in this SAE J366b revision. Accordingly, the previous new truck noise level data based on J366a are used herein as the baseline noise levels for current production trucks. A brief description of the SAE J366b test procedure follows.

The test site for performing the SAE J366b exterior truck noise level test is illustrated in Figure 3-1. A microphone is located 50 feet from the centerline of the truck passby. The truck approaches the acceleration point with the engine operating at about two thirds of maximum rated or governed engine speed. At the acceleration point, the accelerator is rapidly and fully depressed. The truck engine must reach the maximum rated or governed RPM within the end zone of the acceleration lane. Several runs are performed in different directions and the average of the two highest A-weighted sound levels, which are within 2dBA of each other and measured on the noisiest side of the vehicle, are reported. During the test, the truck never exceeds 35 mph. Since tires are relatively quiet at low speed, the J366 test results are primarily an indicator of engine-related noise, which includes noise from the cooling fan, air intake, engine, exhaust, transmission, and rear axle.

NOISE LEVELS FOR NEW TRUCKS

A histogram of the noise levels of new diesel trucks, measured according to the SAE J366 test procedure, is shown in Figure 3-2 [1]. For the total of 384 diesel trucks measured, the mean noise level was 84.7 dB(A) with a standard deviation of 2.24 dB(A). The trucks measured included trucks from the eight truck manufacturers which produced approximately 85 percent of the new diesel trucks sold in 1971. Not included in this total are experimental trucks such as those developed under the Quiet Truck Program of the Department of Transp rtation or those trucks developed by various truck manufacturers without government sponsorship.

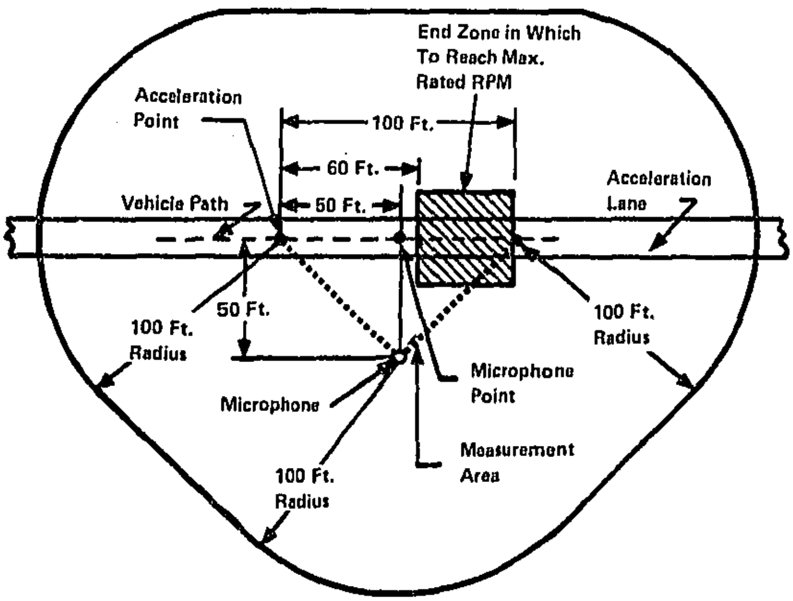

Figure 3-1. Test Site for SAE Standard J366b

Data on the noise levels of new trucks with gasoline engines are presented in the histogram shown in Figure 3-3 [1]. For the total of 18 trucks measured, the mean level was 83.5 dB(A) with a standard deviation of 2.35 dB(A). The difference between the mean noise level of gasoline and diesel powered new trucks is 1.2 dB(A).

A cumulative distribution of the new diesel truck noise levels is shown in Figure 3-4 [1]. Approximately 1 percent of newly manufactured 1973 trucks produce 80 dB(A) or less, 30 percent produce under 83 dB(A), and 86 percent produce less than 86 dB(A). Several new trucks did produce noise levels in excess of 90 dB(A).

Histograms of the noise levels measured for new gasoline-powered medium and heavy trucks are shown in Figure 3-5 [1]. The mean noise level for medium trucks appears to be less than 2 dB(A) lower than the mean noise level for heavy, gasoline powered new trucks.

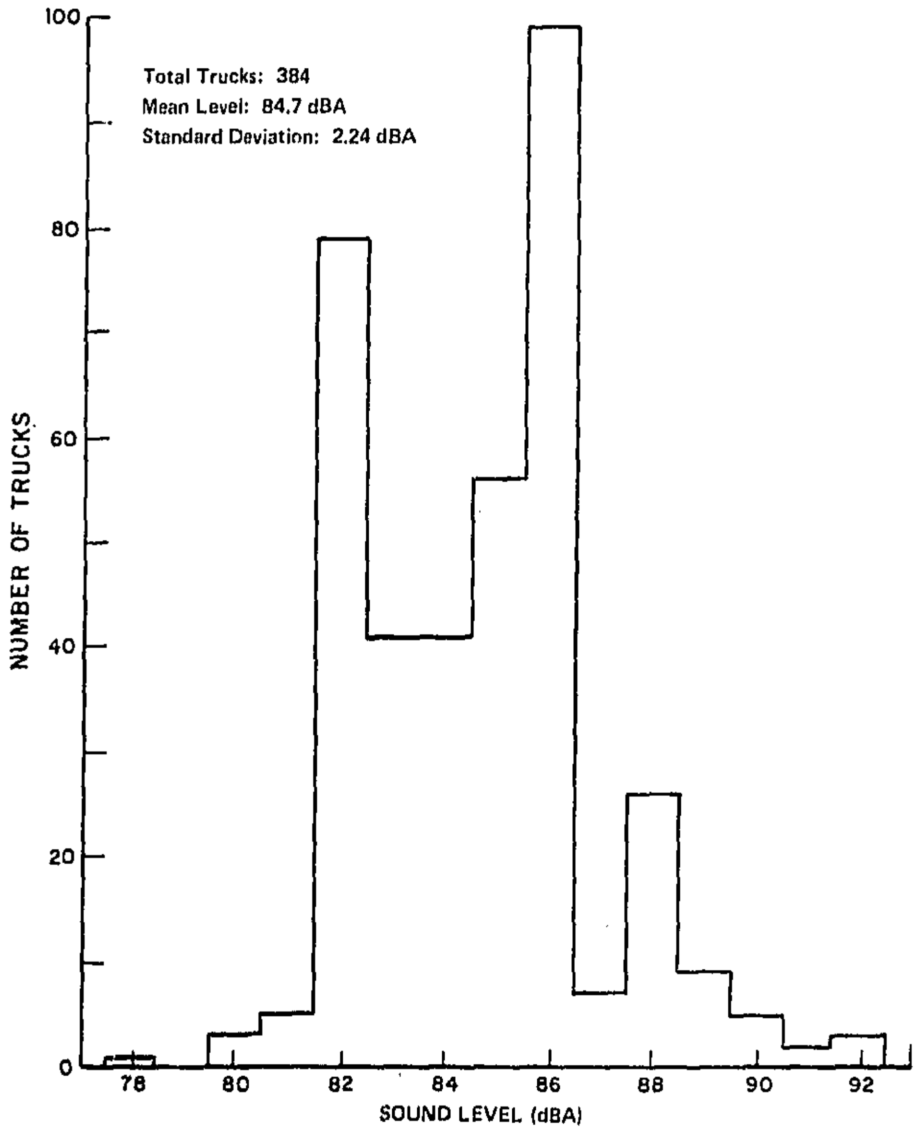

Figure 3-2. Histogram of New Diesel Truck Noise Levels

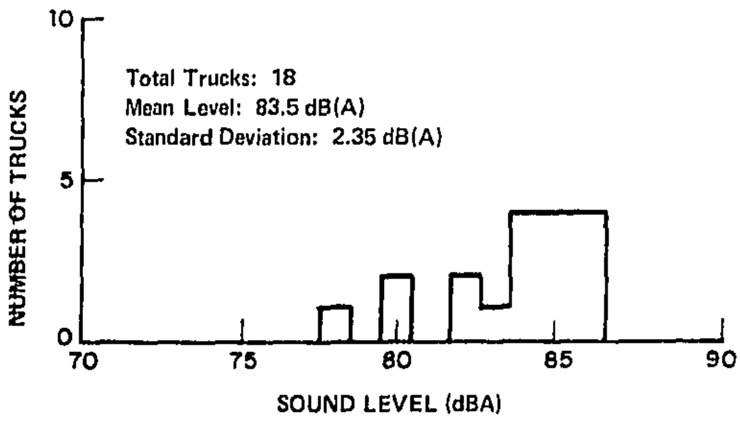

Figure 3-3. Noise Level Histograms of Gasoline-Powered Trucks

STATE AND LOCAL REGULATIONS

Summaries of existing State and local regulations on new medium and heavy trucks that will be preempted by Federal regulations are given in Table 3-1. Note that some States (California and Maryland) have required medium and heavy trucks to meet an 83 dBA standard since as early as 1975. Although the Federal 83 dBA regulation is more stringent due to a tighter enforcement program, manufacturers have been supplying medium and heavy trucks which comply with an 83 dBA regulation.

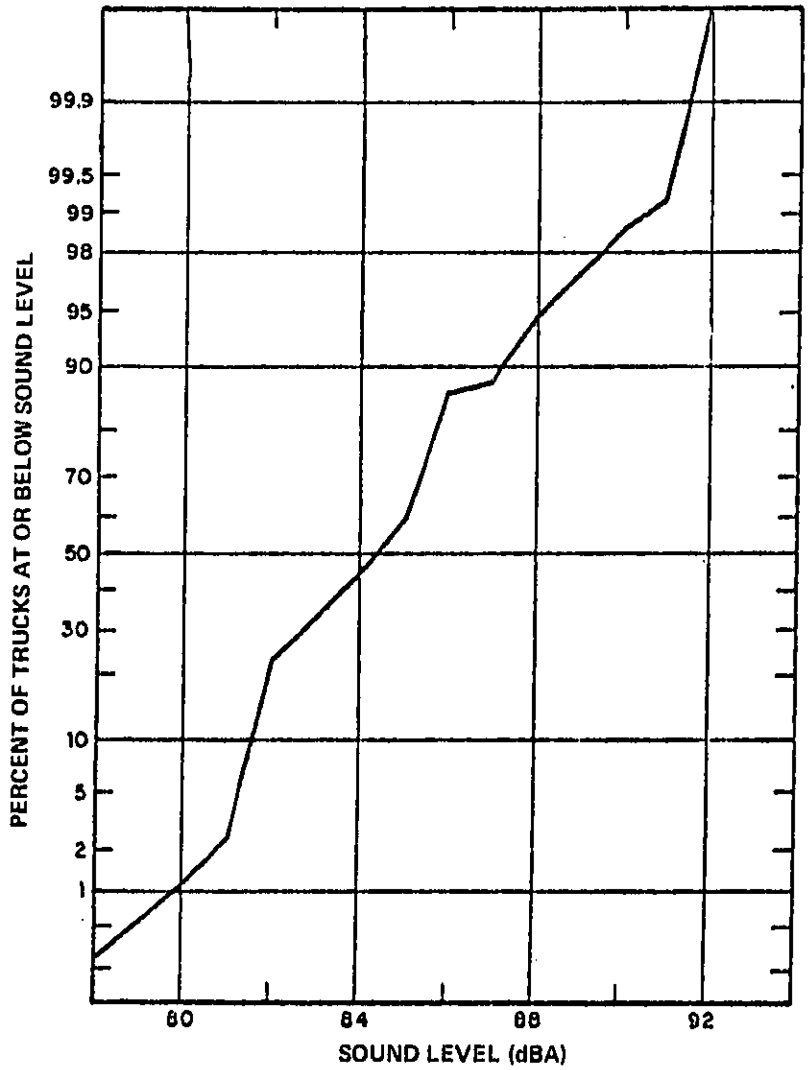

Figure 3-4. Cumulative Distribution of New Diesel Truck Noise Levels

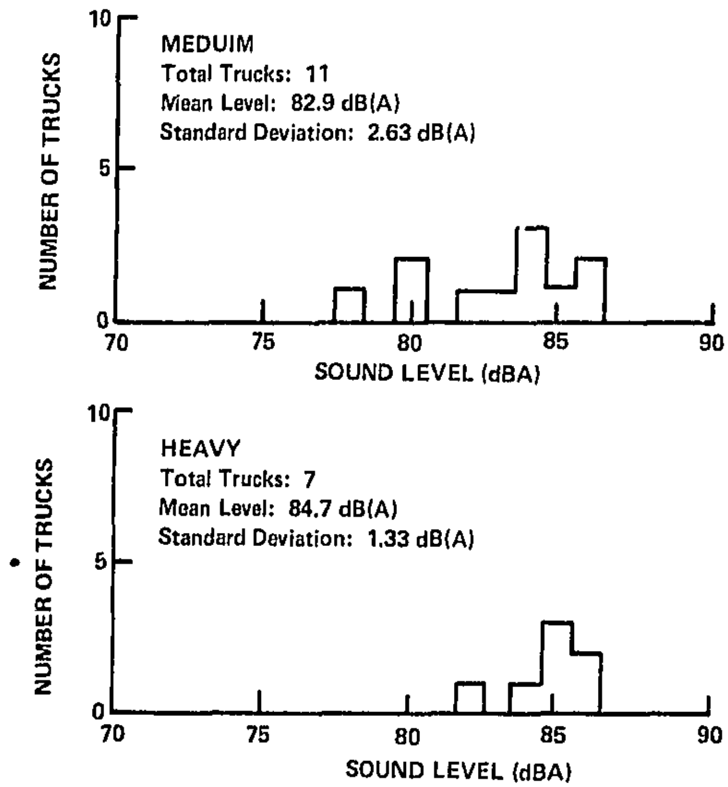

Figure 3-5. Noise Level Histograms of Gasoline-Powered Medium and Heavy New Trucks

Table 3-1
State and Local Noise Regulations on New Medium and Heavy Trucks

Standards (dBA) Measured at 50 Feet

State and Localities	Year										
	1972 or earlier	1973	1974	1975	1976	1977	1978	1979	1980	1981	1983
California	88	86		83			80				70
Colorado	88	86									
Florida		86		83			80			75	
Maryland			86	83			80		75		
Minnesota	88	86									
Nebraska	88	86		84					80		
Nevada	88	86									
Oregon				86	83			80			
Pennsylvania		90									
Washington		86									
Barrington, Illinois*	88	86		84					75		
Boston, Massachusetts	88	86		84					75		
Chicago, Illinois		86		84					75		
Des Plaines, Illinois		86		84					75		
Grand Rapids, Michigan	88	86		84					75		
Madison, Wisconsin				88							
Cook County, Illinois		86		84					75		

All standards based upon SAE J366 test procedure.
*Standards measured at 25 feet.

REFERENCES

[1] BENDER, E.K., W. N. PATTERSON, and G.E. FAX. The technology and cost of quieting medium and heavy trucks, BBN Report 2710. Bolt, Beranek, and Newman, Inc., Cambridge, Mass. 02138 (October 30, 1974).

Section 4
PUBLIC HEALTH AND WELFARE BENEFITS FROM REGULATIONS

INTRODUCTION

The Environmental Protection Agency (EPA) has proposed [1] noise emission regulations on new medium and heavy trucks. The proposed regulations specify not-to-exceed levels of 83 dBA in 1977, 80 dBA in 1981, and 75 dBA in 1983, as measured according to the SAE J366b test procedure, and are intended to control engine-related truck noise. Tire noise will be the subject of separate, future regulations.

Predictions of both costs and benefits involved are required to define the tradeoffs for various options for the regulatory levels. In this analysis, predictions of the potential health and welfare benefits for a range of possible regulatory programs of new truck noise emissions are presented. Costs of compliance and economic impact for different regulatory programs are discussed in sections 6 and 7, respectively.

Because of inherent differences in individual responses to noise, the wide range of traffic situations and environments, and the complexity of the associated noise fields, it is not possible to examine all traffic situations accurately. Thus, in this predictive analysis, certain stated assumptions have been made to approximate typical or average situations. The approach taken to determine the benefits associated with the truck noise regulation is, therefore, statistical in that an effort is made to determine the order of magnitude of the population that may be affected for each regulatory option. There may exist some uncertainties regarding individual cases or situations. However, such effects cannot be completely accounted for; thus, a statistical approach is necessary.

Measures of Benefits to Public Health and Welfare

The phrase public health and welfare, as used here, includes personal comfort and well-being as well as the absence of clinical symptoms such as hearing damage.

Reducing noise emitted by trucks will produce the following benefits [28]:

- Reduction in average traffic noise levels and associated cumulative long-term impact upon the exposed population.
- Fewer activites disrupted by individual (single-event) truck passby noise.

- Associated reduction of noise in truck cabs, which should reduce annoyance, speech interference, and possible hearing damage.

Predictions of vehicle noise levels under various regulatory options are presented in terms of the energy-average of the peak noise levels associated with a continuous sequence of passbys. The passby noise levels are weighted according to traffic populations or mixes before averaging. Reductions in average of the passby noise levels from current conditions (i.e., with no noise emission regulations) are presented for 14 regulatory options on new medium and heavy trucks, both with and without reductions in the noise emission from other traffic noise sources. Projections of the population impacted as well as the relative reductions in impact from current conditions are determined from reductions in average passby noise levels.

The reduction in the energy-average of the passby levels for a mix of vehicles in traffic does not adequately describe the annoyance produced by a single truck passby for all situations, since the average noise level tends to average out the disruptive and annoying peak noise level produced by a single passby. In addition, annoyance frequently depends on the activity and location of the individual. As an additional measure of benefits, noise levels that produce annoyance or interference in eight activity/location scenarios are compared to the noise levels from single passbys for trucks that are regulated at different levels. Truck passby distances from an observer at which annoyance or interference with activities occur are calculated for regulated trucks. These distances are compared to distances determined for existing trucks, after correcting appropriately for propagation and building transmission losses.

Regulatory Options

Predictions of traffic noise reductions and the population impacted are presented for both freeway and urban street traffic conditions under the 14 regulatory options shown in Table 4-1. For predictions of health and welfare benefits with concurrent reductions in emission from new automobiles, motorcycles, and buses, an effective date for the regulations of January 1, 1976, is assumed. In addition, the EPA Interstate Motor Carrier Regulations apply to all trucks as of October 1, 1975

Outline of Section 4

The predictions of the reduction in average passby noise levels and the population impacted are contained in the following discussion. Both freeway (high speed—55 mph) and urban street (low speed—27 mph) traffic conditions are treated, and the sum of the number of people impacted is given. The traffic mixes used in this discussion are presented in Appendix B.

Table 4-1
Regulatory Options for Medium and Heavy Trucks

Regulatory Options	Not-to-Exceed Regulatory Level – dBA				
	CY1978	CY1982	CY1984	CY1986	CY1988
A	83	80	75	–	–
B	83	80	–	75	–
C	83	80	78	–	–
D	83	–	78	–	–
E	83	80	–	–	–
F	83	–	80	–	–
G	83	–	–	–	–
H	–	–	–	–	–
I	83	–	80	–	75
J	83	–	–	75	–
K	83	80	75 (gas) 78 (diesel)		
L	83	80	75 (gas only)		
M	83	80	75 (medium) 78 (heavy)		
N	83	80	75 (medium only)		

In the next discussion, predictions of changes in annoyance or interferences with activities resulting from different regulatory levels are determined for a range of different activity/location situations.

Reduction of in-cab noise levels is discussed in the final portion of this section.

REDUCTIONS IN THE IMPACT FROM TRAFFIC NOISE

Projections of reductions in average traffic passby noise levels are presented for scenarios of both urban street traffic, where the average vehicle speed is assumed to be 27 mph, and freeway traffic, where the average vehicle speed is assumed to be 55 mph. Note, however, that the benefits accrued from the regulatory programs for new trucks considered here will be less for freeway traffic than for urban street traffic for the following reasons:

- The number of people exposed to freeway traffic noise is less than the number of people exposed to urban street traffic noise.

- The reductions in traffic noise levels resulting from the regulations on new trucks will be less in freeway traffic than in urban street traffic.

As depicted in Figure 4-1, the number of people currently exposed to outdoor noise levels that are greater than L_{dn} = 55 dBA dominated by urban street traffic noise is significantly higher than the number exposed to freeway traffic noise (93.4 million as opposed to

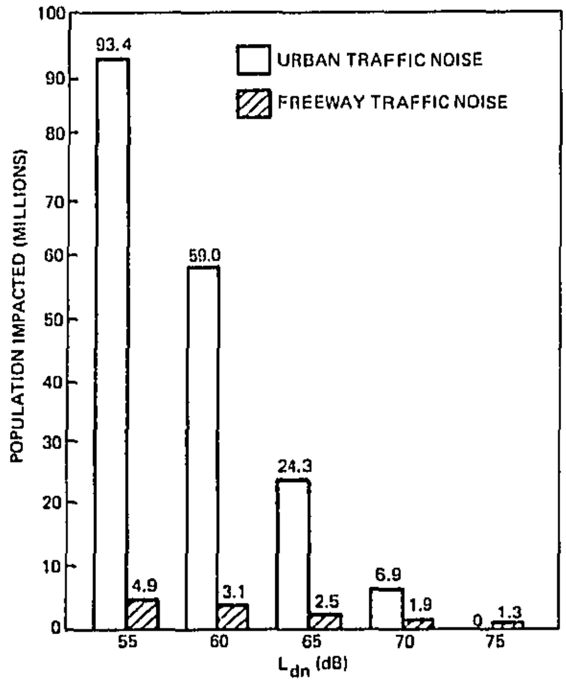

Figure 4-1. Estimated Number of People in Residential Areas Currently Subjected to Traffic Noise Above L_{dn} = 55 dB.

4.9 million). Thus, reducing urban street traffic noise will benefit significantly more people than will similar reductions in freeway traffic noise.

The new truck regulations considered are based on truck noise emissions measured in accordance with the SAE J366b test procedure. In the SAE J366b test procedure, truck noise emissions are measured with the truck speed less than 35 mph and the truck engine fully loaded. Since, in general, engine-related noise emissions increase with engine speed and load, and noise generated by tires increases with vehicle speed, the SAE J366b test procedure is designed so that maximum engine-related noise levels are measured. The noise generated by tires under SAE J366b test conditions is significant. Therefore, the new truck regulations considered here should have little effect in reducing truck tire noise.

At freeway speeds, truck tires contribute significantly to the overall passby noise levels. Therefore, the reduction of engine-related noises produced by the new truck regulations will be partially masked by tire noise in freeway traffic. Because vehicle speeds are lower in urban street traffic, tire noise contributes less to the overall noise emissions. Thus, reductions in overall truck noise levels by lowering engine-related noise emissions will be less affected by tire noise.

Reduction of tire noise levels will be necessary before the benefits from new truck regulations can be fully realized in freeway traffic. The EPA has expressed its intent to regulate tires in the future [1].

Description of Traffic Noise Impact

To perform the analysis described in this discussion, a noise measure is utilized that condenses the information contained in the noise environment into a simple indicator of quantity and quality of noise. This measure correlates well with the overall long-term effects of noise on the public health and welfare [2] and was developed as a result of the Noise Control Act of 1972, which required EPA to present information on noise levels "requisite to protect the public health and welfare with an adequate margin of safety."

EPA has chosen the equivalent A-weighted sound level in decibels as its general measure for environmental noise [3]. The general symbol for equivalent level is L_{eq}, and its basic definition is:

$$L_{eq} = 10 \log_{10}\left(\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} \frac{P^2(t)}{P_0^2} \cdot dt\right), \tag{4-1}$$

where $t_2 - t_1$ is the interval of time over which the levels are evaluated, $P(t)$ is the time varying magnitude of the sound pressure, and P_0 is a reference pressure, standardized at 20 micropascal. The L_{eq} will be used to describe traffic noise emissions. When expressed in terms of A-weighted sound level, L_A, the equivalent A-weighted sound level, L_{eq}, is defined as:

$$L_{eq} = 10 \log_{10} \frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} 10^{[L_A(t)/10]} \cdot dt$$

In describing the impact of noise on people, the measure called the day-night sound level (L_{dn}) is used. This is a 24-hour measure with a weighting applied to nighttime noise levels to account for the increased sensitivity of people to intruding noise associated with the decrease in background noise levels at night. The L_{dn} is defined as the equivalent noise level during a 24-hr period, with a 10-dB weighting applied to the equivalent noise level during the nighttime hours of 10 p.m. to 7 a.m. This may be expressed by the following equation [3]:

$$L_{dn} = 10 \log_{10} \frac{1}{24} \left[15 \left(10^{L_d/10} \right) + 9 \left(10^{(L_n + 10)/10} \right) \right] \quad (4\text{-}2)$$

where L_d is the daytime equivalent level obtained between 7 a.m. and 10 p.m. and L_n is the nighttime equivalent level obtained between 10 p.m. and 7 a.m.

Urban Street Traffic Noise

Two averages are taken to predict the average noise level from urban street traffic. First, an energy average is taken of the noise emissions from several passbys of each type of noise source. Next, the average traffic noise level is then computed by energy averaging the derived passby levels for each vehicular source, after appropriate weighting for the number of each type of vehicle in urban traffic.

Vehicle noise levels in urban street traffic

The following noise sources are considered in modeling urban street traffic noise:

- Noise treated and untreated automobiles, motorcycles and buses
- Medium and heavy trucks that are unregulated, regulated by the Interstate Motor Carrier regulations and regulated by not-to-exceed levels of 83, 80, 78 or 75 dBA.

For a population of instantaneous noise levels observed at equally spaced time intervals that has a normal (Gaussian) distribution, the energy-average of the noise levels over time (see equation 4-1) is given by [3, 4]

$$L_{eq} = L'_{50} + 0.115\, \sigma_T^2 \quad (4\text{-}3)$$

where L'_{50} is the median noise level and σ_T is the standard deviation. It is assumed that the distribution of roadside passby noise levels for each type of vehicle is approximated by a normal (Gaussian) distribution and that there is a steady stream of closely spaced passbys. This assumption permits calculation of the energy-average of the passby noise levels from median passby noise levels in a manner similar to the computation of L_{eq} in Equation 4-3; that is

$$L_a = L_{50} + 0.115\, \sigma^2 \quad (4\text{-}4)$$

where L_a is the energy-average of the passby levels, L_{50} is the median level and σ is the standard deviation of vehicle passby noise levels. As Equation 4-4 demonstrates, vehicle passby noise depends on both median level and the variability of these levels. The median levels and standard deviations used for each type of noise source in computing the traffic noise levels are given in Table 4-2.

Table 4-2
Assumed Passby Noise Levels for Vehicles in Urban Street Traffic

	Urban Street -- 27 mph		
	dBA		
Type of Vehicle	L_{50}	σ	L_a
1. Heavy Trucks			
(a) Unregulated	85.0	3.7	86.6
(b) Interstate Motor Carrier Regulations	82.0	3.0	83.0
(c) 83 dBA New Truck Regulation	77.3	2.0	77.8
(d) 80 dBA New Truck Regulation	74.6	2.0	75.1
(e) 78 dBA New Truck Regulation	73.0	2.0	73.5
(f) 75 dBA New Truck Regulation	70.8	2.0	71.3
2. Medium Trucks			
(a) Unregulated	77.0	3.7	78.6
(b) Interstate Motor Carrier Regulations	77.0	3.7	78.6
(c) 83 dBA New Truck Regulation	77.0	2.0	77.5
(d) 80 dBA New Truck Regulation	74.6	2.0	75.1
(e) 78 dBA New Truck Regulation	73.0	2.0	73.5
(f) 75 dBA New Truck Regulation	70.8	2.0	71.3
3. Automobiles			
(a) Untreated	65.0	3.7	66.6
(b) Treated	61.0	2.0	61.5
4. Buses			
(a) Untreated	79.0	3.7	80.6
(b) Treated	75.0	2.0	75.5
5. Motorcycles			
(a) Untreated	82.0	3.7	83.6
(b) Treated	78.0	2.0	78.5

The data in Table 4-2 demonstrate that regulating the noise emissions from vehicles lowers the median noise levels as well as the variability of the noise levels within each vehicle class. This is because all the vehicles within each class are subject to the same regulatory level, which tends to decrease the spread in the noise levels.

Median Noise Levels for Trucks

Levels for Current Trucks

Since most medium trucks are powered by gasoline engines and most heavy trucks by diesel engines [5], medium trucks are generally quieter than heavy trucks. Therefore, medium and heavy trucks will be treated separately.

In a survey of truck noise emissions [6] trucks were classified by number of axles rather than vehicle weight or engine type. A median level of about 76 dBA was reported for trucks with two axles in speed zones less than 35 mph when measured at grassy sites 50 ft from the street. A characteristic of many urban street sites, however, is a hard surface between the truck and the observation point. A hard surface will usually increase the observed truck noise levels over those that would be expected at a grassy site. Some medium trucks have more than two axles and, therefore, were grouped with trucks having higher reported median levels. Given these factors, it is assumed that medium trucks at typical sites will emit a median level approximately 1 dBA higher than that reported for two-axle trucks near grassy sites. Thus, a level of 77 dBA observed at 50 ft was selected as the median noise level for medium trucks.

A median level of approximately 84 dBA measured at a distance of 50 ft over grassy areas is reported for trucks with 5 axles at speeds less than 35 mph [6]. Because many urban sites have hard surfaces between the truck and observer, a median level of 85 dBA is selected.

Levels for Regulated Trucks

The Interstate Motor Carrier regulations are in-use standards specifying maximum permissible noise emissions for old and new medium and heavy trucks. At low speeds, the regulation states that the roadside levels generated by trucks shall not exceed 86 dBA. This regulation will not significantly impact medium trucks that currently emit a median level of 77 dBA. However, the current median roadside level for heavy trucks is approximately 85 dBA. Therefore, so that most heavy trucks can comply with the Interstate Motor Carrier regulations, a median level of 82 dBA has been assumed.

The median roadside passby levels for regulated new trucks will actually be below the specified regulatory levels for the following reasons:

- Trucks will be designed and built with median test noise levels below the not-to-exceed regulation levels, so that most of the trucks of a given model will comply with the regulation.

- Less noise is produced under typical road operating conditions than under test conditions.

- There are differences between roadside sites and test sites so that the observed noise levels will often be lower at roadside sites.

Since the regulations prescribe levels not to be exceeded, trucks must be designed and built so that the measured levels will fall below the prescribed level. If the desired median level is set two standard deviations below the regulatory level, 97.7 percent of the trucks should be below the regulatory level.

In the selective enforcement auditing procedure in the regulations, 10 percent of the tested vehicles are allowed to exceed the regulatory level, so that a median level two standard deviations below the regulatory level should be low enough for compliance, if design tolerances and uncertainties in measured levels are ignored. Available noise control technology for trucks does not permit a designer to confidently hit a median noise level goal exactly [7]. That is, some uncertainty should be related to the variation in the noise levels.

A design tolerance, or safety factor, on the median level of one standard deviation is assumed. Therefore, a median level of three standard deviations below the regulatory level is assumed sufficient to account for design tolerances and variations in noise levels from different trucks of one configuration. The standard deviation of noise levels measured from 30 nominally identical trucks tested at the same site, with the same instrumentation and in accordance with SAE J366b test procedures, was approximately 0.5 dBA [8]. Therefore, a level approximately 1.5 dBA below the regulatory level should be adequate to compensate for design tolerances and variation in the noise levels.

Measurement uncertainties associated with the test site and measurement instrumentation will be approximately 1.0 dBA. Thus, a median level of 2.5 dBA below the regulatory level should be sufficient to account for variations in noise emissions and measurement uncertainties. The 2.5-dBA factor is in agreement with most of the comments received from truck manufacturers in response to the proposed regulations.

The SAE J366b test procedure is designed to measure maximum engine-related noise. However, because the engine will not always be at maximum load and speed for trucks in urban street traffic, observed noise levels for typical operating conditions on urban streets will be lower than the levels measured in accordance with the SAE J366b test procedure. The average difference between the noise levels measured according to SAE J366b procedure and the levels measured during typical city startup conditions for 15 heavy diesel trucks is approximately 1.0 dBA [9]. However, little data is available regarding the differences between SAE J366b measured noise levels and the passby noise levels of the tested trucks cruising at speeds of less than 35 mph. In addition, little data exists regarding driving cycles of trucks to show the amount of time trucks are accelerating or cruising.

For predicting typical roadside noise levels, cruising trucks are assumed to emit levels 3.0 dBA below the SAE J366b noise level. Further, it is assumed that trucks cruise 80 percent of the time and accelerate 20 percent of the time while in urban street traffic. Weighting according to this assumption on the driving cycle, the average roadside level for trucks is estimated to be 2.5 dBA below the median SAE J366b test level.

In the test procedure required in the EPA proposed regulations, a hard surface between the truck and measurement point is required. Many roadside sites have grassy surfaces between the truck and an observer 50 ft from the truck passby. Therefore, some of the noise will be absorbed by the soft grassy surface, so that the observed noise levels will be lower than the levels that would be observed at sites similar to the required test site. The difference in the noise levels observed at sites with concrete or sealed asphalt between the trucks and the observer and the levels observed at sites with grass between the trucks and the observer is approximately 2 dBA [9]. By assuming that about half of the urban street sites have a soft surface, the median level of the observed noise emitted by trucks in urban street traffic will be approximately 1.0 dBA below those observed at test sites for the same trucks and operating conditions.

By considering all of the preceding factors, the median noise level of the engine-related noise 50 ft from an urban street is assumed to be 6.0 dBA below the regulatory level. The 6.0 dBA represents a summation of the following factors:

- Designing 2.5 dBA below the regulatory level.
- Typical operating conditions producing noise levels 2.5 dBA below the test noise levels.
- A reduction of 1.0 dBA due to differences in test and roadside sites.

The data in Table 4-2 for the median level of regulated new trucks are the energy sum of engine-related noise and tire noise. The tire noise is assumed to have a level of 66 dBA at 50 ft for speeds of 27 mph, which is representative of ribbed tires [10].

Median Noise Levels for Automobiles

A median roadside noise level of 65 dBA is given in Table 4-2 for untreated automobiles with speeds below 35 mph as observed at 50 ft from the centerline of the automobile passby. This level represents the average of the following published survey data: 68 dBA [11], 68 dBA [12], 64.4 dBA [13], 61.4 dBA [14], 62 dBA [15], and 64.2 dBA [16]. The lowest of these levels (61.4 dBA) is the average of the noise emitted from eight new automobiles operated at a constant speed of 35 mph [14]. Selection of 61 dBA as a median passby level for new noise-treated automobiles was based on the assumption that treating automobiles will lower the median level of new automobiles operated on urban streets to the current average level for new automobiles operating at constant speed. This is one of the quietest of normal operating conditions.

Median Noise Levels for Buses

The 79-dBA median level for untreated buses, shown in Table 4-2, represents the average noise emission level for buses operating in urban street traffic [17]. This level is 2 dBA higher than the median level assumed for medium trucks and 6 dBA lower than the median level assumed for heavy trucks. Treated new buses are assumed to have passby levels of 4 dBA lower than untreated buses. This reduction in passby levels for buses is identical to the reduction assumed for automobiles.

Median Noise Levels for Motorcycles

The 82-dBA median level for untreated motocycles, shown in Table 4-2, represents the average level for motorcycles operating in urban street traffic [17]. This level is 3 dBA below the median level assumed for heavy trucks. It is assumed that treating new motorcycles will reduce roadside levels by 4 dBA, which is identical to the reductions assumed for automobiles and buses.

Standard Deviations

The average of the standard deviations for the roadside noise levels from trucks at speeds of less than 35 mph is approximately 3.9 dBA [6]. The California Highway Patrol found a 2.8-dBA standard deviation for trucks cruising at speeds less than 35 mph [12]. A standard deviation, 4.0 dBA, is given by Olson [13]. The average standard deviation for trucks calculated from the preceding data is 3.6 dBA. For automobiles, a standard deviation of 3.7 dBA was reported by the California Highway Patrol [18]. For motorcycles, values of 4.4 dBA [19] and 3.0 dBA [20] have been reported. Averaging these values gives 3.7 dBA as a representative standard deviation for motorcycles. From this data, it appears that the standard deviation of typical roadside noise levels does not significantly vary for different types of motor vehicles. Thus, a typical standard deviation of 3.7 dBA is assumed for all untreated vehicles.

For regulated new trucks, a standard deviation of 2.0 dBA is assumed. This value is higher than the expected 0.5-dBA standard deviation of SAE J366b measured noise levels because it also includes the effects of variations in operating conditions and roadside site characteristics. By assuming that the standard deviation for the roadside noise levels of regulated trucks is 2.0 dBA, only the noise levels exceeding the median level by more than three standard deviations would be higher than the regulatory level, since the median roadside level is assumed to be 6.0 dBA below the regulatory level.

Thus, assuming that the noise levels for trucks do not change with truck age, only a small percentage (less than 0.1 percent) of the regulated trucks would be capable of producing noise levels above the regulatory level and, therefore, would have been out of compliance with the regulations when they were new.

A standard deviation of 2.0 dBA is also assumed to apply to new noise-treated automobiles, motorcycles, and buses. Since the Interstate Motor Carrier regulations are applicable to both old and new trucks, a larger variation in roadside noise levels is anticipated for trucks complying with these regulations than for the trucks complying with the new truck regulations. Thus, a standard deviation of 3.0 dBA is assumed for heavy trucks regulated by the Interstate Motor Carrier regulations. Note that this standard deviation is higher than the 2.0 dBA standard deviation assumed for trucks subject to the new truck regulations and is lower than the 3.7 dBA standard deviation assumed for unregulated trucks.

Reduction of average urban street traffic noise levels

From the figures regarding traffic population percentage in urban street traffic presented in Appendix B and the average passby noise levels given previously, average passby noise level for urban street traffic noise levels ($\bar{L}_a$) may be computed using the following equation

$$\bar{L}_a = 10 \log_{10} \Sigma_i \ \gamma_i \ 10^{L_a^i} \qquad (4\text{-}5)$$

where γ_i is the fraction of the total traffic population for the *ith* type of noise source (see tables in the Appendix B) and L^i_a is the average passby noise level for the *ith* type of noise source (see Table 4-2).

The reduction in the average passby noise levels relative to existing average passby noise levels are presented in Tables 4-3 and 4-4 for the years 1978, 1982, 1984, 1986, 1991, and 2001, for each of the regulatory programs for new trucks given in Table 4-1. In Table 4-3, it is assumed that automobiles, motorcycles, and buses are not treated so that the new truck regulations are supported only by the Interstate Motor Carrier regulations. The effectiveness of the Interstate Motor Carrier regulations will decrease as a larger portion of the trucks become subject to new truck regulations that reduce the noise emissions to levels below the levels specified in the Interstate Motor Carrier regulations. In Table 4-4, it is assumed that new truck and Interstate Motor Carrier regulations are supported by treatment of new automobiles, motorcycles, and buses, that reduce their roadside noise levels by 4 dBA.

For the purposes of these computations, it is assumed that the total population of urban street vehicles remains constant. This assumption should have little impact on the relative

Table 4-3
Reduction in Urban Street Traffic Noise – Without Reductions in Noise from Automobiles, Motorcycles and Buses

Regulatory Option	Reduction in Average Noise – dBA at 50 Ft					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
A	0.7	1.2	1.6	2.1	2.7	3.0
B	0.7	1.2	1.6	1.9	2.6	3.0
C	0.7	1.2	1.6	2.0	2.4	2.6
D	0.7	1.2	1.4	1.8	2.4	2.6
E	0.7	1.2	1.6	1.9	2.2	2.3
F	0.7	1.2	1.4	1.7	2.1	2.3
G	0.7	1.2	1.4	1.4	1.6	1.6
H	0.7	0.7	0.7	0.7	0.7	0.7
I	0.7	1.2	1.4	1.7	2.4	3.0
J	0.7	1.2	1.4	1.4	2.4	2.9
K	0.7	1.2	1.6	2.0	2.6	2.9
L	0.7	1.2	1.6	2.0	2.6	2.9
M	0.7	1.2	1.6	2.0	2.6	2.9
N	0.7	1.2	1.6	2.0	2.6	2.9

magnitudes of urban street traffic noise levels, because the average noise levels for all of the regulatory programs will be affected equally by changes in total vehicle population.

Reduction in noise impact from urban street traffic

To assess the impact of traffic noise, a relation between the changes in traffic noise just discussed and the responses of the people exposed to the noise is needed. The responses may vary depending upon previous exposure, age, socioeconomic status, political cohesiveness, and other social variables. In the aggregate, however, for residential locations, the average response of groups of people is related to cumulative noise exposure as expressed in a measure such as L_{dn}. For example, the different forms of response to noise, such as hearing damage, speech or other activity interference, and annoyance, were related to L_{eq} or L_{dn} in the EPA Levels Document [3]. For the purposes of this study, criteria based on L_{dn} presented in the EPA Levels Document are used. Furthermore, it is assumed that if the outdoor level of L_{dn} = 55 dB, which is identified in the EPA Levels Document as requisite

Table 4-4
Reduction in Urban Street Traffic Noise – With a 4 dBA Reduction in Noise from Automobiles, Motorcycles and Buses

Reduction in Average Noise – dBA at 50 Ft						
Regulatory Option	Calendar Year					
	1978	1982	1984	1986	1991	2001
A	1.1	2.5	3.7	5.0	6.3	7.1
B	1.1	2.5	3.7	4.6	6.2	7.1
C	1.1	2.5	3.7	4.8	5.8	6.3
D	1.1	2.5	3.3	4.4	5.7	6.3
E	1.1	2.5	3.7	4.6	5.2	5.5
F	1.1	2.5	3.3	4.2	5.1	5.5
G	1.1	2.5	3.3	3.8	4.0	4.1
H	1.1	1.9	2.4	2.7	2.7	2.7
I	1.1	2.5	3.3	4.2	5.7	7.0
J	1.1	2.5	3.3	3.8	5.8	6.9
K	1.1	2.5	3.7	4.9	6.2	6.9
L	1.1	2.5	3.7	4.9	6.2	6.8
M	1.1	2.5	3.7	4.9	6.2	6.9
N	1.1	2.5	3.7	4.9	6.2	6.8

to protect the public health and welfare, is met, no adverse impact in terms of general annoyance and community response exists.

The intelligibility of sentences (first presentation to listeners) drops to 90 percent when the level of the noise environment is increased approximately 19 dB above the level identified in the EPA Levels Document and to 50 percent when the level is increased approximately 24 dB. The intelligibility of sentences (known to listeners) drops to 90 percent when the level is increased approximately 22 dB above the identified level and to 50 percent when the level is increased approximately 26 dB [5]. Thus, since normal conversation contains a mixture of some new and some familiar material, it is clear that when the level of environmental noise is increased more than 20 dB above the identified level, the intelligibility of conversational speech deteriorates rapidly with each decibel of increase. For this reason, a level 20 dB above the identified level is considered to result in 100 percent impact on the people exposed. For environmental noise levels that are between 0 and 20 dB above the identified level, the impact is assumed to vary linearly with level; i.e., a 5-dB excess constitutes a 25 percent impact and a 10-dB excess constitutes a 50 percent impact.

A similar conclusion can be drawn from the community reaction and annoyance data contained in Appendix B of the Levels Document [3]. The community reaction data show that the expected reaction to an identifiable source of intruding noise changes from "none" to "vigorous" when the day-night sound level increases from 5 dB below the level existing without the presence of the intruding noise to 19.5 dB above the level before intrusion. Thus, 20 dB is a reasonable value to associate with a change from 0 to 100 percent impact. Such a change in level would increase the percentage of the population that is highly annoyed by 40 percent of the total exposed population [3]. Further, the data in the Levels Document suggest that within these upper and lower bounds the relationship between impact and level varies linearly; that is, a 5-dB excess (60 L_{dn}) constitutes a 25 percent impact and a 10-dB excess (65 L_{dn}) constitutes a 50 percent impact.

For convenience of calculation, percentages of impact may be expressed as Fractional Impact (FI). A FI of 1.0 represents an impact of 100 percent, in accordance with the following formula:

$$FI = \begin{cases} \frac{1}{20}(L-55) & \text{for } L > 55 \\ 0 & \text{for } L \leq 55 \end{cases} , \qquad (4\text{-}6)$$

where L is the observed or measured L_{dn} of the environmental noise. Note that FI can exceed unity for exposures greater than L_{dn} = 75 dB.

The magnitude of the impact associated with a given level of traffic noise (L^i_{dn}) may be assessed by multiplying the number of people exposed to that level of traffic noise by the fractional impact associated with the level as follows:

$$P^i_{eq} = (FI_i)P_i, \qquad (4\text{-}7)$$

where P^i_{eq} is the magnitude of the impact on the population exposed to traffic noise L^i_{dn} and is numerically equal to the number of people, all of which would have a fractional impact equal to unity (100 percent impacted). FI_i is the fractional impact associated with a day-night noise level of L^i_{dn} over 55 dB, and P_i is the population exposed to this level of traffic noise.

When assessing the total impact associated with traffic noise, the observed levels of noise decrease as the distance between the source and receiver increase. The magnitude of the total impact may be computed by determining the number of people exposed at each level and summing over the resulting impacts. The total impact is given in terms of the equivalent number of people impacted by the following formula:

$$P_{eq} = \sum_i P_i \cdot FI_i, \qquad (4\text{-}8)$$

where FI_i is the fractional impact associated with L_{dn}^i and P_i is the population associated with L_{dn}^i. In this study, the mid-level of each 5-dBA sector of levels above $L_{dn} = 55$ dB will be used for L_{dn}^i in computing P_{eq}.

The change in impact associated with regulations on the noise emissions from traffic vehicles may be assessed by comparing the magnitude of the impacts, both with and without regulations, in terms of the percent reduction in impact (Δ), which is calculated from the following expression:

$$\Delta = 100 \frac{[P_{eq}(\text{before}) - P_{eq}(\text{after})]}{P_{eq}(\text{before})} . \qquad (4\text{-}9)$$

The population figures (P_i) in Equation 4-7 are based on a survey in which the total population exposed to outdoor noises of L_{dn} above 55 dB was estimated from measurements taken at 100 sites throughout the United States [21]. The sites were selected far enough from freeway traffic and airports so that these sources of noise were not significant contributors to the measured outdoor noise levels. Thus, urban street traffic was a dominant noise source for each of the survey sites. Results from this study are given in Table 4-5.

Using the data contained in Table 4-5, a P_{eq} for existing traffic conditions of 34.6 million is calculated, as shown in Table 4-6. The P_{eq}s associated with the previously calculated reductions in the average passby noise levels for urban street traffic presented in Tables 4-3 and 4-4 are predicted by shifting (reducing) the values of L_{dn} in Table 4-5 by the average passby noise reduction of interest and performing computations similar to those shown in Table 4-6. In following this procedure for estimating P_{eq}, it is assumed that

- Reductions in the average passby noise level in urban street traffic will produce equal reductions in the L_{dn} for the outdoor noise.

- The population in urban areas will remain constant.

The projected values of P_{eq} for urban street traffic noise are presented in Tables 4-7 and 4-8 for the years 1978, 1982, 1984, 1986, 1991, and 2001, for each of the regulatory programs for new trucks given in Table 4-1. The results, as depicted in Table 4-7, pertain to the noise reductions presented in Table 4-3, in which no noise treatment of new automobiles, motorcycles, and buses are assumed. Likewise, the results in Table 4-8 pertain to the noise reductions presented in Table 4-4, in which the new truck regulations are assumed to be

Table 4-5
Distribution of Urban Population at or Greater Than a Specified L_{dn}

L_{dn}	Cumulative (in Millions of People)	L_{dn}	Cumulative (in Millions of People)
55	93.427	70	6.853
56	87.665	71	5.155
57	81.237	72	3.826
58	74.222	73	2.776
59	66.738	74	1.963
60	58.997	75	1.347
61	51.234	76	0.889
62	43.668	77	.559
63	36.542	78	.332
64	30.061	79	.187
65	24.320	80	.093
66	19.352	81	.039
67	15.200	82	.012
68	11.791	83	.002
69	9.046	84	.0

complimented by a 4 dBA reduction in passby noise levels from automobiles, motorcycles, and buses.

Freeway Traffic Noise

The same methodology used to predict reductions in the average passby noise in urban street traffic noise is used to predict reductions in freeway traffic noise levels.

Table 4-6
Calculation of Equivalent Number of People Impacted by Urban Street Traffic Noise

L^i_{dn}	Population Exposed to L^i_{dn} or Higher P^i_c (millions)	Population Exposed to Levels Between L^i_{dn} and L^{i+1}_{dn} $P_i = P^{i+1}_c - P^i_c$	Fractional Impact to Mid-Level FI_i	Equivalent Number of People Impacted FI_iP_i
55	93.4	34.4	0.125	4.3
60	59.0	34.7	0.375	13.0
65	24.3	17.5	0.625	10.9
70	6.8	5.5	0.875	4.9
75	1.3	1.2	1.125	1.4
80	0.1	0.1	1.375	0.1

(P_{eq} = 34.6 million)

Vehicle noise levels in freeway traffic

The following types of noise sources are included in the freeway traffic noise prediction model:

- Noise – treated and untreated automobiles.
- Unregulated medium and heavy trucks.
- Medium and heavy trucks regulated by the Interstate Motor Carrier regulations.
- Medium and heavy trucks regulated at not-to-exceed levels of 83, 80, 78, or 75 dBA as measured in accordance with SAE J366b test procedure.

The assumed median noise levels, standard deviations, and average passby noise levels for each type of noise source are given in Table 4-9. The average passby noise levels are computed using Equation 4-4.

Median Noise Levels for Trucks

For purposes of predicting freeway traffic noise, medium and heavy trucks are grouped together. The median level for medium and heavy truck passbys is approximately 85.5 dBA when the average speed is 57 mph [6]. The Interstate Motor Carrier regulations are assumed to lower the median passby level for existing trucks by 1.0 dBA. The median levels for trucks subject to new truck regulations are computed by adding tire noise levels at 55 mph to

Table 4-7
Equivalent Number of People Impacted (P_{eq}) by Urban Street Traffic Noise –
Without Reductions in Noise from Automobiles, Motorcycles and Buses

	P_{eq} – Millions Calendar Year					
Regulatory Option	1978	1982	1984	1986	1991	2001
A	31.4	29.3	27.6	25.6	23.3	22.0
B	31.4	29.3	27.6	26.4	23.5	22.0
C	31.4	29.3	27.6	26.0	24.4	23.5
D	31.4	29.3	28.4	26.8	24.4	23.5
E	31.4	29.3	27.6	26.4	25.2	24.8
F	31.4	29.3	28.4	27.3	25.6	24.8
G	31.4	29.3	28.4	28.4	27.6	27.6
H	31.4	31.4	31.4	31.4	31.4	31.4
I	31.4	29.3	28.4	27.3	24.4	22.0
J	31.4	29.3	28.4	28.4	24.4	22.5
K	31.4	29.3	27.6	26.0	23.5	22.5
L	31.4	29.3	27.6	26.0	23.5	22.5
M	31.4	29.3	27.6	26.0	23.5	22.5
N	31.4	29.3	27.6	26.0	23.5	22.5

the median levels for engine-related noise from trucks cruising in urban street traffic. The engine-related median noise level is assumed to be 6.5 dBA below the regulatory level.

The 6.5 dBA factor includes 2.5 dBA for designing below the regulatory level, 3.0 dBA for differences in testing and typical cruising conditions, and 1.0 dBA for differences in test and typical roadside sites. An 81-dBA median tire noise level is assumed [7], corresponding to the peak level observed at 50 ft for a single unit (two-axle) loaded truck with half-worn tires passing by at 55 mph [10]. No corrections for the differences in test and roadside sites are assumed for tire noise, since most of the tire noise is generated at points near the road surface, so that the noise suffers few reflections from the surface between the truck and observer.

Median Noise Levels for Automobiles

A median roadside noise level of 75 dBA is given in Table 4-9 for untreated automobiles in freeway traffic observed at 50 ft from the centerline of the automobile passby. This level is an average computed from the following levels as reported in studies on

Table 4-8
Equivalent Number of People Impacted (P_{eq}) by Urban Street Traffic Noise – With a 4 dBA Reduction in Noise from Automobiles, Motorcycles and Buses

	P_{eq} – Millions Calendar Year					
Regulatory Option	1978	1982	1984	1986	1991	2001
A	29.7	24.0	19.7	15.4	12.0	9.9
B	29.7	24.0	19.7	17.0	12.3	9.9
C	29.7	24.0	19.7	16.3	13.4	12.0
D	29.7	24.0	21.0	17.5	13.6	12.0
E	29.7	24.0	19.7	17.0	15.0	14.1
F	29.7	24.0	21.0	17.9	15.2	14.1
G	29.7	24.0	21.0	19.4	18.7	18.4
H	29.7	27.3	24.4	23.3	23.3	23.3
I	29.7	24.0	21.0	17.9	13.6	10.2
J	29.7	24.0	21.0	19.4	13.4	10.5
K	29.7	24.0	19.7	15.7	12.3	10.8
L	29.7	24.0	19.7	15.7	12.3	10.8
M	29.7	24.0	19.7	15.7	12.3	10.8
N	29.7	24.0	19.7	15.7	12.3	10.8

Table 4-9
Assumed Passby Noise Levels (dBA) for Vehicle in Freeway Traffic

Type of Vehicle	Freeway – 55 mph		
	L_{50}	σ	L_a
1. Medium and Heavy Trucks			
(a) Unregulated	85.5	3.5	86.9
(b) Interstate Motor Carrier Regulations	84.5	3.0	85.5
(c) 83 dBA New Truck Regulation	82.3	2.0	82.8
(d) 80 dBA New Truck Regulation	81.7	2.0	82.2
(e) 78 dBA New Truck Regulation	81.5	2.0	82.0
(f) 75 dBA New Truck Regulation	81.2	2.0	81.7
2. Automobiles			
(a) Untreated	75	3.5	76.4
(b) Treated	71	2.0	71.5

automobile passby levels in freeway traffic: 74.2 dBA [11], 78.9 dBA [12], 78.6 dBA [22], 73 dBA [13], 71.5 dBA [13], and 72.6 dBA [18]. Assuming that the median level for treated new automobiles will be at least as low as the lowest of the reported values, a median level of 71 dBA is used for treated automobiles.

Standard Deviations

A standard deviation of 3.5 dBA given in Table 4-9 for untreated vehicles in freeway traffic is taken from the same study [18] that reported a standard deviation for passby noise of 3.7 dBA for vehicles in urban street traffic. For treated vehicles, a standard deviation identical to those used for urban street noise is used for freeway noise levels.

Reduction of average freeway traffic noise levels

From the traffic population percentage data for freeway traffic given in Appendix B and from the average passby noise levels given in Table 4-9, the average passby noise level for freeway traffic noise levels ($\bar{L}_a$) are computed using Equation 4-5. Reduction of the average passby noise levels from average passby noise levels for existing freeway traffic are presented in Tables 4-10 and 4-11 for the years 1978, 1982, 1984, 1986, 1991, and 2001 for each of the regulatory programs given in Table 4-1. In Table 4-10 it is assumed that automobiles are not treated. Thus, the new truck regulations are assumed to be complemented only by the Interstate Motor Carrier regulations. In Table 4-11, it is assumed that new truck and Interstate Motor Carrier regulations complemented by noise treatments on new automobiles, which will reduce their passby noise levels by 4 dBA.

For purposes of predicting the impact of freeway traffic noise, the total vehicle population is assumed to remain constant. This assumption is anticipated to have little effect on the predictions, since changes in the total vehicle populations should have an equal effect on all of the predictions shown in Tables 4-10 and 4-11.

Reduction in noise impact from freeway traffic

The equivalent number of people impacted (P_{eq}) by freeway traffic noise is computed using Equation 4-8. The population exposed to different levels of freeway noise, expressed in terms of L_{dn}, is estimated from predictions of noise levels as a function of distance and population densities near freeways.

Table 4-10
Reduction in Freeway Traffic Noise – Without Reductions in Noise from Automobiles

Regulatory Option	Reduction in Average Noise – dBA at 50 Ft					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
A	0.7	1.2	1.5	1.7	2.0	2.1
B	0.7	1.2	1.5	1.7	2.0	2.1
C	0.7	1.2	1.5	1.7	1.9	2.0
D	0.7	1.2	1.4	1.6	1.9	2.0
E	0.7	1.2	1.5	1.7	1.8	1.9
F	0.7	1.2	1.4	1.6	1.8	1.9
G	0.7	1.2	1.4	1.6	1.7	1.8
H	0.7	0.7	0.7	0.7	0.7	0.7
I	0.7	1.2	1.4	1.6	1.9	2.1
J	0.7	1.2	1.4	1.6	1.9	2.1
K	0.7	1.2	1.5	1.7	2.0	2.1
L	0.7	1.2	1.5	1.7	2.0	2.1
M	0.7	1.2	1.5	1.7	2.0	2.1
N	0.7	1.2	1.5	1.7	2.0	2.1

For existing freeway traffic, the distances (in miles) from freeways at which different noise levels occur are computed according to Equation 4-10. Equation 4-10 was derived from the data shown in Figure 4-2, which was derived from design data for freeways [28].

$$L_{dn}^{i} = 30 - 30 \log d_i. \qquad (4\text{-}10)$$

Differences in the distances (Δd_i) for levels above L_{dn} = 55 dB and 5 dB apart are computed. In computing Δd_i, a minimum distance of 70 ft (0.013 mi) is used, since it is assumed that there are no residents closer than 70 ft from freeways. Assuming that

1. There are 8000 miles of freeways in urban areas [23],

2. People are exposed on both sides of freeways,

3. The average population density in residential urban areas is 5000 people/mi^2 [24], and

4. One-half of urban areas are residential,

Table 4-11
Reduction in Freeway Traffic Noise With a 4 dBA Reduction in Noise from Automobiles

	Reduction in Average Noise – dBA at 50 Ft					
	Calendar Year					
Regulatory Option	1978	1982	1984	1986	1991	2001
A	1.0	2.5	3.5	4.3	4.8	5.0
B	1.0	2.5	3.5	4.2	4.8	5.0
C	1.0	2.5	3.5	4.3	4.7	4.8
D	1.0	2.5	3.4	4.2	4.6	4.8
E	1.0	2.5	3.5	4.2	4.6	4.7
F	1.0	2.5	3.4	4.2	4.6	4.7
G	1.0	2.5	3.4	4.0	4.3	4.4
H	1.0	1.8	2.2	2.6	2.6	2.6
I	1.0	2.5	3.4	4.2	4.7	5.0
J	1.0	2.5	3.4	4.0	4.7	5.0
K	1.0	2.5	3.5	4.3	4.8	5.0
L	1.0	2.5	3.5	4.3	4.8	5.0
M	1.0	2.5	3.5	4.3	4.8	5.0
N	1.0	2.5	3.5	4.3	4.8	5.0

the following equation is used to calculate the number of people living within 5 dB sectors above L_{dn} = 55 dB near freeways:

$$P_i = \Delta d_i (8000)(2)(5000)(0.5), \tag{4-11}$$

which equals 40.0 (Δd_i) million people.

Using Equations 4-10 and 4-11 to calculate P_{eq} for existing freeway traffic results in a value of 2.72 million, as shown in Table 4-12. Using data on the population exposed to different levels of outdoor noise derived from measurements of outdoor noise taken near freeways [21], a P_{eq} of 2.77 million was computed, which is in agreement with the value computed in Table 4-12.

Predictions of P_{eq} associated with the freeway traffic noise reductions presented in Tables 4-10 and 4-11 are computed following the methodology just discussed, with the following modification of Equation 4-10:

$$L_{dn}^{i} - \delta = 30 - 30 \log d_i', \tag{4-12}$$

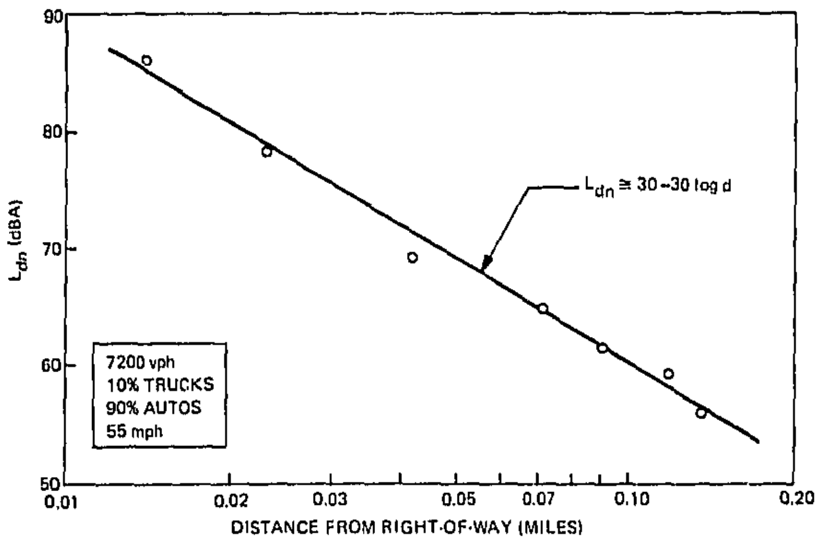

Figure 4-2. Noise Environment Adjacent to Urban Freeway.

where δ represents the reduction in the average passby noise levels in freeway traffic of interest and d_i' is the distance from the freeway where the level $L_{dn}^{i} - \delta$ occurs. The predicted values of P_{eq} for freeway traffic are presented in Tables 4-13 and 4-14 for each of the regulatory options for new trucks given in Table 4-1. The data included in Table 4-13 are derived from the noise reduction data in Table 4-10, in which it is assumed that automobiles are not treated. The results presented in Table 4-14 are derived from the noise reductions given in Table 4-11, in which the new truck regulations are assumed to be supported by noise treatment of new automobiles.

Total noise impact from urban street and freeway traffic

The total noise impact in urban areas due to urban street and freeway traffic is derived by adding the equivalent numbers of people impacted by urban street and by freeway traffic noise. Combining the data contained in Tables 4-7 and 4-12 yields the total noise impact shown in Table 4-15 for different regulatory programs on new trucks, when it is assumed that the noise emissions of other types of vehicle are not reduced.

Table 4-12
Calculation of Equivalent Number of People (In Millions)
Impacted by Freeway Noise

L_{dn}^{i}	$d_i' = 10^{\frac{30-\delta-L_{dn}^{i}}{30}}$ (miles)[1]	$\Delta d_i'$	Population Exposed to Levels Between L_{dn}^{i} and L_{dn}^{i+1} P_i (millions)[2]	Fractional Impact to Mid-Level FI_i	Equivalent Number of People Impacted FI_iP_i
55	0.147	0.047	1.88	0.125	0.24
60	0.100	0.032	1.28	0.375	0.48
65	0.068	0.022	0.88	0.625	0.55
70	0.046	0.014	0.56	0.875	0.49
75	0.032	0.010	0.40	1.125	0.45
80	0.022	0.007	0.28	1.375	0.38
85	0.015	0.002	0.08	1.625	0.13
90	0.013	–	–	–	–

$P_{eq} = 2.72$

[1]Stop d_i' at 70 ft = 0.013 mi.
[2]$P_c = \Delta d_i'$ (8000 mi of freeway) $\times$ 2 sides $\times$ (5000 people/mi^2) $\times$ 0.5 = 40 $\times$ 10^6 Δd_i.

Table 4-13
Equivalent Number of People Impacted (P_{eq}) by Freeway
Traffic Noise – Without Reductions in Noise from Automobiles

Regulatory Option	P_{eq} – Millions Calendar Year 1978	1982	1984	1986	1991	2001
A	2.56	2.40	2.32	2.29	2.21	2.19
B	2.56	2.40	2.32	2.29	2.21	2.19
C	2.56	2.40	2.32	2.29	2.23	2.21
D	2.56	2.40	2.35	2.30	2.23	2.21
E	2.56	2.40	2.32	2.29	2.25	2.23
F	2.56	2.40	2.35	2.30	2.25	2.23
G	2.56	2.40	2.35	2.30	2.29	2.25
H	2.56	2.56	2.56	2.56	2.56	2.56
I	2.56	2.40	2.35	2.30	2.23	2.19
J	2.56	2.40	2.35	2.30	2.23	2.19
K	2.56	2.40	2.32	2.29	2.21	2.19
L	2.56	2.40	2.32	2.29	2.21	2.19
M	2.56	2.40	2.32	2.29	2.21	2.19
N	2.56	2.40	2.32	2.29	2.21	2.19

Table 4-14
Equivalent Number of People Impacted (P_{eq}) by Freeway
Traffic Noise -- With a 4 dBA Reduction in Noise from Automobiles

Regulatory Option	P_{eq} -- Millions Calendar Year					
	1978	1982	1984	1986	1991	2001
A	2.49	2.10	1.86	1.73	1.65	1.62
B	2.49	2.10	1.86	1.75	1.65	1.62
C	2.49	2.10	1.86	1.73	1.66	1.65
D	2.49	2.10	1.92	1.75	1.68	1.65
E	2.49	2.10	1.86	1.75	1.68	1.65
F	2.49	2.10	1.92	1.75	1.68	1.65
G	2.49	2.10	1.92	1.79	1.73	1.71
H	2.49	2.25	2.17	2.08	2.08	2.08
I	2.49	2.10	1.92	1.75	1.66	1.62
J	2.49	2.10	1.92	1.79	1.66	1.62
K	2.49	2.10	1.86	1.73	1.65	1.62
L	2.49	2.10	1.86	1.73	1.65	1.62
M	2.49	2.10	1.86	1.73	1.65	1.62
N	2.49	2.10	1.86	1.73	1.65	1.62

Assuming that the noise emissions from vehicles other than medium and heavy trucks are reduced by 4 dBA, the total noise impact due to both urban street and freeway traffic is obtained by summing the data in Tables 4-8 and 4-14 to yield the results shown in Table 4-16. The percent reductions in the P_{eq} for existing urban traffic (37.3 million) in Tables 4-15 and 4-16 are given in Tables 4-17 and 4-18, respectively. For a graphic comparison, the results in Tables 4-17 and 4-18 are plotted in Figures 4-3 and 4-44. For the calendar years 1984, 1986, 1991, and 2001, the total population in urban areas exposed to different outdoor traffic noise levels is given for each option in Figures 4-5 through 4-8.

Increasing the lead time by 2 years (regulatory option A to B, or E to F) produces losses in benefits of approximately 1 to 2 percent in 1991. Larger increases in lead times (regulatory options A to I) produce higher losses in benefits of 2.9 to 4.5 percent in 1991. Dropping the 75-dBA regulation (regulatory option A to E) shows losses of 6.1 to 8.8 percent in 1991. Relaxing the 75-dBA regulation to 78 dBA (regulatory option A to C) produces about half these losses (2.9 to 4.0 percent) in 1991. The relaxation of the 75-dBA regulation to 78 dBA yields losses similar to the losses associated with the longer lead times in option I. Dropping the 80-dBA regulation (regulatory option E to G) results in losses of 6.7 to 9.9 percent in 1991, which are slightly higher than the losses associated with dropping

Table 4-15
Total Equivalent Number of People Impacted (P_{eq}) by Urban Traffic Noise
(Urban Street or Freeway) – Without Reductions in Noise from Nontruck Vehicles

Regulatory Option	P_{eq} – Millions Calendar Year					
	1978	1982	1984	1986	1991	2001
A	34.0	31.7	29.9	27.9	25.5	24.2
B	34.0	31.7	29.9	28.7	25.7	24.2
C	34.0	31.7	29.9	28.3	26.6	25.7
D	34.0	31.7	30.8	29.1	26.6	25.7
E	34.0	31.7	29.9	28.7	27.4	27.0
F	34.0	31.7	30.8	29.6	27.8	27.0
G	34.0	31.7	30.8	30.7	29.9	29.8
H	34.0	34.0	34.0	34.0	34.0	34.0
I	34.0	31.7	30.8	29.6	26.6	24.2
J	34.0	31.7	30.8	30.7	26.6	24.7
K	34.0	31.7	29.9	28.3	25.7	24.7
L	34.0	31.7	29.9	28.3	25.7	24.7
M	34.0	31.7	29.9	28.3	25.7	24.7
N	34.0	31.7	29.9	28.3	25.7	24.7

the 75-dBA regulation. Eliminating the 80-dBA regulation in regulatory option C to produce option D results in small losses in benefits (0.0 percent to 0.5 percent) in 1991. Total losses for regulatory option D relative to option A are 2.9 to 4.5 percent in 1991. Eliminating the 80-dBA regulation in regulatory option B to produce option J results in losses of 2.4 to 3.2 percent in 1991. These losses are larger than the losses associated with the elimination of the 80-dBA regulation from option C.

Because medium gasoline trucks are regulated at 75 dBA in 1983 in regulatory options K, L, M and N and they comprise a majority of the medium and heavy truck population in low speed traffic, the benefits for these options are nearly the same as the benefits for option A. For example, losses in benefits of 0.5 to 0.8 percent occur for option K, L, M and N in 1991.

ACTIVITY INTERFERENCE BY INDIVIDUAL (SINGLE-EVENT) TRUCK PASSBY NOISE

The activity interference produced by noise from single events depends upon the type of activity in which the observer is engaged as well as the location of the observer. For

Table 4-16
Total Equivalent Number of People Impacted (P_{eq}) by Urban Traffic Noise (Urban Street or Freeway) – With a 4 dBA Reduction in Noise from Nontruck Vehicles

	P_{eq} – Millions Calendar Year					
Regulatory Option	1978	1982	1984	1986	1991	2001
A	32.2	26.1	21.6	17.1	13.6	11.5
B	32.2	26.1	21.6	18.8	13.9	11.5
C	32.2	26.1	21.6	18.0	15.1	13.6
D	32.2	26.1	22.9	19.3	15.3	13.6
E	32.2	26.1	21.6	18.8	16.7	15.7
F	32.2	26.1	22.9	19.7	16.9	15.7
G	32.2	26.1	22.9	21.2	20.4	20.1
H	32.2	29.5	26.6	25.4	25.4	25.4
I	32.2	26.1	22.9	19.7	15.3	11.8
J	32.2	26.1	22.9	21.2	15.1	12.1
K	32.2	26.1	21.6	17.4	13.9	12.2
L	32.2	26.1	21.6	17.4	13.9	12.4
M	32.2	26.1	21.6	17.4	13.9	12.2
N	32.2	26.1	21.6	17.4	13.9	12.4

purposes of this analysis, interference with activities caused by single events is assumed to occur when the noise level exceeds by 10 dBA the maximum acceptable ambient noise level for the specified activity [3]. Acceptable ambient noise levels for different indoor and outdoor activities have been identified [5]. Thus, to characterize the unacceptability of single-truck passbys, it is necessary to determine the minimum acceptable distance from truck passbys to an observer at which the truck noise levels are 10 dBA above the acceptable ambient noise level for specified activities, for both unregulated and regulated trucks.

Activity Interference Levels

Three activities are considered in this analysis: normal conversation, thought process, and sleeping. Acceptable ambient noise levels for these activities, both indoors and outdoors, are shown in Table 4-19. For activities indoors, noise attenuation due to transmission through exterior structures is considered for both opened and closed windows. With windows closed, an attenuation of 25 dBA is assumed, and with windows open, an attenuation of 15 dBA is assumed [5, 25].

Table 4-17
Percent Reduction in Total Equivalent Number of People Impacted by Urban Traffic Noise (Urban Street or Freeway) – With a 4 dBA Reduction in Noise from Nontruck Vehicles

Regulatory Option	Calendar Year 1978	1982	1984	1986	1991	2001
A	8.8%	15.0%	19.8%	25.2%	31.6%	35.1%
B	8.8	15.0	19.8	23.0	31.1	35.1
C	8.8	15.0	19.8	24.1	28.7	31.1
D	8.8	15.0	17.4	22.0	28.7	31.1
E	8.8	15.0	19.8	23.0	26.5	27.6
F	8.8	15.0	17.4	20.6	25.5	27.6
G	8.8	15.0	17.4	17.7	19.8	21.1
H	8.8	8.8	8.8	8.8	8.8	8.8
I	8.8	15.0	17.4	20.6	28.7	35.1
J	8.8	15.0	17.4	17.7	28.7	33.8
K	8.8	15.0	19.8	24.1	31.1	33.8
L	8.8	15.0	19.8	24.1	31.1	33.8
M	8.8	15.0	19.8	24.1	31.1	33.8
N	8.8	15.0	19.8	24.1	31.1	33.8

Maximum Activity-Interference Distances

In this context, Maximum Activity-Interference Distance is the distance between a truck producing noise and an observer, when the truck passby produces a noise level at the observer that is 10 dBA in excess of the acceptable levels for various outdoor or indoor activities specified in Reference 5. By assuming that the noise level from an individual truck decreases 6 dBA with each doubling of distance, the maximum activity-interference distance (d_m) is computed from the following equation:

$$L_i - 20 \log \frac{d_m}{50} = L_n + N_a + 10\text{dBA} = L_c \qquad (4\text{-}13)$$

where L_i is the truck passby noise level at 50 ft, L_n is the acceptable noise level given in Table 4-19, N_a is the noise attenuation for indoor situations and L_c is the activity-interference level.

Activity-interference distances from truck passbys are determined only at low speeds (urban street). The differences in the noise levels for unregulated and regulated trucks at high speeds are small enough that little differences in activity-interference distances are expected for trucks in freeway traffic.

Table 4-18
Percent Reduction in Total Equivalent Number of People Impacted by Urban Traffic Noise (Urban Street or Freeway) – With a 4 dBA Reduction in Noise From Nontruck Vehicles

Regulatory Option	Calendar Year					
	1978	1982	1984	1986	1991	2001
A	13.7%	30.0%	42.1%	54.2%	63.5%	69.2%
B	13.7	30.0	42.1	49.6	62.7	69.2
C	13.7	30.0	42.1	51.7	59.5	63.5
D	13.7	30.0	38.6	48.2	59.0	63.5
E	13.7	30.0	42.1	49.6	55.2	57.9
F	13.7	30.0	38.6	47.2	54.7	57.9
G	13.7	30.0	38.6	43.2	45.3	46.1
H	13.7	20.9	28.7	31.9	31.9	31.9
I	13.7	30.0	38.6	47.2	59.0	68.4
J	13.7	30.0	38.6	43.2	59.5	67.6
K	13.7	30.0	42.1	53.4	62.7	67.3
L	13.7	30.0	42.1	53.4	62.7	66.8
M	13.7	30.0	42.1	53.4	62.7	67.3
N	13.7	30.0	42.1	53.4	62.7	66.8

Table 4-20 shows the median passby noise levels for low speed trucks. For existing trucks and trucks subject to the Interstate Motor Carrier regulations, the median levels given in Table 4-2 are weighted according to the truck population of 1 percent heavy and 6 percent medium trucks. For trucks subject to not-to-exceed new truck regulatory levels of 83, 80, 78, and 75 dBA, the median passby levels for accelerating trucks are used in computing the levels given in Table 4-20. That is, the engine-related noise levels are assumed to be 4.5 dBA below the regulatory levels. The 4.5 dBA difference includes 2.5 dBA for designing below regulatory levels, 1.0 dBA for differences in test and typical acceleration conditions and 1.0 dBA for differences in test and typical roadside sites. The median truck passby levels shown in Table 4-20 are derived by adding a 66-dBA tire noise level to the engine-related noise. The level used for the 83-dBA trucks is the weighted average of the levels derived for accelerating heavy and medium trucks. Predictions of the 10, 1, and 0.1 percentiles for truck passby levels are computed from the median levels by assuming that the levels have a Gaussian distribution with a standard deviation of 1.5 dBA. A standard deviation of 1.5 dBA for accelerating trucks is selected so that the difference in the median roadside level and regulatory level is equal to three standard deviations.

Using the passby truck noise levels contained in Table 4-20 and the acceptable activity-interference levels contained in Table 4-19, the maximum activity-interference distances for

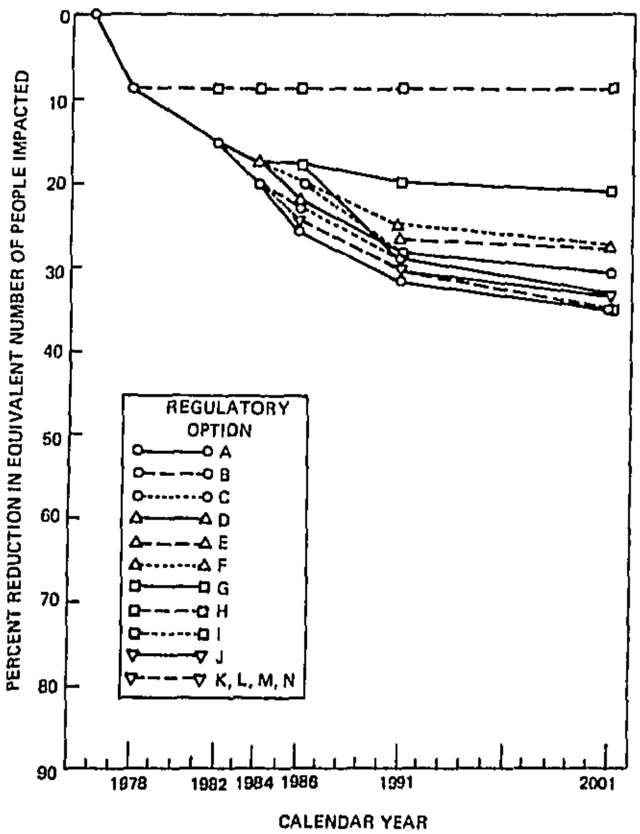

Figure 4-3. Percent Reduction in Total Equivalent Number of People Impacted by Urban Traffic Noise (Urban Street or Freeway) – Without Reductions in Noise from Nontruck Vehicles

the eight situations are computed using Equation 4-12. Figures 4-9 through 4-14 present the largest distances over which disruption of activities occurs. Because homes are assumed to be situated at least 70 ft from the centerline of the truck passby, data depicted in Figures 4-9 through 4-14 are truncated at 70 ft.

Observation of the results in Figures 4-9 through 4-14 indicates that the distances requisite to preclude activity-interference should be reduced almost in half by the

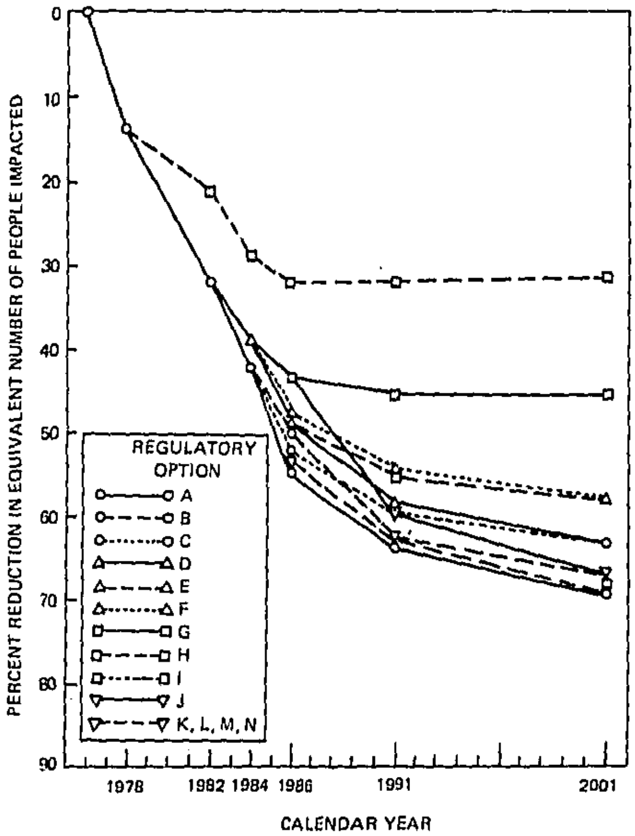

Figure 4-4. Percent Reduction in Total Equivalent Number of People Impacted by Urban Traffic Noise (Urban Street or Freeway) – With a 4 dBA Reduction in Noise from Nontruck Vehicles

Interstate Motor Carrier Regulations. The changes in the distances with reductions in the new truck regulatory levels diminish for levels 80 dBA and below. Results for trucks at high speed and cruising trucks at low speeds will show smaller differences in the maximum distances for new trucks regulated at levels below 83 dBA.

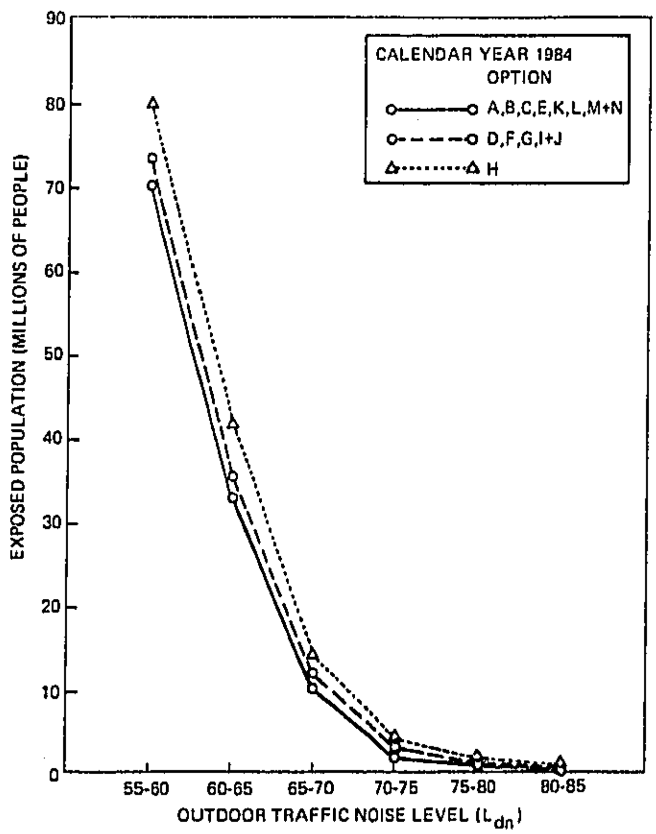

Figure 4-5. Urban Population vs Outdoor Traffic Noise Level in 1984

IN-CAB NOISE

Reductions in exterior truck noise are expected to produce reductions in the noise inside the truck cab. These expected reductions in in-cab noise should reduce the threat to operator hearing damage and should decrease disruption of

- Speech communication
- Reception of warning signals
- Listening to music or a radio.

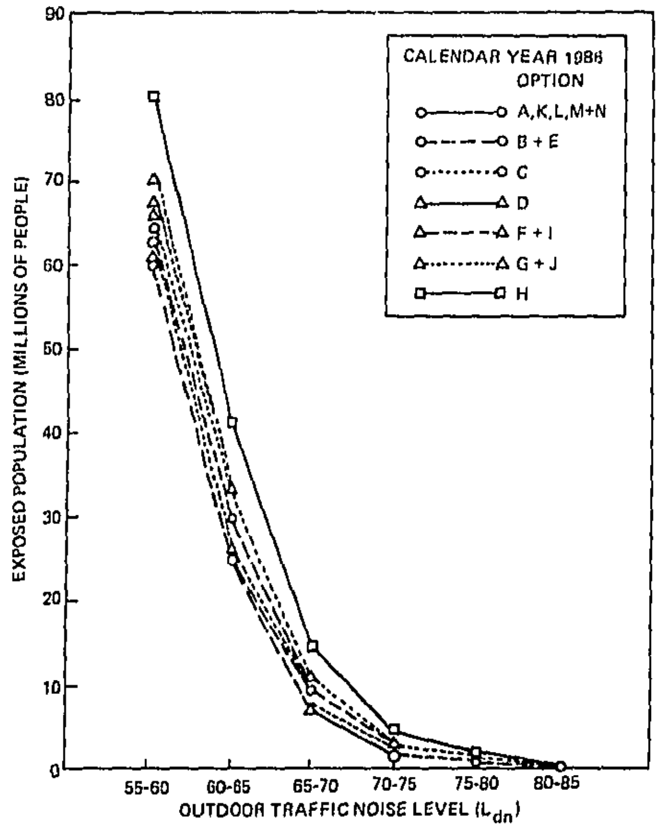

Figure 4-6. Urban Population vs Outdoor Traffic Noise Level in 1986

In addition, reductions in the noise in the cabs of new trucks will decrease the effort required to comply with Bureau of Motor Carrier Safety noise exposure regulations.

Existing In-Cab Noise Levels

The equivalent noise levels estimated using measured data taken near the operator's right ear in three heavy diesel trucks with the windows closed under normal operating conditions [9] are 84, 88, and 86 dBA over periods of about 9, 7, and 11 hours, respectively.

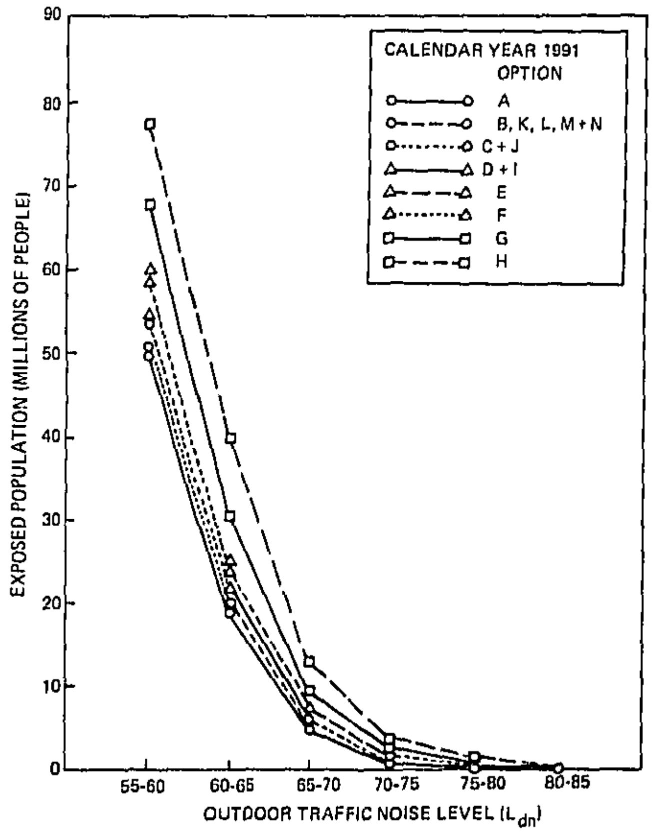

Figure 4-7. Urban Population vs Outdoor Traffic Noise Level in 1991

In-cab noise levels for gasoline trucks are expected to be lower by approximately 5 dBA or more. These data indicate that levels inside most medium and heavy trucks will probably be higher than the level of $L_{eq(8)}$ = 75 dBA identified by EPA as requisite to protect hearing [3].

In-Cab Noise for Quieted Trucks

With the following relations, it would be possible to estimate the average interior noise levels under normal operating conditions for quieted trucks with known SAE J366b exterior noise levels.

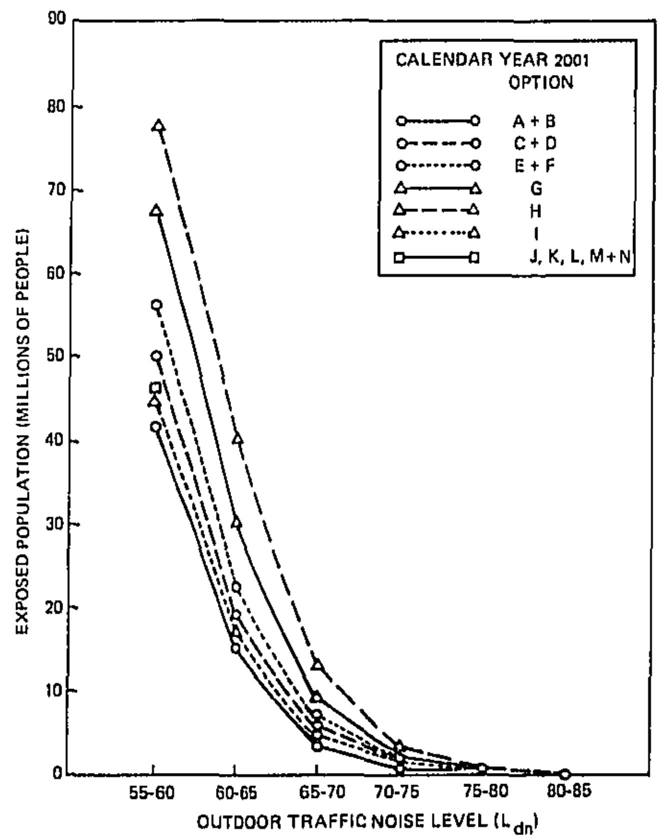

Figure 4-8. Urban Population vs Outdoor Traffic Noise Level in 2001

- Relation between exterior noise levels measured in accordance with the SAE J366b test procedure and interior noise levels observed during tests.

- Relation between interior noise levels observed under SAE J366b test conditions and levels under normal operating conditions.

SAE J366b exterior and interior levels

Data taken concerning exterior and interior noise levels for heavy trucks operated in accordance with the SAE J366b test procedure are plotted in Figure 4-15. Most of the data

Table 4-19
Noise Levels from Individual Truck Passbys That Interfere With Activities

Situation	Acceptable Outdoor Ambient Noise Level (L_n)	Noise Reduction (N_a)	Annoyance Criteria	Individual Truck Passby Noise Levels That Interfere With Activities at 50 Ft (L_c)
Normal conversation Indoors – windows closed	60 dBA	25 dBA	10 dBA	95 dBA
Normal conversation Indoors – windows open	60 dBA	15 dBA	10 dBA	85 dBA
Thought process Indoors – windows closed	45 dBA	25 dBA	10 dBA	80 dBA
Thought process Indoors – windows open	45 dBA	15 dBA	10 dBA	70 dBA
Sleeping Indoors – windows closed	40 dBA	25 dBA	10 dBA	75 dBA
Sleeping Indoors – windows open	40 dBA	15 dBA	10 dBA	65 dBA
Normal conversation Outdoors	60 dBA	0 dBA	10 dBA	70 dBA
Thought process Outdoors	51 dBA	0 dBA	10 dBA	61 dBA

Table 4-20
Percentile Noise Levels for Individual Truck Passbys

Truck Type	Percentile Passby Noise Levels				σ
	L_{50}	L_{10}	L_1	$L_{0.1}$	
Existing trucks	83.5 dBA	88.2 dBA	91.8 dBA	94.9 dBA	3.7 dBA
Interstate motor carrier trucks	78.2 dBA	82.0 dBA	84.9 dBA	87.5 dBA	3.0 dBA
83 dBA regulated trucks	77.2 dBA	79.1 dBA	80.5 dBA	81.8 dBA	1.5 dBA
80 dBA regulated trucks	76.0 dBA	77.9 dBA	79.3 dBA	80.6 dBA	1.5 dBA
78 dBA regulated trucks	74.2 dBA	76.1 dBA	77.5 dBA	78.8 dBA	1.5 dBA
75 dBA regulated trucks	71.8 dBA	73.7 dBA	75.1 dBA	76.4 dBA	1.5 dBA

in Figure 4-15 are for existing unquieted trucks [9] and show little correlation between exterior and interior levels. Only three of the data points in Figure 4-15 are for quieted trucks. The reduction in the exterior noise levels for the Freightliner DOT Quiet Truck from 88 to 75 dBA was accompanied by a reduction in the interior noise level from 93 to 74 dBA [26].

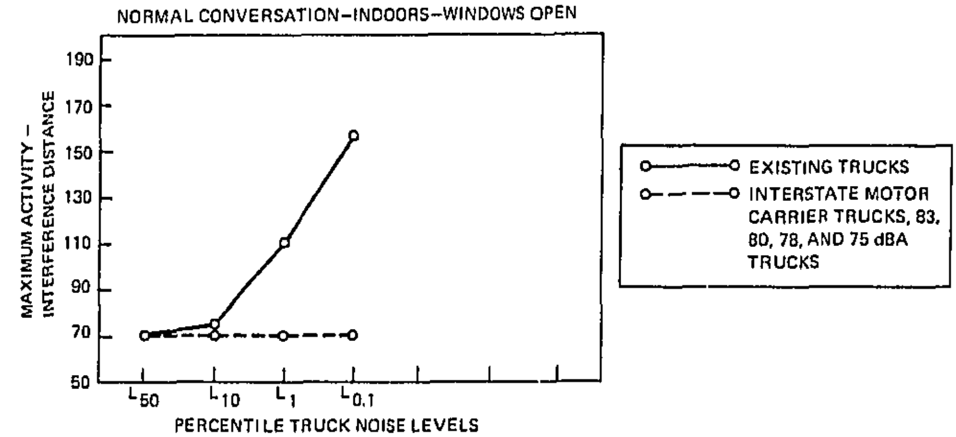

Figure 4-9. Maximum Activity-Interference Distances for Normal Conversation Indoors With Windows Closed

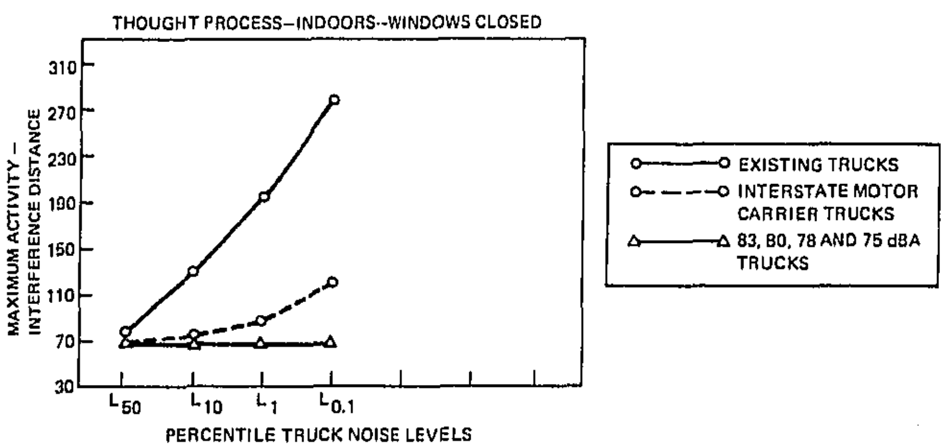

Figure 4-10. Maximum Activity-Interference Distances for Thought Process Indoors With Windows Closed

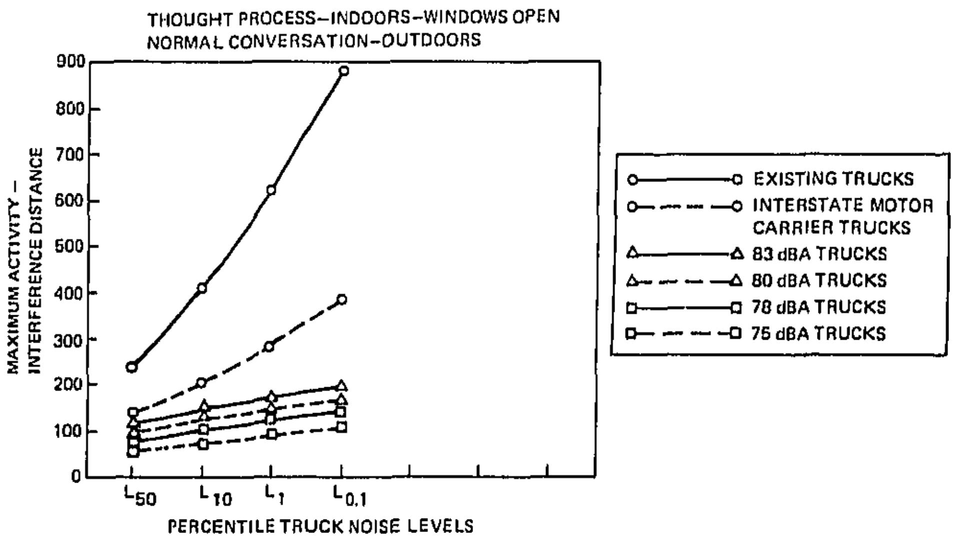

Figure 4-11. Maximum Activity-Interference Distances for Thought Process Indoors With Windows Open and Normal Conversation Outdoors

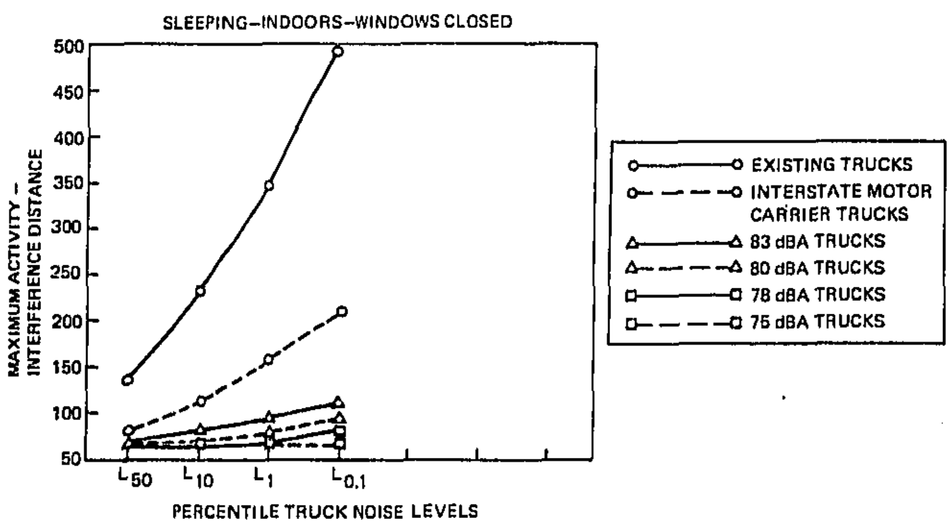

Figure 4-12. Maximum Activity-Interference Distances for Sleeping Indoors With Windows Closed

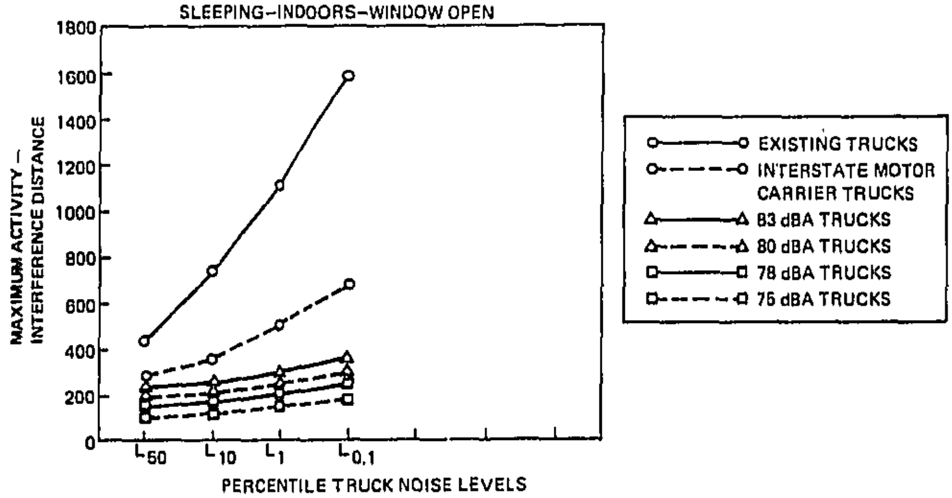

Figure 4-13. Maximum Activity-Interference Distances for Sleeping Indoors With Windows Open

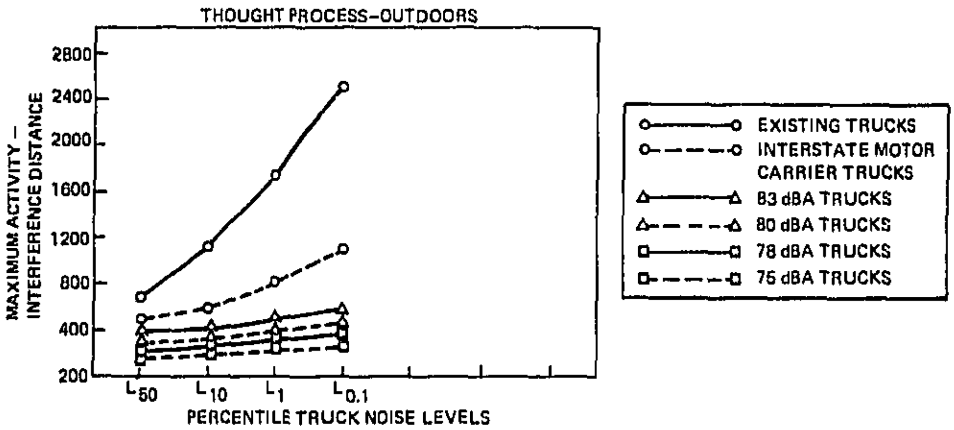

Figure 4-14. Maximum Activity-Interference Distances for Thought Process Outdoors

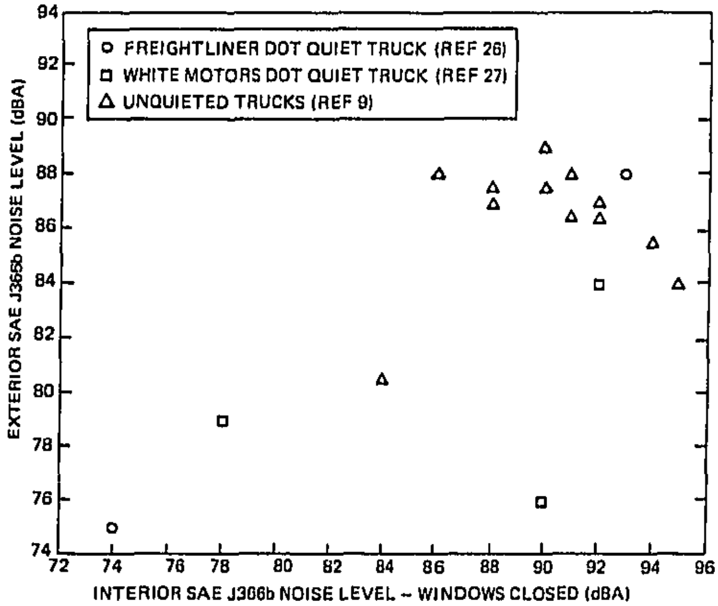

Figure 4-15. Exterior and Interior Noise Levels Observed Under SAE J366b Test Conditions

On the White Motors DOT Quiet Truck, the reduction in exterior noise from 84 to 79 dBA produced a reduction in interior noise from 92 to 78 dBA [27]. However, a further reduction in exterior noise from 79 to 76 dBA resulted in an increase in the interior noise level from 78 to 90 dBA [27]. Therefore, data from the DOT Quiet Truck Program does not show a good correlation between exterior and interior noise levels.

Interior SAE J366b levels and levels for normal operating conditions

On the average, the interior levels under SAE J366b test conditions were found to be approximately 1 dBA higher than the interior levels observed with the engine at maximum speed (high idle) and the truck stationary [9]. On three heavy diesel trucks, the interior level at high idle was approximately 4 dBA higher than the average level observed under normal operating conditions [9]. These limited amounts of data indicate that the interior level under SAE J366b test conditions is approximately 5 dBA higher than the average in-cab noise level under normal operating conditions. Applying this 5-dBA factor to the three interior noise levels given in Figure 4-15 for the quieted trucks shows that in two cases the average interior levels under typical operating conditions would probably be less than 75 dBA.

In-Cab Noise Levels for Regulated Trucks

The paucity of data from which relations between exterior and interior noise levels can be drawn prevents reliable estimates of the in-cab noise levels for medium and heavy trucks complying with the EPA regulations. However, the data indicates that some reductions will result from decreases in exterior noise.

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Section 5
TECHNOLOGY

COMPONENT NOISE CONTROL

The most significant of the truck components contributing to total truck noise levels at low speeds are the engine, fan, intake, and exhaust. The relative importance of each of these sources varies according to the truck model and type of truck operation. This section describes noise abatement techniques for reducing the component source levels.

Engine

Internal combustion engines convert the chemical energy of fuel to mechanical energy through the controlled combustion of fuels in a cylinder. The motion of engine components and the sudden increase in cylinder pressure occurring during combustion excites the engine structure, causing vibration of the external surfaces and attendant sound radiation. The magnitude of the radiated noise depends more on engine type and design than on engine size or power [11].

Gasoline-fueled engines tend to be quieter than diesel-fueled engines. The reason is that in present production diesel engines, the combustion forces are greater especially in the mid to high frequencies where resonant structural modes are present in the engine.

Possible noise control treatments include modifications to the engine and modifications to control the path of engine structural noise radiating to the exterior. The choice of methods depends on the degree of noise reduction required, cost, lead time, and any associated penalties in performance.

Reduction of combustion-related noise is particularly desirable for diesel engines. However, reducing this noise by reducing combustion power would also entail a reduction in engine output power. An alternative approach is to smooth out the rapid rise in pressure [1]. One method is to control the fuel delivery rate, but with present production tolerances in the injection system this would be difficult. Another method is to use a turbocharger on 4-stroke diesel engines. Turbocharging increases peak cylinder pressures while decreasing the rate of pressure rise. Still another technique is to redesign the combustion

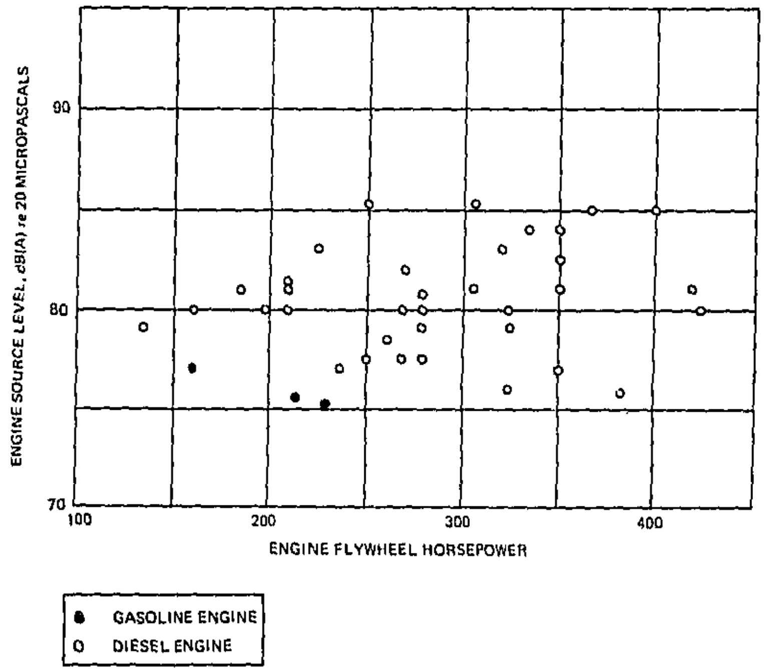

Figure 5-1. Engine Noise as a Function of Horsepower

chamber and injector spray pattern [2]. At present, all these solutions are being tested by the major engine manufacturers. One major manufacturer is phasing out of production all naturally aspirated engines and replacing them with turbocharged models.

Control of machinery-related forces (e.g., oscillating pistons slapping the cylinder walls [3]) in present engines is aimed primarily at changing or reducing the structural response of the engine. Investigators are experimenting with better ways to support the piston in the cylinder and are trying to obtain better balance and closer tolerances in production engines. This technique (in combination with turbocharging) was used by one manufacturer to reduce the overall noise of a diesel-powered truck to 75 dBA.

Several engine manufacturers are presently marketing engine quieting kits that attenuate engine structural noise by altering its transmission path. Depending on the particular quieting kit and truck configuration, engine noise reduction ranges from 0 to 4 dBA, with most kits providing about a 2 to 3 dBA reduction. The kits generally consist of covers for the sides of the engine block and oil pan, vibration isolation of the valve covers or air-intake manifolds and crossovers, and possibly, damping treatment on sheet metal covers [4]. Thien [5] reports that a close-fitting enclosure extending over the entire engine structure provided about 15 to 20 dBA reduction in engine noise. Discussions with one major engine manufacturer indicated that such enclosures could reduce the overall truck noise by 10 to 15 dBA. However, the engine manufacturers also indicated that these enclosures are not presently acceptable for production utilization because problems with cooling and service access have yet to be resolved.

To obtain the lowest possible overall truck noise level, most engine manufacturers appear to prefer an enclosure built into the truck cab rather than fitted onto the engine. Under DOT contracts, three truck manufacturers (International Harvester, White and Freightliner) have investigated enclosure designs for cab-over engine trucks. The enclosures involved a tunnel configuration with the cooling fan at the enclosure entrance. Air flows through the enclosure and around the engine, exiting through openings in the rear of the enclosure. The partial engine enclosure reduced engine noise on the Freightliner truck by 10.5 dBA [8]. On the International Harvester truck, the partial enclosure reduced engine noise by 7 dBA. The difference between the reductions for the enclosures used on the Freightliner and International Harvester trucks may be partly attributed to the use of thicker layers of absorption material on the Freightliner enclosure. The use of a partial enclosure allowed an overall noise reduction for the White Motors truck of over 10 dBA [6].

Fan

Truck cooling fans have been designed with primary emphasis on purchase price rather than on aerodynamic efficiency or noise abatement. Accordingly, most fans have been made of stamped sheet metal blades riveted to a hub that is turned by means of a belt and pulley arrangement connected to the engine. The fans tend to be small and operate at high speeds leading to high noise levels, since fan noise generation is proportional to fan speed. The fan cross-section is not aerodynamically shaped, and the blade pitch angle often does not vary with radius as it should if it is to properly develop uniform flow through all portions of the radiator. In order to minimize tractor length, it appears that manufacturers tend to squeeze the fan between the engine and radiator. Under favorable conditions, the fan would move air axially; in the usually cramped engine compartment, the flow is mostly radial, with a nonuniform velocity distribution.

Noise data for various truck fans are shown in Figure 5-2 as a function of engine flywheel horsepower. The brackets on the five points in the 300 to 400 hp region designate limits of uncertainty resulting from 0.5 dBA levels of uncertainty in the measurements used to estimate the fan noise levels. Fan noise on gasoline-powered trucks tends to be nearly equal to levels on diesel-powered trucks because the greater heat rejection of the combustion process in gasoline engines is compensated for by higher surface area-to volume ratios. Neither cab type nor engine power appear to have a significant effect of diesel-powered truck fan noise.

The control of fan noise must be viewed in terms of total cooling system design. Some noise reduction can be achieved by modifying the radiator, radiator shutters, fan shroud, and fan. Radiator design is closely related to fan performance and noise. Radiators designed with low airflow requirements allow the use of slower turning and, thus, quieter fans. The amount of noise reduction achievable through modifications to the radiator depends on the initial design, but even well-designed cooling systems can often be quieted by 2 to 3 dBA through modifications to radiator design [7].

Thermostatically controlled shutters are used on many trucks to regulate air flow through the radiator. The primary purpose of the shutters is to prevent cold water from overcooling the engine. Shutters significantly influence fan noise. When the shutters are closed and air flow to the fan is substantially reduced, the fan blades stall and generate more noise.

Shrader and Page [7] report a 5 dBA increase in fan noise as a result of closed shutters. One manufacturer reported approximately a 2 to 3 dBA increase in total truck noise when shutters were closed. Several manufacturers feel that shutters could be replaced by thermostats and bypass tubing.

The fan shroud, which ducts air from the radiator to the fan, is important in maximizing fan effectiveness and preventing recirculation of hot air back through the radiator. Shrouds that do not channel this air smoothly into the fan can lead to stalled blade tips with an attendant increase in noise. Shrader and Page [7] claim that improved shroud designs can produce a 3 to 5 dBA reduction in fan noise levels.

The fan itself can often be changed to reduce noise. One of the most effective changes is to increase fan diameter and decrease fan speed. A 2- to 3-inch increase in fan diameter typically allows a 3 to 5 dBA reduction in noise for a constant volume flow rate. The extent that the fan diameter may be increased is limited by the configuration of the radiator and essential structural members of the truck.

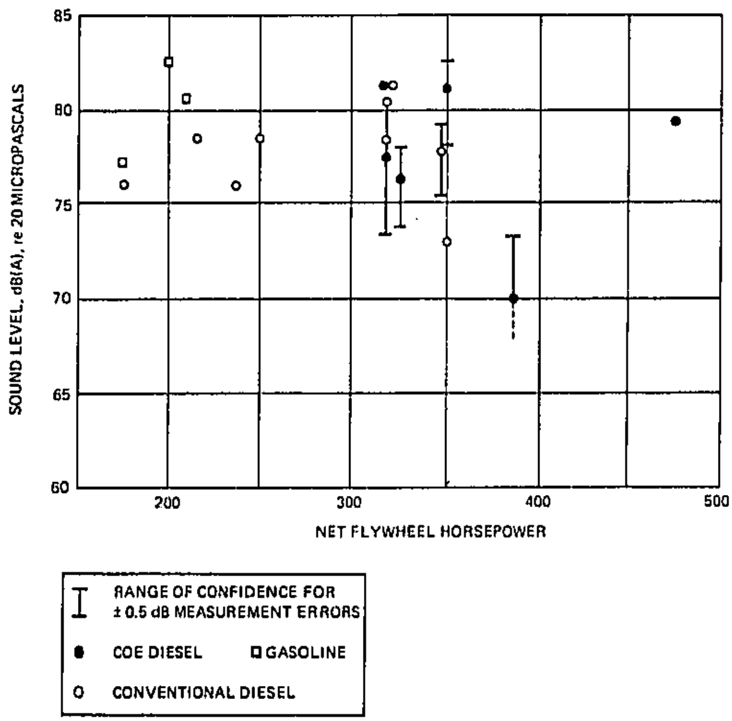

Figure 5-2. Truck Fan Noise Levels as a Function of Engine Horsepower

The Cab Over Engine (COE) tractor is particularly suitable for a large, slow fan. Because of the large, blunt front on the COE, the forward motion of the truck tends to develop a high pressure rise in front of the radiator that supplements the flow created by the fan. With this type of cab and a large radiator with a frontal area of 2,000 square inches, Freightliner was able to use a 31-inch fan to reduce the fan noise level by 14 dBA [8]. The fan (thermostatically controlled) operates for about 1 percent of the time. For the remainder of the time, the forward motion of the truck is able to force sufficient cooling air through the radiator. On the White Motors truck, fan noise was reduced by 6 to 8 dBA by replacing the original 28-inch fan with a 30-inch fan of better design [6]. International Harvester reported changes in a noise level of 3 dBA by using fans of the same size but of different design [7].

The data in Figure 5.2 indicates that many fans generate less than 80 dBA. Those that are noisier can be replaced by a slightly different fan model and fan/engine speed ratio. Reduction of fan noise of 74 dBA should be possible with the use of better radiator, fan, and shroud designs without increasing fan or radiator size. Levels can be reduced to 64 dBA with larger radiator cores, larger and slower fans, careful design of fan shrouds, and a thermostatically controlled fan clutch that is phased with a shutter thermostat to prevent fan operation while the shutters are closed.

The Department of Transportation (DOT), during its Quiet Truck Program, has investigated many cases of thermostatically controlled radiator fan clutch systems. These systems require the fan to operate only when the extra cooling is needed; the fan does not operate when sufficient ram-air is provided by the forward motion of the truck, or if the truck engine is not heavily loaded.

Data shown in Appendix I demonstrates the time that the fan actually does operate. It shows that, for the on-off units, the annual average total fan-on time is less than 3 percent. For both types of clutches the annual average *significant* time on (from a noise point of view) is below 1 percent.

Intake

Air intake systems supply truck engines with the continuous flow of clear air needed for fuel combustion. These systems can range in size and complexity from a simple air filter mounted on top of a carburetor to an external air filter with ducts leading to the engine and a cab mounted snorkel unit. Noise is generated by an unsteady flow of air into engine cylinders. Supercharged engines with Rootes blowers also exhibit tones associated with the lobe-passage frequency of the blowers. Turbochargers tend to smooth flow irregularities associated with cylinder charging.

The majority of air intake systems have noise levels less than 72 dBA with a few as low as 57 dBA [9]. It is expected that few trucks will require air intake system treatment to comply with not-to-exceed regulatory levels of 83 or 80 dBA. To comply with a 78 or 75 dBA regulatory level, it may be necessary to add an air intake silencer. A 6 dBA reduction in air intake noise was reported by International Harvester for an air intake silencer [10].

Exhaust

Exhaust outlet noise emanates from the exhaust system terminus and is generated by the pressure pulses of exhaust gases from the engine. Shell-related exhaust noise consists of radiation from the external surfaces of the pipes and mufflers of the exhaust system. It is generated by two mechanisms, the transmission and subsequent radiation of engine vibration to the exhaust system and the transmission of internal sound to the exterior of the pipe.

Hunt et al. [14] found that the source levels of unmuffled outlet noise for diesel engines can range from 82 to 105 dBA at 50 feet, with the levels from 2-stroke diesel engines about 10 dBA higher than the levels for 4-stroke diesel engines. The exhaust noise levels for present exhaust systems given in Table 5-1 are derived from data presented by Hunt et al.

Table 5-1
Exhaust Noise Levels for Present Exhaust Systems

Diesel Engine	Average Level	Lowest Level
Naturally aspirated, 4-stroke	79.4 dBA	71 dBA
Turbocharged, 4-stroke	80.2 dBA	70 dBA
Naturally aspirated, 2-stroke	84.0 dBA	77 dBA
Turbocharged, 2-stroke	82.5 dBA	76 dBA

[13] and Donnelly et al. [9]. For 4-stroke diesel engines, exhaust systems are available which reduce exhaust noise to below 73 dBA. The exhaust systems with the lowest noise levels are not always the most costly [14]. For 2-stroke diesel engines, the present exhaust system noise levels are 2 to 5 dBA higher on the average than for 4-stroke diesel engines. All of the levels reported by Hunt and Donnelly for 2-stroke diesel engines are above 75 dBA.

Since exhaust gases pass through turbochargers, some additional attenuation of exhaust noise is expected. Attenuation on the order of 5 to 10 dBA have been reported. The data in Table 5-1 indicate that present exhaust systems on 4-stroke diesel engines do not take advantage of the additional attenuation provided by turbochargers.

Almost all of the noise control efforts in the trucking industry have centered on the diesel truck. Consequently, little information is available on exhaust source levels for gasoline trucks. Muffled exhaust noise levels of about 80 dBA have been measured on present gasoline trucks. This is similar to the present muffled levels for 4-stroke diesel engines (See Table 5-1). It is expected that the exhaust treatments required to bring gasoline trucks into compliance with noise emissions regulations will be similar to treatments required for the 4-stroke diesel engines.

Noise control techniques for exhaust noise consist of muffling exhaust outlet noise, sealing exhaust leaks, and using double-wall construction on pipes and mufflers to reduce exhaust shell noise. Exhaust systems with high backpressure will increase the work the engine must expend for pushing exhaust gases out of the exhaust port resulting in the degradation of overall engine performance. A comparison of the backpressure developed by several muffler systems shows that some quiet systems have the same backpressure as noisier ones. There are systems available, therefore, that have low muffled exhaust noise levels that do not degrade engine preformance.

In the DOT Quiet Truck Program, several exhaust system noise treatments proved effective in reducing exhaust outlet and shell noise. The use of stack silencers and larger mufflers reduced the exhaust outlet on the Freightliner DOT Quiet Truck from 82 dBA to 70 dBA [12]. Sealing exhaust leaks reduced exhaust shell noise from 75 dBA to 71 dBA [8]. The manifold muffler used had an insertion loss of approximately 7 dBA.

The use of larger wrapped mufflers on the International Harvester DOT Quiet Truck reduced the exhaust noise from 83 dBA to 72.5 dBA [10]. The International Harvester truck was the only truck in the DOT Quiet Truck Program to have a 2-stroke diesel engine producing, in general, more exhaust noise than the 4-stroke diesel engines. Most of the exhaust noise from the quieted exhaust system on the International Harvester truck was the exhaust shell noise which was not reduced below 72 dBA. The use of double wall piping (where the two walls were in contact with each other) was found to be ineffective by International Harveste in reducing shell noise. Isolating the walls from each other would probably improve the reduction of pipe shell noise.

On the White Motors DOT Quiet Truck, the exhaust noise was reduced from 76 dBA to 67 dBA with a larger muffler [6]. Stack silencers and exhaust resonators were found to be ineffective on the White Motors truck.

TOTAL TRUCK NOISE CONTROL

The component noise control measures described may be combined in a variety of ways to meet specified limits for overall truck noise. In general, the noise control strategy is determined by the source level of the noisiest and most difficult-to-control component, usually the engine. Gasoline and diesel trucks are discussed separately because of the difference in their engine source levels.

The combinations of source levels suggested for achieving specified overall truck levels are intended to be representative of practical examples. In some cases, a manufacturer may prefer to have one source level higher and another lower than suggested. As required in the new truck noise emission regulations, in order that the noise emission levels from most trucks of a single configuration are below the regulatory level, component levels are selected so that the median overall truck noise level will be at least 2 to 3 dBA below the regulatory level.

83 dBA Regulatory Level

Present production medium and heavy diesel trucks display the following ranges of measured source levels (in dBA) under prescribed test conditions:

Engine	Fan	Exhaust
75-85	75-85	75-85

All manufacturers are currently able to reach an 86 dBA overall level with off-the-shelf hardware with apparent concentration on quieting the noisiest production trucks first. Thus, trucks having engines with source levels of 80 to 85 dBA have quieter fans and exhaust systems than trucks with quieter engines.

The source levels measured in gasoline trucks are (in dBA)

Engine	Fan	Exhaust
75-77	80-85	80

Table 5-2 shows one combination of source levels that will yield a production line truck

Table 5-2
Component Source Levels for an 83 dBA Regulatory Level

Component	Noise Level, dBA
Engine	77
Fan	73
Exhaust	73
Air intake	72
All others	70
Total	80.6

that generates an overall noise level of less than 80.6 dBA. The use of better-designed, slower turning fans with shrouds, the best mufflers presently being produced, and available engine quieting kits should be sufficient to bring all but the noisiest diesel trucks into compliance with the 83 dBA regulatory level. For the noisiest of the presently available diesel engines, noise side-shields may be required.

For gasoline trucks, modifications to the cooling fan and use of better available mufflers should be sufficient for compliance to a 83 dBA regulation. No engine treatment is needed.

80 dBA Regulatory Level

Component source levels which will bring trucks into compliance with the 80 dBA regulatory level are shown in Table 5-3. In most diesel trucks, the required noise treatment of the cooling system will include larger slower-turning fans, fan shrouds and thermostatically controlled fan clutches. On most diesel trucks advanced exhaust mufflers will be needed that are similar to those demonstrated in the DOT Quiet Truck Program but not presently being mass-produced. Engine noise side shields and an underpan should be adequate to reduce the noise from most presently available diesel engines to 74 dBA. The noisiest of the presently available diesel engines may require partial engine enclosures. However, the lead time for the 80 dBA regulation should be adequate to allow engines

Table 5-3
Component Source Levels for an 80 dBA Regulatory Level

Component	Noise Level, dBA
Engine	74
Fan	70
Exhaust	69
Air intake	69
All others	70
Total	77.5

to be quieted so that the partial enclosures will be eliminated. Side shields should be adequate to allow gasoline trucks to comply with the 80 dBA regulatory level.

Additional cooling system treatment of the fan, fan shroud and/or radiator can be used to reduce fan noise from 73 to 70 dBA for the 80 dBA regulatory level. To reduce exhaust noise to 69 dBA, longer, more advanced mufflers should be sufficient.

78 dBA Regulatory Level

In Table 5-4, the component levels suggested for a 78 dBA regulation are given. Additional engine noise treatment, such as larger side shields and underpans, can be used to reduce engine noise an additional 2 dBA from the engine noise design level used for the 80 dBA regulatory level.

Larger fans and radiators with engine-mounted shrouding should be sufficient to reach cooling system noise levels of 64 dBA or below. The same exhaust system treatments discussed under the 80 dBA regulatory level apply here. Air intake silencers can be employed to reduce air intake noise to 65 dBA or below.

75 dBA Regulatory Level

Table 5-4 shows a combination of component levels that will produce a truck which complies with a regulatory level of 75 dBA.

Table 5-4
Component Source Levels for a 78 dBA
Regulatory Level

Component	Noise Level, dBA
Engine	71
Fan	64
Exhaust	69
Air Intake	65
All Others	70
Total	75.6

Additional engine noise treatment is necessary to reduce the engine noise level given in Table 5-4 for a 78 dBA regulatory level to the level given in Table 5-5 for a 75 dBA regulatory level. Most existing diesel engines will require engine enclosures and special engine mounts to achieve engine noise levels of 68 dBA. The noisiest of the existing diesel engines will need quiet kits in addition to engine enclosures. However, modifications to diesel engines is expected to lower engine noise enough that the use of both enclosures and quiet kits will not be necessary for a 75 dBA regulation. For gasoline trucks, side shields and an underpan should be sufficient to reduce engine noise to 68 dBA or below.

Exhaust system treatments necessary to reach levels of 65 dBA or below for most trucks include manifold mufflers, advanced mufflers, muffler jackets and double-wall exhaust piping.

Silencers on the air intake should be adequate to reduce the air intake noise on diesel trucks to low enough levels so the truck can comply with the 75 dBA regulatory level. All sources other than the engine, fan, and exhaust will be 65 dBA or below with transmission noise treated by the engine enclosure. Tire noise should be below 65 dBA under test conditions and the noise from the rear axle below 60 dBA on most trucks.

Table 5-5
Component Source Levels for a 75 dBA Regulatory Level

Component	Noise Level, dBA
Engine	68
Fan	64
Exhaust	65
Air intake	65
All others	65
Total	72.6

BEST AVAILABLE TECHNOLOGY

The Noise Control Act requires that in setting noise emission standards for products distributed in commerce, the administrator take into account the level achievable through application of the "best available technology." The term "best available technology" is not defined. Based upon caselaw precedent relating to identical or similar language under other statutes, EPA believes that this term, as applied to the mass production of quiet products, refers to levels which can be achieved by application of conventional techniques and materials. Further, these levels need not be levels routinely achieved by products already on the market. At the same time, they cannot be levels EPA has arrived at by crystal ball inquiry.

Accordingly, as applied to new medium and heavy trucks, EPA believes that the level achievable through application of the best available technology is the level which it can be reliably predicted, through the exercise of sound engineering analysis, that assembly line trucks of all classes subject to the standard will be able to meet by the effective date, through application of currently known noise attenuation techniques and materials.

On this basis EPA has determined that, given a lead time of 8 years, the not-to-exceed regulatory level achievable by application of the best available technology is 75 dBA. The sources of truck noise have been isolated, and have been found to be reducible in even the noisiest trucks to levels which, when combined, will result in a truck which produces 72.9 dBA. The techniques used for reducing to these levels are commonly known, and are applicable to all classes of medium and heavy trucks. Furthermore, the noise reduction applications can be readily integrated into the assembly line process. Finally, the 2.1 dBA margin beyond the 75 dBA regulatory level is sufficient to account for the design tolerance necessary in translating to a population of mass-produced trucks.

The achievability of the 75 dBA regulatory level has been demonstrated by the DOT quiet truck program, where one manufacturer successfully built a 72 dBA truck which has been operating in regular line-haul service for over one year. This truck applies the conventional quieting techniques discussed by EPA in developing these standards, the same kinds of applications which EPA has said are transferable to the general truck population. Moreover, this experience has shown that a previously noisy truck can be quieted without impairing its performance capabilities or its utility to the user.

Engineering Information

The design of quiet trucks involves the application of established acoustical principles. The body of this type of information is large and, since truck quieting is relatively new, enough time has not yet elapsed for this reservoir of knowledge to be properly tapped. The future should bring additional quieting techniques not presently available. It is necessary, however, to confine the discussion to methods utilized today. Over the years information has been collected on mufflers, fans, and transmission of sound through barriers, which can be applied to the truck noise reduction problem. The most recent and directly applicable data was obtained in the DOT Quiet Truck Program. In this effort, quieting techniques were studied and applied to an existing model truck. Analysis of component test data show that the major noise sources in a truck (tested according to SAE-366b) can be reduced to the levels in Table 5-6. The individual sources are briefly discussed.

Table 5-6
Major Truck Noise Components

Source	Level dBA (366b Test)	Reference
Engine	65	[8]
Fan	64	[8]
Exhaust	70	[8], [10]
All Other	66	[8], [10]
Total	72.9	

Engine noise treatment

The noise level of a heavy-duty diesel engine currently in production is around 75 dBA [15] so that the technology exists to design and build diesel engines with noise levels of 75 dBA. With a 75 dBA engine, the use of a partial enclosure providing a noise reduction of 10.5 dBA [11] will give engine noise levels around 64.5 dBA. Full enclosures and two-stage engine mounts are available techniques and have been applied to reduce engine noise from 84 to 59 dBA [11]. These techniques could be used to reduce the noise levels from all other engines to levels below 65 dBA. The technology required to redesign truck cabs to accommodate engine enclosures and additional cooling for the enclosed engine is solved routinely. It involved routine engineering design, such as enlarging cab space and rearranging equipment.

Fan noise treatment

The installation of a larger, slower-turning, well-designed fan has been demonstrated to reduce fan noise from 83 to 64 dBA [11] allowing the truck to comply with the 75 dBA regulation.

Exhaust noise treatment

On a 4-stroke diesel engine, the exhaust outlet noise was reduced to 61 dBA using a manifold muffler and larger exhaust mufflers [11]. The exhaust shell noise was reduced to 68 dBA using available muffler jackets and pipe joint seals [8]. On a 2-stroke diesel engine, the outlet noise was reduced to 64.5 dBA and the shell noise to 72 dBA without wrapping the exhaust piping [12]. Wrapping the exhaust piping has been shown to reduce exhaust shell noise by more than 4 dBA [10]. Therefore, the technology has been demonstrated that will bring exhaust noise levels down to 70 dBA for both 2- and 4-stroke diesel engines. Gasoline engine exhaust noise treatment is similar to 4-stroke diesel engine exhaust treatment.

Treatment of other sources of noise

Other noise sources include tires, transmission, rear axles and air intakes. Ribbed tires, on the Freightliner DOT Quiet Truck, had a noise level below 61 dBA under test conditions [8]. The noise level from the rear axle was measured at approximately 58 dBA [8]. The treatment of noise from transmissions is included in the engine enclosures. Air intake silencers have been used to reduce air intake noise to below 63 dBA [10], [8]. Therefore, the noise from sources other than the engine, exhaust, and fan can be reduced to 66 dBA or below using demonstrated technology.

Summary

On the basis of individual source levels, the discussion indicates that a total level of 72.9 dBA or less is achievable. For a "not to exceed" standard of 75 dBA, this leaves a margin of 2.1 dBA or more, which should be adequate to account for variations in noise levels from trucks of a single configuration and measurement uncertainties.

Demonstration (The 72 dBA Truck)

The Freightliner Corporation has built a heavy diesel truck using the discussed technology and the overall noise level reduced from 88 dBA to 72 dBA [10] is low enough to comply with the 75 dBA regulatory level allowing for a tolerance of 3 dBA. This 72 dBA truck has completed 100,000 miles of linehaul service. It was employed in normal fleet operations for aperiod of 1 year. No unusual maintenance problems were observed and the noise abatement components have performed generally quite well [13]. It should also be noted that the introduction of the noise reduction hardware produced no oddities in the appearance of the truck. To the casual viewers, it appeared no different from other trucks.

Applicability of Quieting Techniques

A careful review of the Freightliner acoustical treatment indicates that all of the techniques employed on this truck are transferrable to other trucks, if appropriate routine engineering precautions are observed.

Mass Production

All of the elements involved in the noise reduction system are conventional structures. Some of the noise reduction items are:

Larger, slower-turning fans,
Fan clutches
Wrapped exhaust system piping, and
Engine enclosures.

If the truck and the production process are properly designed, trucks containing the required noise treatments should be mass-producible.

Time Allowed for Design Cycle

The shortest time interval considered for the achievement of a 75 dBA level is 8 years. The General Motors Corporation in their docket submission of April 10, 1974, included a detailed bar chart illustrating the steps in noise control development and the production cycle. The total time span of the cycle is 4 years. International Harvester has stated in their docket submission that any major redesign takes 2 and 3/4 years. On the basis of GM's and IH's statements, it is reasonable to deduce that they (and other manufacturers) would be able to meet the required level inside the 8-year time period allotted by the regulation.

A somewhat more extensive discussion of the "lead time" question is given in reference 12.

Conclusions

Perusal of the preceding text reveals the criteria presented earlier are satisfied. Therefore, it is concluded that technology is available to permit the design and mass production of trucks complying with a 75 dBA regulation inside the shortest prescribed time interval considered (i.e., 8 years).

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Section 6
COSTS OF COMPLIANCE

In complying with noise emission regulations on medium and heavy trucks, increases in cost will be accrued by the truck user in the following areas:

1. Increases in truck prices, and

2. Increases in truck operating costs

Estimates of the increases in truck prices and increases in operating costs associated with noise treatment are considered in this section.

The estimates given are estimates of the costs of compliance with not-to-exceed regulatory levels. [19] In deriving the estimates presented, estimates given in the BBN Report No. 2710 [1] and the background document for the proposed regulations [2] are revised to include the following:

1. Information made available since the publication of the BBN Report No. 2710 and the background document for the proposed regulations.

2. Costs of compliance with a 78-dBA regulatory level, that were included in some of the regulatory options considered by EPA in response to public comments on the proposed regulations.

INCREASES IN TRUCK PRICES

Table 6-1 gives the anticipated customer price increases associated with the reduction of noise levels from the engine, fan, exhaust, and air intake to levels below those given at the top of the table. The key for the noise treatments in Table 6-1 is given in Table 6-2. The estimates of price increases are given in terms of 1973 dollars and are based on cost estimates presented in the DOT Quiet Truck Program, manufacturers' estimates of the costs for similar noise treatment hardware, and, when hardware is currently in production, list prices. All of the component noise levels in Table 6-1 are design levels low enough to allow medium and heavy trucks to comply with not-to-exceed regulatory levels. Except where noted, all noise levels are with the truck operated in accordance with the SAE J366b test procedure at a site with a hard surface between the truck and measurement point.

Because the cost for quieting trucks is largely dependent on the initial engine and exhaust noise levels, derived from the engine model used in the truck, Table 6-1 has been organized according to engine model instead of truck model. The range of engine noise levels are given for each engine model with the engine inside the truck cab and at maximum speed and load.

The design levels for each regulatory level were selected to minimize the costs. Because engine noise is usually more costly to reduce, design levels have been selected for the engine that are higher than the levels for other sources. For the 80- and 78-dBA regulatory levels, it was found that the costs for some engine models could be appreciably reduced by selecting one of the two sets of design levels given at the top of Table 6-1.

Finally, to provide additional insight into the relative impact on the increase in purchase price associated with each regulatory level, Table 6-1 shows the approximate percentages of the total truck population comprised of medium or heavy trucks powered by the indicated engine model [2]. In estimating the percentages for medium-duty engines, it is assumed that heavy-duty engines are used only in heavy trucks.

NOISE CONTROL TREATMENTS AND COSTS

Cooling System

Since the noise from untreated cooling systems will depend on the configuration of the truck cab and engine compartment, the treatment associated with each engine model in Table 6-1 will be different for different truck models. Therefore, the average of the noise reductions required to reach the design level is used in estimating the required fan treatment and associated costs in Table 6-1.

A fan noise level of 73-dBA is suggested for the 83-dBA regulatory level. In order to reach this level, fan noise treatment #1 is given in Table 6-1. The average of the fan noise levels as reported in the DOT Quiet Truck Program [3], [5] – [6] and Appendix C of BBN Report No. 2710 [1] is 78-dBA. Therefore, on the average, a reduction in fan noise of approximately 5-dBA should be required to achieve the 73-dBA design level. Reductions of 6- to 8-dBA were obtained on the White Motors DOT Quiet Truck by improving the fan and fan shroud design [3]. The price increase for these design substitutions is estimated at $10. Ten dollars is not unreasonable because the fan and fan shroud used in the final (64-dBA) cooling system treatment on the Freightliner DOT Quiet Truck produced a price increase of $13.50 [7].

Table 6-1
Estimated Increase in Prices for Medium and Heavy Trucks which Comply with Not-to-Exceed Noise Emission Regulations

ENGINE MODEL	TRUCK TYPE	Percentage of Total Truck Population	83 dBA Regulatory Level (Engine 77 dBA, Fan 73 dBA, Exhaust 73 dBA, Air Intake 72 dBA, All Others 70 dBA, TOTAL 80.6 dBA)						80 dBA Regulatory Level (Engine 73 dBA / 74 dBA, Fan 70 dBA / 70 dBA, Exhaust 69 dBA OR 69 dBA, Air Intake 69 dBA / 65 dBA, All Others 70 dBA / 70 dBA, TOTAL 77.5 dBA / 77.5 dBA)					
			Fan	Exhaust	Engine	Cab	Air Intake	TOTAL	Fan	Exhaust	Engine	Cab	Air Intake	TOTAL
Gasoline Medium duty (1) 75-77 dBA (2)	Medium	55.1%	a1 $10	b1 $25			-	$15	a2 $25	b2 $50		d1 $100	$5	$180
	Heavy	30.2%	a1 $110	b1 $25			$	$135	a2 $125	b2 $50		d1 $100	e1 $5	$280
Diesel - 2 Stroke, naturally aspirated Heavy duty Manufacturer A 78-79 dBA	Heavy	12.0%	a1 $110	b1 $80		d1 $100	-	$290	a2 $125	b2 $155		d2 $400	e1 $5	$685
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer B 83-85 dBA	Medium	0.79%	a1 $10	b1 $55		d2 $500	-	$565	a2 $25	b2 $105		d3 $850	e2 $30	$1010
	Heavy	5.21%	a1 $110	b1 $55		d2 $500		$665	a2 $125	b2 $105		d3 $850	e2 $30	$1110
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer B 81-83 dBA	Heavy	6.0%	a1 $110	b1 $55		d2 $400		$565	a2 $125	b2 $105		d2 $500	e2 $30	$760
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer C 76-78 dBA	Heavy	4.8%	a1 $110	b1 $30		d1 $100	-	$240	a2 $125	b2 $55		d1 $200	e2 $30	$410
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer D 80 dBA	Medium	0.29%	a1 $10	b1 $55	-	d1 $100	-	$165	a2 $25	b2 $105	-	d2 $500	e1 $5	$635
	Heavy	1.91%	a1 $110	b1 $55	-	d1 $100	-	$265	a2 $125	b2 $105	-	d2 $500	e1 $5	$735
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer D 76-73 dBA	Heavy	1.5%	a1 $110	b1 $55		d1 $100	-	$265	a2 $125	b2 $105	-	d1 $200	e2 $30	$460
Diesel - 2 stroke, 12 cylinder Heavy duty Manufacturer A 79-81 dBA	Heavy	0.9%	a1 $110	b1 $80		d1 $200	-	$390	a2 $125	b2 $155	--	d2 $500	e1 $5	$785
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer E 78-79 dBA	Medium	0.10%	a1 $10	b1 $30	-	d1 $100	-	$140	a2 $25	b2 $55	c1 $175	d1 $200	e1 $5	$460
	Heavy	0.67%	a1 $110	b1 $30	-	d1 $100	-	$240	a2 $125	b2 $55	c1 $175	d1 $200	e1 $5	$560
Diesel - 4 stroke, naturally aspirated Heavy duty Manufacturer C 78-79 dBA	Heavy	0.47%	a1 $110	b1 $30	-	d1 $100	-	$240	a2 $125	b2 $55	c1 $175	d1 $200	e1 $5	$560
Diesel - 4 stroke, naturally aspirated Heavy duty Manufacturer F 78-79 dBA	Heavy	0.225%	a1 $110	b1 $55	-	d1 $100	-	$265	a2 $125	b2 $105	c1 $200	d1 $200	e1 $5	$635
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer G 78-79 dBA	Medium	0.02%	a1 $10	b1 $55	--	d1 $100	-	$165	a2 $25	b2 $105	c1 $150	d1 $200	e1 $5	$485
	Heavy	0.15%	a1 $110	b1 $55	--	d1 $100	-	$265	a2 $125	b2 $105	c1 $150	d1 $200	e1 $5	$585
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer H 75 dBA	Heavy	0.015%	a1 $110	b1 $30	-	-	-	$140	a2 $125	b2 $55	-	d1 $100	e1 $5	$285
AVERAGES			Medium Gasoline = $15; Heavy Gasoline = 135; Medium Diesel = 436; Heavy Diesel = 387						Medium Gasoline = 180; Heavy Gasoline = 280; Medium Diesel = 865; Heavy Diesel = 715					

ENGINE MODEL	TRUCK TYPE	78 dBA Regulatory Level (Engine 71 dBA / 72 dBA, Fan 64 dBA / 64 dBA, Exhaust 69 dBA / 69 dBA, Air Intake 65 dBA / 65 dBA, All Others 70 dBA / 65 dBA, TOTAL 75.6 dBA / 75.1 dBA)						75 dBA Regulatory Level (Engine 68 dBA, Fan 64 dBA, Exhaust 65 dBA, Air Intake 65 dBA, All Others 65 dBA, TOTAL 72.6 dBA)					
		Fan	Exhaust	Engine	Cab	Air Intake	TOTAL	Fan	Exhaust	Engine	Cab	Air Intake	TOTAL
Gasoline Medium duty (1) 75-77 dBA (2)	Medium	a3 $50	b2 $50	c1 $100	d1 $100	e2 $30	$310	a3 $50	b3 $260	-	d2 $325	e2 $30	$665
	Heavy	a3 $200	b2 $50	c1 $100	d1 $100	e1 $30	$480	a3 $2000	b3 $260	--	d2 $325	e2 $30	$815
Diesel - 2 Stroke, naturally aspirated Heavy duty Manufacturer A 78-79 dBA	Heavy	a3 $200	b2 $155		d2 $500	e2 $30	$885	a3 $125	b3 $365	-	d3 $850	e2 $30	$1370
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer B 83-85 dBA	Medium	a3 $50	b2 $105	-	d4 $1075	e2 $30	$1260	a3 $50	b3 $315	c1 $275	d4 $1075	e2 $30	$1745
	Heavy	a3 $125	b2 $105		d4 $1075	e2 $30	$1335	a3 $125	b3 $315	c1 $275	d4 $1075	e2 $30	$1820
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer B 81-83 dBA	Heavy	a3 $125	b2 $105	-	d3 $850	e2 $30	$1110	a3 $125	b3 $315		d4 $1075	e2 $30	$1545
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer C 76-78 dBA	Heavy	a3 $200	b2 $55		d2 $500	e2 $30	$785	a3 $125	b3 $265	-	d3 $850	e2 $30	$1270
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer D 80 dBA	Medium	a3 $50	b2 $105	-	d2 $500	e2 $30	$685	a3 $50	b3 $315	-	d4 $1075	e2 $30	$1470
	Heavy	a3 $200	b2 $105	-	d2 $500	e2 $30	$835	a3 $125	b3 $315	-	d4 $1075	e2 $30	$1545
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer D 76-73 dBA	Heavy	a3 $200	b2 $105		d2 $500	e2 $30	$835	a3 $125	b3 $315	-	d3 $850	e2 $30	$1320
Diesel - 2 stroke, 12 cylinder Heavy duty Manufacturer A 79-81 dBA	Heavy	a3 $200	b2 $155	c1 $200	d2 $500	e2 $30	$1085	a3 $125	b3 $365	-	d4 $1075	e2 $30	$1595
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer E 78-79 dBA	Medium	a3 $50	b2 $55	-	d2 $500	e2 $30	$635	a3 $50	b3 $265	-	d3 $850	e2 $30	$1195
	Heavy	a3 $200	b2 $55	-	d2 $500	e2 $30	$785	a3 $125	b3 $265	-	d3 $850	e2 $30	$1270
Diesel - 4 stroke, naturally aspirated Heavy duty Manufacturer C 78-79 dBA	Heavy	a3 $200	b2 $55	-	d2 $500	e2 $30	$785	a3 $125	b3 $265	-	d3 $850	e2 $30	$1270
Diesel - 4 stroke, naturally aspirated Heavy duty Manufacturer F 78-79 dBA	Heavy	a3 $200	b2 $105	-	d2 $500	e2 $30	$835	a3 $125	b3 $315	-	d3 $850	e2 $30	$1320
Diesel - 4 stroke, naturally aspirated Medium duty Manufacturer G 78-79 dBA	Medium	a3 $50	b2 $105	-	d2 $500	e2 $30	$685	a3 $50	b3 $315	-	d3 $850	e2 $30	$1245
	Heavy	a3 $200	b2 $105	-	d2 $500	e2 $30	$835	a3 $125	b3 $315	-	d3 $850	e2 $30	$1320
Diesel - 4 stroke, turbocharged Heavy duty Manufacturer H 75 dBA	Heavy	a3 $200	b2 $55	-	d1 $200	e2 $30	$485	a3 $200	b3 $265	-	d2 $500	e2 $30	$995
AVERAGES		Medium Gasoline = 310; Heavy Gasoline = 480; Medium Diesel = 1059; Heavy Diesel = 976						Medium Gasoline = 665; Heavy Gasoline = 815; Medium Diesel = 1624; Heavy Diesel = 1454					

(1) Medium Duty and Heavy Duty refer to the severity of service for the engine, not to the weight class of the truck.

(2) Engine levels are for engines inside the truck as measured according to SAE J366b test procedure.

Table 6-2
Key to Noise Treatments and Costs for TABLE 6-1

SYSTEM	Code for Noise Treatment	Description of Noise Control Treatment	Increase in Truck Purchase Price	Design Source Level of Noise Reduction
Fan	a1	Improved fan and fan shroud design. Thermostatically controlled fan clutch on heavy trucks to allow removal of radiator shutters.	$ 10 - Design substitutes for similar equipment. $110 - Design substitutes ($10) plus net increase for replacing radiator shutters with fan clutch ($100).	73 dBA
	a2	Advanced system with improved fan design, fan shroud and radiator design. Includes fan clutch on heavy trucks.	$ 25 - Net price increase for replacing radiator, fan and fan shroud with ones of improved design. $125 - Improved radiator, fan and fan shroud ($25) and fan clutch ($100).	70 dBA
	a3	Best system possible using available technology; includes larger radiator which requires redesigned cab on heavy trucks.	$ 50 - Radiator, fan and fan shroud of improved design ($25) and larger fan and radiator ($25). $125 - Radiator, larger fan and fan shroud of improved design ($25), and and fan clutch ($100). Costs for larger radiator and redesigned cab are included in cab treatment d3 or d4 $200 - Radiator, fan and fan shroud of improved design ($25), larger fan and radiator ($25), redesigned cab ($50) and fan clutch ($100).	64 dBA
Exhaust	b1	Best of presently available mufflers and seals for exhaust leaks.	$25-75 - Net price increase for replacing existing mufflers. Depends on unmuffled noise level; on 4-stroke engines $25-50 and on 2-stroke engines $75.	73 dBA
	b2	Advanced mufflers better than presently available on 4-stroke engines; manifold muffler and best of available mufflers on 2-stroke engines. Seals for exhaust leaks.	$50-150 - On 4-stroke engines; net increase for advanced mufflers, twice increased for best available mufflers ($25-75), depends on unmuffled noise level.	69 dBA
	b3	Best system possible using available technology; includes advanced mufflers, exhaust seals, double-wall piping and muffler wrapping.	$260-360 - Advanced mufflers ($50-150) depending on unmuffled noise level), manifold muffler ($150), muffler jackets ($30) and insulated double-wall exhaust piping ($30). For diesel trucks, add $5 for exhaust gas seals.	65 dBA
Engine	c1	Engine quieting kits - close fitting covers and isolated or damped exterior parts - supplied by engine manufacturer.	$150-275 - For Diesel engines, estimates based on engine manufacturers' prices for available kits. $100 - For Gasoline engines.	2-3 dBA Noise Reduction
Cab	d1	Underhood treatment, such as acoustic absorbing material, side shields and recirculating panels.	$100-200 - For Diesel trucks; based on truck manufacturers' estimates. Depends on needed noise reduction; 2-3dBA ($100) and 4dBA ($200). $50-100 - For Gasoline trucks.	2-4 dBA
	d2	Underhood treatment and underpan.	$400-500 - For Diesel trucks; underhood treatment ($100-200) plus underpan ($300). $275-325 - For Gasoline trucks.	5-9 dBA Noise Reduction
	d3	Partial (open front and back) engine enclosure and special engine mounts.	$850 - Partial engine enclosure ($775) and special engine mounts ($75). Includes costs for larger radiator and redesigned cab.	10-11 dBA Noise Reduction
	d4	Full engine enclosure and special engine mounts.	$1075 - Average of truck manufacturers' estimates for full engine enclosure ($775-1300) and special engine mounts ($75). Includes costs for larger radiator and redesigned cab.	12-15 dBA Noise Reduction
Air Intake	e1	Improve air intake design	$ 5 - Design substitute for similar equipment.	69 dBA
	e2	Air intake silencer and improved air	$ 30 - Air intake silencer ($25) and design substitute for similar equipment ($5).	65 dBA

On trucks equipped with radiator shutters, the fan usually stalls when the shutters are closed, increasing fan noise levels. With a thermostatically controlled fan clutch, the radiator shutters can be removed. The change in truck price for replacing the radiator shutters and conventional fan hub with a fan clutch is $96 [7]. Adding the cost for replacing the fan and fan shroud with ones of better design gives an approximate price increase for fan treatment a1 of $110. Currently, radiator shutters are not widely used on medium trucks, therefore, the costs of fan clutches are not included in price increases for medium trucks.

For the 80-dBA regulatory level, fan treatment a2 is used in Table 6-1 to reach a design level of 70-dBA. In fan treatment a2, an improved radiator is added to fan treatment a1 to reduce the noise level from 73-dBA to 70-dBA. Using a radiator with the same frontal area but more heat transfer area should be adequate to provide the 3-dBA of additional fan noise attenuation [8]. The addition of an improved radiator, such as the serpentine type used in automobiles, should not increase truck prices significantly. Production costs for a serpentine radiator should be similar to those for a tube and fin radiator, which include the costs of some hand assembling. In some trucks, it may be possible to optimize the fan-to-radiator distance to achieve nearly the same reduction in fan noise [8]. An estimated price increase of $25 for replacing the fan, fan shroud, and radiator with ones of better design is used for fan treatment a2 (Table 6-1). For heavy trucks, the cost of $100 for a fan clutch is added.

A design level for fan noise of 64-dBA is selected for the 78- and 75-dBA regulatory level. With the attenuation provided by engine noise shields, the use of a well-designed fan shroud and larger slower-turning fan should be adequate to achieve a 64-dBA fan noise level [5]. The larger fan will require a larger radiator in most trucks. A $25 price increase is given for replacing the existing radiator with one with a larger frontal area. For medium trucks, the radiators are usually small enough so that larger radiators can be used without requiring enlargement of the engine compartment. In addition, a fan smaller than the 31-in-diameter fan used on the Freightliner DOT Quiet Truck should be adequate for most medium trucks, since the cooling requirements are usually less than those for heavy trucks. Therefore, the total price increase for fan treatment a3 in medium trucks is $50, which includes the costs for cooling system design substitutions and a larger radiator.

On heavy trucks, where cooling requirements are usually greater, original equipment radiators are larger than on medium trucks. For a square radiator, a frontal area of 1200 sq in should be adequate to accommodate the larger fan in treatment a3. This frontal area represents an average increase in radiator size for heavy trucks of approximately 200 sq. in. On the Freightliner DOT Quiet Truck, the net increase in cost for the 2000-sq-in radiator over the cost for the standard 1200-sq-in radiator was estimated by Freightliner as approximately $150. Based on this estimate, an increase in frontal area of about 200 sq in would increase the price of a truck by $37.50. To accommodate an increase in radiator size on most heavy trucks some modifications to the cab will be required to provide additional frontal area. The increase in price for the larger radiator and the cab which had room for a larger radiator and engine on the Freightliner DOT Quiet Truck is $300 [7]. Subtracting $150 for the larger radiator yields a price increase of $150 for the larger cab. However, since only the front part of the cab will need to be modified and radiators smaller than the one used in the Freightliner truck will probably be sufficient, the increase in price for this cab modification is $50. Adding the costs for design substitutions, a larger radiator and fan clutch brings the total price increase to $200 for treatment a3. On heavy trucks where partial or full enclosures are required for treatment of engine noise, the cost for the larger radiator and additional space in the truck cab is included in the cost for cab treatment. The costs for the larger radiator is included with the costs for cab treatments d3 and d4, where applicable, since larger radiators will be required to provide additional cooling for enclosed engines. In these cases, the price increase of $125 is used for fan treatment a3.

In estimating the costs for fan treatments, it is assumed that fans equipped with thermostatically-controlled clutches will be required to be on during testing. If the fan clutch is permitted to be disengaged during testing, then the costs for fan treatment (other than for fan clutches), can be avoided.

Exhaust System

An exhaust system noise level of 73-dBA is given in Table 6-1 for the 83-dBA regulatory level. In order to reach this level, exhaust system noise treatment b1 is used. The noise levels for exhaust systems with the best mufflers currently being manufactured are 73-dBA or below [1]. The retail price for these mufflers range from about $40 to $80. Incremental prices for $25 to $50 are used for replacing the existing mufflers with the best mufflers currently being manufactured. A price increase of $50 is used for the 4-stroke diesel engine models which have higher unmuffled exhaust noise levels. The unmuffled noise levels for 2-stroke diesel engines are about 10-dBA higher than the unmuffled levels for the 4-stroke engines [1]. Therefore, more attenuation of exhaust noise will be required on 2-stroke engines in order to reach the 73-dBA design level. Mufflers, which are similar to the mufflers used on the International Harvester DOT Quiet Truck should provide sufficient attenuation to reduce exhaust noise level to 73-dBA or below [9]. Since the mufflers used in treatment a1 on 2-stroke engines provide more attenuation, their costs will probably be higher than the costs for mufflers on 4-stroke engines which reduce exhaust noise levels to 73-dBA. Therefore, the increase in truck price of $75 is given for treatment a1 for 2-stroke engines. To reduce noise from exhaust leaks, exhaust gas seals are used in treatment a1 on diesel engines. The price increase for exhaust seals should be approximately $5 [7].

An advanced system (Code b2) should be needed to reduce exhaust noise to the design level of 69-dBA for the 80- and 78-dBA regulatory levels. This treatment will probably involve the construction of longer, wider mufflers, possibly with double wall construction to reduce shell noise. The cost of these mufflers will probably be more than the costs of the best available mufflers. For purposes of estimating the price increases in Table 6-1, the incremental price increases for the best available mufflers (Code b1) are doubled and treated as conservative (i.e., high) estimates. The rationale is that mufflers typically provide 10-20 dBA attenuation. While two mufflers in series will not provide twice the attenuation of one, 4-10 dBA of additional attenuation can be expected [1]. Accordingly, the price increase estimates for Code b2 are $50-150.

A design level of 65-dBA for exhaust noise is given in Table 6-1 for the 75-dBA regulatory level. In order to reach this level, a manifold muffler, muffler jackets, and insulated double-wall exhaust piping are added to the mufflers used in Code b2. The manifold muffler used in the "Final Selection" exhaust system on the Freightliner DOT Quiet Truck reduced the exhaust noise level from 70 to 65.5-dBA [5]. The manufacturer's cost for a manifold muffler is estimated at $100 [7]. Using a scaling factor of 1.5, the estimated price increase for a manifold muffler is $150. Price increases of $30 are used for the muffler jackets [7], and $30 for insulated double-wall exhaust piping. Using these estimates, the price increases given in Table 6-1 for Code b3 are obtained by adding $210 to the price increases for the advanced mufflers (Code b2).

Engine and Cab

In order to determine the reduction of engine noise needed to reduce the engine level to the given design noise level, the difference between the engine noise design level and the highest of engine noise levels given for each engine model is determined. By using the highest of engine noise levels, the noise treatment used in Table 6-1 should be adequate to reduce the noise from all engines of a given model enough to allow trucks to comply with the given regulatory level.

Engine quieting kits are available for many diesel engines. These kits consist of close-fitting covers and isolated or damped exterior panels. The estimated prices for these kits are based on prices quoted by engine manufacturers and range from $100 to $275. When the total required engine noise reduction is less than 3 dBA, underhood treatment (Code d1) is used since it is less costly. Engine quiet kits are used in some cases to obtain an additional 2-3dBA attenuation avoiding the need for the more costly underpan or providing additional attenuation beyond the 15-dBA for full engine enclosures.

One truck manufacturer estimated that the increase in truck price for the application of underhood treatment will be about $100 [1] for a truck equipped with a diesel engine. This price is used to achieve the 2-3 dBA of engine noise attenuation. When noise reduction of 4-dBA is required for diesel engines larger side shields may be needed. In this case, an estimated price for Code d1 of $200 is used in Table 6-1. The $200 is the price increase for "Shields" only [5], plus a price increase for "Interior Cab Treatment," [3].

Because gasoline engines have half the side surface area as diesel engines, the size of the engine side shields needed to provide the same noise attenuation for gasoline engines will be about half the size of the shields used for diesel engine noise. Accordingly, the price increases for treatment d1 of $50-100 (estimated for smaller shield size) are used for gasoline engines.

An underpan between the truck frame rails, acting as a barrier to engine noise radiated from underneath the truck cab, is added to the underhood treatment (Code d1) providing total engine noise reduction of 5-9 dBA [10]. Based on the Freightliner DOT Quiet Truck [5], the price increase for the underpan is estimated at $300 as shown in Table 6-3. An underpan of about 5 feet in length is used in making this estimate since a 5-foot underpan should be adequate to cover the length of the engine (Table 6-9) so that engine noise reductions of 4-9 dBA can be achieved. As shown in Table 6-3, the $300 estimate is added to the price estimates for the underhood treatment (Code d1) arriving at estimated prices of $400 to $500 for the cab treatment d2. A price increase of $400 is used for engine noise reductions of 5-6 dBA and $500 for 7-9 dBA noise reductions.

Since gasoline engines are, in general about a foot shorter than diesel engines (Table 6-9), obviously the underpans used on gasoline trucks will be about 1 foot shorter. Using the same procedure as in Table 6.3, price increases for treatment d2 of $275 to $325 is derived for gasoline trucks.

When engine noise reductions of 10-15 dBA are needed, special engine mounts and a partial or full enclosure is used (Table 6-2). A partial enclosure, (open in front and back), is used with special engine mounts (Code d3) to obtain 10-11 dBA of engine noise reduction [5]. The increase in truck price with special engine mounts and a partial enclosure is estimated at $850 [7]. This estimate includes the costs for a cab with a larger engine compartment which may be necessary to accommodate the engine enclosure and for a larger radiator to provide additional cooling for the enclosed engine. A full engine enclosure and special engine mounts (Code d4) are used in Table 6-1 when 12-15 dBA of attentuation is required. Price increases for full enclosures will depend on the initital truck cab configuration. The estimated price increases for full engine enclosure made by truck manufacturers range from $775 to $1300 [1]. For purposes of estimating the increases in truck prices, the average of the estimated price increase of $1,000 is used for full engine enclosures. The price increase of $75 for special engine mounts [7] is added to the price increase for full enclosures to obtain the estimated price increase of $1075 for Code d4. For the 75-dBA regulatory level, two engine models require attenuation of 15 dBA or more. For these engines, an engine quieting kit (Code c1) along with a full enclosure (Code d4) are used.

Table 6-3
Estimation of Price Increase for Cab Treatment d2 on Diesel Trucks

Cab Treatment d2	Purchase Price
Partial enclosure with 9-foot underpan and side shields	773
Side shields	267*
9-foot underpan (difference of 1 and 2, above)	506
5-foot underpan (5/9 of 3, above)	300
Side shields ($100-$200) and 5-foot underpan	$400-$500

* The side shields used on the Freightliner DOT Quiet Truck were part of the partial enclosure which enclosed the engine and transmission and were therefore larger than the engine side shields called for in treatments d1 and d2 in step 5.

Air Intake

Of the 34 air intakes tested on diesel engines, a majority had noise levels below 72-dBA [13]. Therefore, noise treatment should not be necessary for trucks complying with the 83-dBA regulatory level. However, some treatment may be necessary for the other regulatory levels. A design level of 69-dBA for the air intake noise should be low enough to allow most trucks to comply with the 80-dBA regulatory level. Replacing the rain cap on the air intake opening with one of better design reduced the air intake noise on the International Harvester DOT Quiet Truck from 72- to 69-dBA [9]. Thus, it should be possible to quiet most existing systems by replacing equivalent parts with parts of a better design (Code e1). The price has been estimated at $5.

For the 78- and 75-dBA regulatory levels, a design level for air intake noise of 65-dBA is used in Table 6-1. In addition, it was found that by reducing the air intake noise to 65-dBA on some trucks complying with the 80-dBA regulatory level, a savings could be realized by relaxing the required engine noise treatments. An air intake silencer should be sufficient to provide the additional 4-dBA of attenuation [9] needed to reduce air intake noise to 65-dBA or below. An average estimated price of $25 is used in Table 6-1 for air intake silencers, so that the total estimated price increase for Code e2 is $30. In some cases, air intake noise can be reduced to 65-dBA or below at a savings by using a non-snorkle air intake [7]

Other Sources

The noise from sources other than the engine, fan, exhaust, and air intake (such as transmissions, tires, and rear axles) should combine to generate a noise level of less than 70-dBA without treatment. Transmission noise levels for medium and heavy trucks are approximately 70-dBA or below. Maximum transmission noise levels of 68- to 70-dBA are reported for the White Motors DOT Quiet Truck [3], using measurement positions at the same distance (50 feet) specified in the SAE J366b test method, but at different orientations relative to the truck. The transmission noise levels reported for the International Harvester DOT Quiet Truck were below 70-dBA [6], while the truck was in the measurement zone defined for the SAE J366b test procedure. Therefore, few truck transmissions should require noise treatment in complying with the 83-, 80- or 78-dBA regulatory levels. For the 75-dBA regulatory level, the treatment of transmission noise is included in the partial or full enclosures used to treat engine noise. Hence, the levels of the "other sources" category is reduced to 65 dBA. In cases where enclosures were used in Table 6-1 to comply with the 78-dBA regulatory level, the reduction of transmission noise produced by the enclosure is included in the design levels. In one case, the savings associated with the use of a partial enclosure instead of a full enclosure was realized.

The level of noise from ribbed truck tires at SAE J366 test speeds (below 35mph) are approximately 65-dBA or lower [4]. On the Freightliner DOT Quiet Truck, a tire noise level of 62-dBA was measured [5]. On the International Harvester DOT Quiet Truck, the tire noise was 65-dBA or below [6]. Therefore, tires should not need treatment in order for trucks to comply with any of the regulatory levels considered in Table 6-1.

For the rear axle, the noise level reported for the Freightliner DOT Quiet Truck is 58-dBA [5]. No noise treatment for the rear axle is included in the estimates of increases in truck prices.

AVERAGE TRUCK PRICE INCREASES

The average price increases for medium and heavy gasoline and diesel trucks are given at the bottom of Table 6-1. In computing the average price increases for diesel trucks, the price increase associated with each engine model is weighted by the percentage of total truck population for each engine model.

The average truck prices for 1973 presented in Table 6-4 can be obtained by multiplying the 1972 prices [2] by the ratio of wholesale prices for trucks of 1.016 [16].

Using average truck prices for 1973 [2], presented in Table 6-4 and the average increases in truck prices in Table 6-1, the percent increases in truck prices are computed for each truck type. In computing the averages of price increases for all trucks for each regulatory level, the truck price increases are weighted according to truck population figures [2].

Table 6-4
Percent Increases in Truck Prices due to Noise Emissions Regulations

Type of Truck	Average Truck Price	Percentage of New Truck Population	Percent Increase in Truck Price Associated with Given Regulatory Level			
			83dBA	80dBA	78dBA	75dBA
Medium gasoline . . .	$ 5,836	55.1%	0.6%	3.1%	5.6%	11.4%
Heavy gasoline	$11,613	10.2%	1.2%	2.4%	4.1%	7.0%
Medium diesel	$ 7,360	1.2%	5.8%	11.8%	14.4%	22
Heavy diesel	$25,608	33.5%	1.5%	2.8%	3.8%	5.[illegible]
Average for all trucks .	–	–	1.0%	3.0%	4.9%	9.2%

The price increases in Table 6-1 should be considered as conservative or worst-case estimates for the following reasons:

- The demand for some of the noisy diesel engines should decrease. Manufacturer B has indicated that the sales of their noisiest engine has already begun to decrease [14]. In addition, the increased demand for quieter engines will encourage design changes to quiet engines. A decrease in the population of noisy engines will reduce the average price increases given in Table 6-1.

- Most of the estimates of price increase are based on data given in the DOT Quiet Truck Program. In this program, existing heavy diesel trucks were quieted without using major cab or engine modifications; this approach leads to greater costs than would be incurred if such modifications were incorporated in the early design stages. Where cost data was not available, conservative (i.e., high) estimates were made. In addition, cost savings resulting from improvements in noise control technology were not considered.

- Savings due to high volume production of noise control hardware, probably necessary to meet the demand generated by noise emission regulations on trucks, has been ignored.

The sensitivity of estimations of truck price increases to the above assumptions is briefly explored.

Projections of Truck Prices with Improved Technology and Reduction in Production Costs

There are several areas where improvements in the noise reduction technology demonstrated in the DOT Quiet Truck Program may occur in the production of new trucks complying with noise emission regulations. One of these areas is the reduction of engine noise by modifying the engine itself. Modification of the engine was outside the scope of the DOT Quiet Truck Program.

It should be possible to reduce the noise levels from all diesel engines to 77-dBA and the levels from all gasoline engines to 75-dBA without significant increases in manufacturing costs per engine. Truck gasoline engines are presently available which have noise levels of 75-dBA. A heavy-duty diesel engine is currently manufactured with an average noise level of approximately 77-dBA. This engine is given in Table 6-1 as the turbocharged heavy-duty diesel engine from manufacturer D. This engine model comprises over 4 percent of the truck diesel engine market and is priced comparable to noisier engines of similar size.

By assuming that all diesel engine noise levels are 77-dBA and all gasoline engine noise levels are 75-dBA, the average price increases given in Table 6-5 can be derived by applying the same procedure used in deriving the average increases presented in Table 6-1.

If, in addition to the assumption that engines can be quieted, it is assumed that the costs of noise control hardware currently in production (e.g., fan clutches and exhaust mufflers) will be reduced by 10 percent as a result of increased production and the costs of hardware not currently in production (e.g., manifold mufflers, and cab side-shields and underpans) will be reduced by 50 percent when demand forces full production, the increases in the truck prices given in Table 6-1 are obtained.

The above assumptions used in estimating the price increases given in Tables 6-5 and 6-6 are not based on published information on past experience in quieting trucks, but represent projections of possible applications of available technological principles in the production of quiet trucks and predictions of future cost reductions. Therefore, these estimated price increases are not supported by published data on noise treatment costs, as are the estimated price increases given in Table 6-1. However, the estimated price increases in Table 6-1 are conservative and the price increases given in Tables 6-4 and 6-5 indicate the savings which may be achieved by quieting engines and degree to which the estimated price increases in Table 6-1 may be overstated.

Truck Price Increases with Fan-Off Compliance Testing

On trucks equipped with fan clutches, the fan should be turned off a large percentage of the time during normal operation, so that the contribution to environmental noise from the fan would be significantly reduced. If trucks equipped with fan clutches are permitted to be compliance tested with the fans off, then these trucks can be designed with the assumption that there will be no noise contribution from the cooling system. Eliminating the fan noise in the design levels given at the top of Table 6-1, raising the engine noise design levels by 1 dBA, and using only a $100 fan clutch as the most costly cooling system treatment, the price increases in Table 6-1 can be reduced to give the average price increases presented in Table 6-7. The largest savings occur for heavy trucks which will use fan clutches

Table 6-5
Estimated Increases in Prices for Regulated Trucks,
Assuming that all Engines can be Quieted*

Type of Truck	Regulatory Levels			
	83dBA	80dBA	78dBA	75dBA
Medium Gasoline ...	$ 10	$130	$230	$ 540
Heavy Gasoline	110	230	380	690
Medium Diesel	63	256	515	891
Heavy Diesel	170	370	677	1055

*Diesel = 77dBA, and gasoline = 75dBA

Table 6-6
Estimated Increases in Prices for Regulated Trucks,
Assuming that all Engines can be Quieted and Manufacturing
Costs will Decrease with Increased Production

Type of Truck	Regulatory Levels			
	83dBA	80dBA	78dBA	75dBA
Medium Gasoline	$ 9	$ 90	$161	$368
Heavy Gasoline	99	180	276	484
Medium Diesel	57	171	344	511
Heavy Diesel	153	271	318	636

Table 6-7
Estimated Increases in Truck Prices Assuming
Fan-Off Compliance Testing

Type of Truck	Regulatory Levels			
	83dBA	80dBA	78dBA	75dBA
Medium Gasoline	$ 35	$180	$ 330	$ 665
Heavy Gasoline	125	255	380	715
Medium Diesel	426	850	1059	1624
Heavy Diesel	356	589	860	1363

even if testing is done with the fan on. If for reasons other than noise reduction trucks are equipped with fan clutches before the effective date of the 83-dBA regulatory level, then the net price increase for fan clutches ($100) can be saved on heavy trucks.

CHANGES IN OPERATING COSTS

Noise treatments affect the operating costs of medium and heavy trucks by (1) changing the truck performance which affects the rate of fuel consumption, and (2) changing the ease and amount of required maintenance.

Costs of Changes in Rates of Fuel Consumption

In this section, the changes in fuel costs per truck-mile are predicted for each engine model, regulatory level, and noise treatment by:

1. Estimating the changes in truck operating properties produced by noise treatments which affect the rate of fuel consumption,

2. Estimating the sensitivity of the rate of fuel consumption to the changes in truck properties, and

3. Multiplying the product of the changes in truck operating properties and the factors of fuel consumption sensitivity by average fuel costs.

Changes in Truck Operating Properties

Table 6-8 shows the estimates of the changes in truck tare (empty) weight, exhaust backpressure and required accessory power for each of the noise treatments used in Table 6-1. The derivation of these estimates are described.

Cooling System Treatments

Design Substitutes (Code a1)

This cooling system treatment involves the substitution of the existing fan and fan shroud with ones of better design, so that the fan speed can be reduced without loss in volumetric air flow. The change in weight is negligible. Medium trucks are assumed not to use fan clutches. Without fan clutches, the average power saving for medium diesel trucks is estimated at 5 hp. The maximum power savings with fan and fan shroud substitutions, other than fan clutches, for the trucks in the DOT Quiet Trucks Program were approximately 5.5 hp [3], [7] and [9]. For medium diesel trucks, the maximum savings should be fairly close to the average savings, since diesel engines are designed to run close to maximum rated speed at all loads. For medium gasoline trucks, the lower power requirements are assumed to cause the average speed to be approximately 75 percent of the rated speed, yielding approximately half the power savings (2.5 hp).

The only available data on fan power requirements relate to diesel engines. To estimate the requirements for gasoline engines, it should be noted that two competing effects occur in going from diesel to gasoline engines. The net heat rejection into the block for gasoline engines is higher than that for diesel engines [11]. On the other hand, the surface area-to-volume ratio is higher for gasoline engines, as well as the clearances between the engine and surrounding structures. These lead to higher heat rejection effectiveness for gasoline engines [11]. It is therefore assumed that for a given rated engine horsepower, cooling fans on gasoline and diesel engines require the same power input.

For heavy trucks, fan clutches are used to replace radiator shutters. The extra weight of the fan clutch hub is approximately 20 pounds, but this is almost exactly balanced by the weight of the removed shutters [7]. Because the fan clutch should be disengaged most of the time [12], virtually all of the power needed to drive the fan will be saved. The power requirements for the fan reported in the DOT Quiet Truck Program for heavy diesel trucks with engines at the governed speed of about 2100 rpm were between 17 and 19.5 hp [8] and [7]. Since both gasoline and diesel engines are typically operated at speeds near 2000 rpm, the average power savings with the fan off should be near the maximum power requirements reported in the DOT Quiet Truck Program. Therefore, the average power savings with fan clutches is assumed to be 15 hp for heavy trucks.

Table 6-8
Change in Physical Properties of Trucks with Noise Treatments

Noise Treatment Code	Description	Increase in Truck Weight: Gasoline Trucks (Pounds)	Increase in Truck Weight: Diesel Trucks (Pounds)	Increase in Exhaust Back Pressure or Air Intake Restriction (Inches of H_2O): 4-Stroke	Increase in Exhaust Back Pressure or Air Intake Restriction (Inches of H_2O): 2-Stroke	Decrease in Accessory Power Requirements: Medium Truck, Gasoline (hp)	Decrease in Accessory Power Requirements: Medium Truck, Diesel (hp)	Decrease in Accessory Power Requirements: Heavy Truck (hp)
a1	Fan design substitutes without fan clutch	0	0	–	–(1)	2.5	5	–
	Fan design substitutes with fan clutch	0	0	–	–	–	–	15
a2	Advanced system without fan clutch	0	0	–	–	4.5	9	–
	Advanced system with fan clutch	0	0	–	–	–	–	15
a3	Best available technology system without fan clutch	10	10	–	–	6	12	–
	Best available technology system with fan clutch	10	10	–	–	–	–	15
b1	Best available mufflers	25	25,50 or 100(2)	0	0	–	–	–
b2	Advanced mufflers	50	50,100 or 150(2)	0	2	–	–	–
b3	Best available technology system	135	135,185 or 235(2)	2	20	–	–	–
c1	Engine quiet kit	12	25	–	–	–	–	–
d1	Underhood treatment and side shields	25	55	–	–	–	–	–
d2	Treatment d1 with underpan	60	120	–	–	–	–	–
d3	Partial engine enclosure	–	500	–	–	–	–	–
d4	Full engine enclosure	–	500	–	–	–	–	–
e1	Air intake design substitutes	0	0	0	0	–	–	–
e2	Air intake silencer and design substitutes	0	0	0	0	–	–	–

(1) The treatment has no effect or is not used on this type of truck.
(2) Depending on unmuffled level -- highest weight for 2-stroke diesel engines.

Advanced System (Code a2)

This treatment consists of improvements in the fan, fan shroud and radiator design to reduce the fan speed without reducing volumetric air flow. Improvements in the fan, fan shroud and radiator designs, and optimization of radiator-to-fan distance are included in the treatment. Increasing the fan size enough to require a larger radiator is not included in this treatment. On medium trucks, a fan clutch is not used. The power savings on medium diesel trucks is expected to be nearly 9 hp [8]. On medium gasoline trucks, half the savings (4.5 hp) is used in Table 6-7. As discussed above, the fan clutches on heavy trucks should provide a power savings of about 15 hp without significantly increasing the weight of the truck.

Best Available Technology (Code a3)

The principal feature of this treatment is a larger fan which should require a radiator with a larger frontal area. The increase in weight for the larger radiator should be small (less than 11 pounds, [5]), since the increase in frontal area is accompanied by a decrease in radiator thickness. A value of 10 pounds is given in Table 6-8. Without the fan clutch, the power savings for medium diesel trucks should be about 12 hp [12]. Half the savings is assumed for medium gasoline trucks. The fan clutch on heavy trucks should provide power savings of nearly 15 hp.

Exhaust System Treatments

Best of Currently Available Mufflers (Code b1)

This treatment consists of replacing stock mufflers with currently available mufflers which provide the highest noise attenuation. The net increase in weight for the mufflers used on the Freightliner DOT Quiet Truck was approximately 50 pounds [7]. Therefore, for 4-stroke engines with unmuffled noise levels similar to the Freightliner truck, a net increase in weight of 50 pounds is given. A net increase in weight of 25 pounds is used for 4-stroke engines with lower unmuffled noise levels. Since the unmuffled noise levels for 2-stroke diesel engines are higher than the levels for 4-stroke diesel engines, larger heavier mufflers will probably be needed to achieve the same muffled exhaust noise level. The mufflers used on the 2-stroke diesel engine in the International Harvester DOT Quiet Truck were 130 pounds heavier than the original equipment mufflers [9]. However, these mufflers provided more attenuation than needed for treatment b1. Therefore, the mufflers for treatment b1 on 2-stroke diesel engines should be lighter. Accordingly, a net increase in weight of 100 pounds is given in Table 6-8.

A comparison of the backpressures developed by several systems shows that systems with mufflers which provide higher noise attenuation have nearly the same backpressure as systems with mufflers which provide less attenuation [1]. Therefore, insignificant increases in backpressure are expected for exhaust systems with the best available mufflers (Code b1).

Advanced Mufflers (Code b2)

For exhaust treatment b2 on 4-stroke engines, the weight increase of twice the increase for treatment b1 is given in Table 6-8. For exhaust treatment b2 on 2-stroke diesel engines, 50 pounds is added to the weight increase of treatment b1. These increases in weight should result from the use of larger heavier mufflers than used in treatment b1.

For treatment b2 on 4-stroke engines, the backpressure is not expected to increase significantly over the backpressure for treatment b1, since larger mufflers will be employed. However, an increase in backpressure for 2-stroke diesel engines similar to the 2-inch increase for the "Final-Selection" exhaust system on the Freightliner DOT Quiet Truck [7] is expected.

Best Available Technology System (Code b3)

In going from treatment b2 to b3, a manifold muffler, double-wall exhaust piping and muffler wraps are added. The net increase in weight for the manifold muffler is 50 pounds [7], and the muffler wraps 20 pounds [7]. The net weight increase for the double-wall exhaust piping is estimated at 15 pounds. Therefore, a total of 85 pounds is added to the weight increases for treatment b2 in estimating the weight increases for treatment b3. The weight increases in Table 6-8 for treatment b3 are nearly equal to the weight increases of 140 and 160 pounds reported for the exhaust system with a manifold muffler used on the Freightliner DOT Quiet Truck [7].

The increase in backpressure of 2 inches of H_2O is given in Table 3-8 for treatment b3 on 4-stroke engines. This is similar to the increase in backpressure for the "Final-Selection" system used on the Freightliner DOT Quiet Truck [7]. For 2-stroke diesel engines, increases in backpressure of about 20 inches of H_2O are expected. These increases are similar to the increases produced by the mufflers used on the International Harvester DOT Quiet Truck [9]. The addition of double wall piping and muffler wraps should not increase backpressure.

Engine Treatments

Engine Quiet Kits (Code c1)

The engine quiet kit used on the Freightliner DOT Quiet Truck increased the truck weight by 20 pounds [7]. On the White Motors DOT Quiet Truck, the engine quiet kit weighed 25 pounds [3]. Thus, a conservative estimate of the average increase in the weight of diesel trucks with the addition of quiet kits is 25 pounds. For gasoline engines, no commercial kits are presently available. Because gasoline engines have approximately half the surface area of diesel engines (see Table 6-9), the weight for quiet kits for gasoline engines is estimated at 12 pounds.

Cab Treatments

The cab treatments consist of baffles and panels attached to the cab structure to provide shielding from engine noise. The first two treatments (d1 and d2) are designed to baffle only the engine block. Therefore, the size and weight of these treatments will depend on the size of the engine. Since there is a significant difference in the size of diesel and gasoline engines, separate estimates of weights for treatments d1 and d2 will be given for diesel and gasoline engines. The other treatments (d3 and d4) are not used on trucks with gasoline engines, so that weight estimates are given only for diesel trucks.

Underhood Treatment and Side Shields (Code d1) and Underpan (Code d2)

The rationale for deriving the weights of treatments d1 and d2 is as follows [11]. First, the dimensions of a typical engine block were obtained from catalog information. Then, the dimensions of the smallest rectangular prism were obtained which would enclose the engine on its sides, top and bottom were estimated. These dimensions are given in Table 6-9. This prism includes the turbocharger where appropriate, but not the air intake. The dimensions of this prism are multiplied by a factor of 1.5 to allow for clearances and overhang at the ends. On the basis of the Freightliner DOT Quiet Truck design, the underhood treatment was assumed to cover the top of this prism and one-third of the side area. Similarly, side shields were assumed to cover one-sixth of the side area, and the underpan was assumed to cover the bottom of the prism and the lower one-third of the side area. The remaining one-sixth of the side area was assumed to be taken up by the frame rails. By this means, the dimensions of the underhood treatment, the side shields and the underpan given in Table 6-9 were established.

To obtain weights, the area of the underhood treatment, which should require no structural members, is multiplied by an area density of 1-lb/ft^2 to account for the installation of sound absorbing materials [7]. This procedure gives the weights shown in Table 6-9. From Table 6-9, rounding the weights up to the nearest 5 pounds, the weight estimates given in Table 6-8 for treatments d1 and d2 can be obtained.

Engine Enclosures (Codes d3 and d4)

Engine enclosures should not be required on gasoline trucks to comply with regulatory levels of 75-dBA or above. The weight of the partial enclosure on the Freightliner DOT Quiet Truck was 455 pounds [7], including the weight increase for a cab with a larger engine compartment. The full engine enclosure on the Freightliner DOT Quiet Truck increased the truck weight by 463 pounds [7]. These weight increases are rounded to the nearest 50 pounds to allow for additional structural modifications which may be required in trucks with conventional cabs.

Table 6-9
Dimensions and Weights for Cab Treatments d1 and d2

Diesel Engine (Overall Engine Dimensions: 50" long x 50" high x 30" side)(1)

Treatment	Area (ft^2)	Density (lb/ft^2)	Weight (lb)
Underhood	33	1	33
Side shields	9	2	18
Underpan	33	2	66
		Total	117

Gasoline Engine (Overall Engine Dimensions: 35" long x 30" high x 25" wide) (2)

Treatment	Area (ft^2)	Density (lb/ft^2)	Weight (lb)
Underhood	16	1	16
Side shields	4	2	8
Underpan	16	2	32
		Total	56

(1) Source: Catalog information from Cummins and Catapillar
(2) Source: Chrysler catalog information

Air Intake Treatments

Design Substitutes (Code e1) and Silencer (Code e2)

On the International Harvester DOT Quiet Truck, it was possible to apply treatment to the air intake without increasing the air intake restriction. On the Freightliner DOT Quiet Truck, a reduction in the air intake restriction was reported for the quieter non-snorkle air intake. No air intake treatment was needed on the White Motors DOT Quiet Truck. Therefore, on the average, treatments of air intake noise should not decrease engine performance. Increases in truck weight with air intake treatments are expected to be negligible.

Effect of Noise Treatment on Rates of Fuel Consumption

The change in the rate of fuel consumption (in gallons per mile) are given in Tables 6-10 per unit increase in truck weight, exhaust backpressure and accessory horsepower [1]. Both 4-stroke and 2-stroke engines have approximately the same sensitivity to exhaust backpressure [15]. To determine the change in the rate of fuel consumption for each noise treatment presented in Table 6-2, changes in truck weight, exhaust backpressure or accessory power, (given in Table 6-8), are multiplied by the appropriate coefficients in Table 6-10. The products are summed for each treatment to yield the results presented in Table 6-11. Following the procedure used in Table 6-1, the data in Table 6-11 can then be used to compute the average changes in the rates of fuel consumption given in Table 6-12. By comparing the rates of fuel consumption given in Table 6-11 with the rates in Table 6-12, it can be

Table 6-10
Effect of Truck Properties on Rate of Fuel Consumption

Increase in Fuel Consumption

Type of Truck	Per Unit Increase in Weight (GPM/lb)	Per Unit Increase in Backpressure (GPM/in H_2O)	Per Unit Increase in Accessory Power (GPM/hp)
Medium gasoline.	3.25×10^{-6}	0	3.5×10^{-3}
Heavy gasoline . .	3.25×10^{-6}	0	1.9×10^{-3}
Medium diesel . .	1.77×10^{-6}	3.6×10^{-5}	1.9×10^{-3}
Heavy diesel. . . .	1.77x10	1.5×10^{-4}	1.0×10^{-3}

Table 6-11
Effect of Noise Treatment on Rate of Fuel Consumption

Noise Treatment	Change in Rate of Fuel Consumption (Gallons/Mile)			
	Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel
a1	-8.75×10^{-3}	-2.85×10^{-2}	-9.5×10^{-3}	-1.50×10^{-2}
a2	-1.58×10^{-2}	-2.85×10^{-2}	-1.71×10^{-2}	-1.50×10^{-2}
a3	-2.1×10^{-2}	-2.85×10^{-2}	-2.28×10^{-2}	-1.50×10^{-2}
b1	8.1×10^{-5}	8.1×10^{-5}	4.4×10^{-5}	4.4×10^{-5}
			8.8×10^{-5}	8.8×10^{-5}
			1.8×10^{-4}	1.8×10^{-4}
b2	1.6×10^{-4}	1.6×10^{-4}	8.8×10^{-5}	8.8×10^{-5}
			1.8×10^{-4}	1.8×10^{-4}
			2.6×10^{-4}	5.6×10^{-4}
b3	4.4×10^{-4}	4.4×10^{-4}	3.1×10^{-4}	5.4×10^{-4}
			4.0×10^{-4}	6.3×10^{-4}
			4.9×10^{-4}	3.4×10^{-3}
c1	3.9×10^{-5}	3.9×10^{-5}	4.4×10^{-5}	4.4×10^{-5}
d1	8.1×10^{-5}	8.1×10^{-5}	9.7×10^{-5}	9.7×10^{-5}
d2	2.0×10^{-4}	2.0×10^{-4}	2.1×10^{-4}	2.1×10^{-4}
d3	–	–	8.8×10^{-4}	8.8×10^{-4}
d4	–	–	8.8×10^{-4}	8.8×10^{-4}
e1	0	0	0	0
e2	0	0	0	0

observed that the changes in the rate of fuel consumption are dominated by the decrease in fuel consumption associated with the decrease in accessory power which results from fan treatments.

Changes in Fuel Costs

By multiplying the figures in Table 6-12 by fuel costs per gallon and annual truck mileage, the change in annual fuel costs can be determined. Using the average fuel costs per gallon for 1973 and the average annual mileages given in Table 6-13 [1], the savings in average annual fuel costs given in Table 6-14 are determined.

Noise emission regulations on trucks will encourage the use of more efficient fans and fan clutches. However, other considerations, such as fuel savings, are also factors presently encouraging the use of more efficient fans and fan clutches and will probably continue to encourage their use in the absence of noise emission regulations. Therefore, to credit all of the savings from more efficient fans and fan clutches on all trucks to noise emission regulations may not be realistic. If credit for the savings from more efficient fans and fan clutches is not taken, the change in average annual fuel costs given in Table 6-15 are computed.

Table 6-12
Estimates of Changes in Rates of Fuel Consumption

Type of Truck	Changes in Rate of Fuel Consumption (Gallons/Miles)			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline .	-8.7×10^{-3}	-1.56×10^{-2}	-2.08×10^{-2}	-2.04×10^{-2}
Heavy gasoline . .	-2.84×10^{-2}	-2.83×10^{-2}	-2.83×10^{-2}	-2.79×10^{-2}
Medium diesel . .	-9.4×10^{-3}	-1.62×10^{-2}	-2.19×10^{-2}	-2.15×10^{-2}
Heavy diesel	-1.47×10^{-2}	-1.44×10^{-2}	-1.42×10^{-2}	-1.24×10^{-2}

Since the assumptions used in deriving the truck price increases in Tables 6-5, 6-6 and 6-7 do not effect fan treatments and the power savings from fan treatments are the dominant factor in determining the changes in fuel costs given in Table 6-14, these assumptions are not expected to significantly impact fuel costs. Therefore, the fuel costs given in Table 6-14 and/or derivable from Table 6-12 can be used with price increases in Table 6-5, 6-6 or 6-7.

Table 6-13
Annual Mileage and Fuel Prices by Type of Truck

Type of Truck	Annual Mileage (10^3 mi/yr)	Fuel Price ($/gal)
Medium gasoline	10	0.50
Heavy gasoline	18	.50
Medium diesel	21	.30
Heavy diesel	54	.30

Table 6-14
Estimates of Changes in Average Increases in Annual Fuel Costs, Including Savings from More Efficient Fans and Fan Clutches

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ (44)	$ (78)	$ (104)	$ (102)
Heavy gasoline	(256)	(255)	(255)	(251)
Medium diesel	(59)	(121)	(138)	(135)
Heavy diesel	(238)	(233)	(230)	(201)

Table 6-15
Estimates of Changes in Average Increases in Annual Fuel Costs, Excluding Savings from More Efficient Fans and Fan Clutches

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ 0	$ 1	$ 1	$ 3
Heavy gasoline	1	2	2	6
Medium diesel	2	6	6	10
Heavy diesel	4	10	12	41

CHANGES IN COSTS FOR MAINTENANCE

Changes in costs for maintenance will probably occur as a result of the addition of engine noise shields or enclosures, and improved exhaust systems. No appreciable changes in maintenance costs are expected for treatment of cooling system or air intake noise. The added maintenance cost for fan clutches is expected to be offset by the decrease in maintenance cost for the removed radiator shutters. [7]. Estimates of the changes in annual maintenance costs are shown in Table 6-16 for each exhaust, engine and cab treatments. The derivations of these estimates are described below.

Exhaust System Treatments

The changes in maintenance costs given in Table 6-16 for exhaust system treatments are based on replacing the mufflers three times in 8 years [1]. For diesel trucks, credit for the labor savings of 3 man-hr/yr. at an hourly rate of $10 and for $25 per year savings in material costs associated with the use of exhaust gas seals [7] is subtracted from the increased maintenance costs attributed to muffler replacements.

Engine and Cab Treatments

The estimate in Table 6-16 for the engine quiet kit is based on an increase in maintenance labor of 1.25 man-hr/yr at $10 per man-hour and $60 costs per year for additional materials. These are the estimates given for the quiet kit used on the Freightliner DOT Quiet Trucks [7]. No increase in maintenance costs are given for the underhood treatment and side shields used on the Freightliner truck. For the partial enclosure, an increase in labor of 6 man-hr/yr. is estimated. For the full enclosure, 32 man-hr/yr of increased maintenance labor is reported. No added material costs were required for maintenance of either type of enclosure [7]. Using a labor rate of $10 per man-hr., the increased maintenance costs given in Table 6-16 are obtained. Increases in maintenance costs similar to the costs for the partial enclosure are used for treatment d2, since the removal of the underpan in both treatments should be the source of most of the maintenance costs.

Table 6-16
Changes in Annual Maintenance Costs Caused by Noise Treatments

Noise Treatment	Description	Change in Annual Maintenance Costs			
		Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel
b1	Best available mufflers	$ 9	$19	$ (46)	$ (36)
b2	Advanced mufflers	19	38	(36)	(17
b3	Best available technology system	38	76	(17)	21
c1	Engine quiet kit	72	72	72	72
d1	Underhood treatment and side shields	0	0	0	0
d2	Treatment d1 with underpan	60	60	60	60
d3	Partial engine enclosure	–	–	60	60
d4	Full engine enclosure	–	–	320	320

The average changes in maintenance costs can be derived using the same procedure used in Table 6-12 for estimating the changes in rates of fuel consumption. Instead of the changes in rates of fuel consumption, the annual changes in maintenance costs in Table 6-16 are used. The results are presented in Table 6-17. When credit for the savings in maintenance costs for exhaust gas seals are not taken, $55 is added to the costs given in Table 6-17 for diesel trucks.

The total change in maintenance costs on the Freightliner DOT Quiet Truck during 112,000 miles of linehaul service was $250 [17]. With an average annual mileage of 54,000 miles, the average change in maintenance costs would be $120/year. This figure is lower than the estimate given in Table 6-17 for heavy diesel trucks that comply with the 75-dBA regulatory level.

Average Annual Operating Costs

By adding the average annual maintenance costs in Table 6-17 to the average changes in annual fuel costs presented in Table 6-14, the average changes in annual operating costs in Table 6-18 are obtained. Using the results for changes in fuel costs in Table 6-15, where savings from more efficient fans and fan clutches are not included, the average changes in annual operating costs given in Table 6-19 are obtained.

The average operating costs for Class I Common Carriers of general freight are $0.129 per truck mile [20]. This cost estimate includes costs for fuel, tires and tubes, repairs and service, but it does not include state and federal fuel taxes. Using the average annual mileage figures in Table 6-13, one can compute the estimates of the average annual operating costs per truck given in Table 6-20. The percent increases in the operating costs, when credit for savings from noise treatments is not taken, are computed from the average annual operating costs and the changes in operating costs in Table 6-19. In computing the averages of the percent changes in operating costs, we weighted the percent changes in operating costs according to the truck population figures in Table 6-4.

Table 6-17
Estimates of Changes in Annual Maintenance Costs

Type of Truck	Changes in Annual Maintenance Costs — Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ 9	$ 19	$ 91	$ 98
Heavy gasoline	19	(38	110	136
Medium diesel	(6)	25	195	277
Heavy diesel........	(20)	32	85	180

Table 6-18
Estimates of Changes in Annual Operating Costs, Including Savings from More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ (35)	$ (54)	$ (13)	$ (4)
Heavy gasoline	(237)	(217)	(145)	(115)
Medium diesel	(65)	(96)	57	142
Heavy diesel........	(258)	(201)	(145)	(21)

Table 6-19

Estimates of Changes in Annual Operating Costs, Excluding Savings from More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ 9	$ 20	$ 92	$ 101
Heavy gasoline	20	40	112	142
Medium diesel	51	86	256	342
Heavy diesel	39	97	152	276

Table 6-20

Percent Increases in Operating Costs Due to Noise Emission Regulations

Type of Truck	Average Annual Operating Costs Per Truck	Percent Increase in Operating Costs Without Credit for Savings from More Efficient Fans, Fan Clutches, and Exhaust Gas Seals			
		83 dBA	80 dBA	78 dBA	75 dBA
Medium gasoline...	$ 1290	0.7%	1.6%	7.1%	7.8%
Heavy gasoline	2322	0.9	1.7	4.8	6.1
Medium diesel	2709	1.9	3.2	9.4	12.6
Heavy diesel......	6966	0.6	1.4	2.2	4.0
Average of all trucks	–	0.7%	1.6%	5.2%	6.4%

Total Increase in Truck User Costs

The total change in costs to the user of a truck which complies with noise emission regulations can be expressed in terms of the present value of the changes in the costs incurred during the life of the truck. In computing the present value of the total change in costs per truck, we discounted the changes in the costs attributed to noise treatments during each year of the truck life at a specified rate of return according to the following equation [7].

$$C = \sum_{n=0}^{m} \frac{\Delta R_n}{(1+i)^n} \qquad \ldots (1)$$

where,

C is the present value of the total change in costs per truck,

ΔR_n is the change in costs in the n^{th} year of the truck life,

m is the total life of the truck in years, and

i is the rate of return on invested capital.

In equation (1) ΔR_0 is the increase in purchase price, ΔR_n, $n = 1, 2, \cdots, m-1$ is the change in annual operating costs (a negative value of ΔR_n indicates savings), and ΔR_m is the change in annual operating costs minus the resale value of the noise treatments on the truck after the m^{th} year of service.

In computing the present value of the total change in costs per truck, we used the following assumptions.

1. The average life of trucks is 10 years [2]; thus, m=10 in equation (1). At the end of 10 years, the value of the noise treatments is zero.

2. During the 10-year life, the average annual mileages for each type of truck is as presented in Table 6-21 [2].

3. For the trucking industry, the rate of return on capital before taxes is 10 percent [18]. Thus, i = 0.1 in equation (1).

With the above assumptions, the present values given here are changes in the total costs or savings before taxes over the life of the truck.

In Table 5-22, the present value of the total change in costs per truck for regulated trucks is presented with fan-on testing and credit for costs and savings for more efficient fans, fan clutches and exhaust gas seals included. If credit for more efficient fans, fan clutches and exhaust gas seals is not included, the present values of the total change in costs per truck in Table 6-23 can be computed. The present values given in Tables 6-24 and 6-25 assuming fan-off testing permitted are estimated by subtracting the differences in the price increases in Tables 6-1 and 6-8 from the present values given in Tables 6-22 and 6-23.

With the average truck prices in Table 6-4, the estimated operating costs of \$0.129 per truck mile [20], and the annual truck mileages in Table 6-21, one can use equation (1) to estimate the present value of the total costs per truck; e.g., for medium gasoline trucks – \$16,779, heavy gasoline trucks – \$28,384; medium diesel trucks – \$23,760, and heavy diesel trucks – \$67,628. The results in Tables 6-22 through 6-25 can be compared to these estimates of total costs to indicate the relative increase in costs per truck associated with noise emission regulations.

Table 6-21
Average Annual Truck Mileage

Age of Truck (Years)	Medium Gasoline (10^3 miles)	Heavy Gasoline (10^3 miles)	Medium Diesel (10^3 miles)	Heavy Diesel (10^3 miles)
1	23	33	30	73
2	20	29	27	67
3	16	25	24	61
4	13	21	22	55
5	11	18	19	50
6	10	16	17	45
7	9	15	15	40
8	8	13	13	37
9	7	12	12	34
10	7	10	11	31

Table 6-22
Present Value of Total Change in Costs per Truck with Fan-On Testing and Credit for Costs and Savings for More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	\$ -283	\$ -365	\$ 7	\$ 402
Heavy gasoline	-1594	-1333	-690	-162
Medium diesel	33	286	1422	2512
Heavy diesel	-1169	-489	111	1346

Table 6-23
Present Value of Total Change in Costs per Truck with Fan-On Testing and Without Credit for Costs and Savings for More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Levels			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ 80	$ 280	$ 848	$ 1243
Heavy gasoline	149	403	970	1494
Medium diesel	724	1373	2475	3595
Heavy diesel	511	1180	1729	3015

Table 6-24
Present Value of Total Change in Costs per Truck with Fan-Off Testing and Credit for Costs and Savings for More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Levels			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ -283	$ -365	$ 7	$ 402
Heavy gasoline	-1604	-1357	-790	-262
Medium diesel	33	271	1422	2512
Heavy diesel	-1200	615	-5	1255

Table 6-25
Present Value of Total Change in Costs per Truck with Fan-Off Testing and Without Credit for Costs and Savings for More Efficient Fans, Fan Clutches and Exhaust Gas Seals

Type of Truck	Regulatory Level			
	83dBA	80dBA	78dBA	75dBA
Medium gasoline	$ 80	$ 280	$ 848	$ 1243
Heavy gasoline	139	377	870	1394
Medium diesel	724	1348	2475	3595
Heavy diesel	480	1054	1613	2924

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Section 7
ECONOMIC IMPACT

This section considers the economic impact of alternate standards and the impact of the time phasing of these standards. Section 6 has already considered the cost per truck. In assessing the impact of 83-, 80-, 78-, and 75-dBA regulatory levels, examined are the expected demand reductions and total cost for the adjusted sales volume for each of the four levels (Price and Quantity Impacts); impact upon truck manufacturers and major suppliers (Impact on Truck and Engine Manufacturers); and, the impact of price and operating cost changes on common carriers and other truck-using sectors (Impact upon Truck-Freight Companies and Financial Impact on the Trucking Industry).

PRICE AND QUANTITY IMPACTS

Price and quantity impacts are given for each successively more stringent noise standard. In each case, the price increases are for the year of proposed enforcement over the 1973 levels. Demand reductions are based on an assumed demand elasticity of -0.7* for all truck types. Tables 7-1 and 7-2 give the reduction in number of units sold and adjusted sales forecast for the first year for each proposed standard. The impacts of the various standards are discussed separately, first, on an initial cost and demand-reduction basis, and then in terms of operating costs. As will be seen, the greatest impact is on the medium diesel truck market; this, however, is the smallest of the four markets being considered.

Initial Costs and Demand Reductions*

Prices used were arrived in Section 6 using a markup of 1.5 x manufacturing cost.

83-dBA Regulatory Level

If a regulated level of 83 dBA is established and testing is permitted with the fan off, the average price increase for medium and heavy gasoline-powered trucks will be $35 each – a 0.6 percent increase over the current price for medium gasoline trucks and $125 for heavy gasoline trucks – 1.1 percent increase over the current price for heavy gasoline trucks. For medium and heavy diesel-powered trucks, the average prices will increase by $426 (or 5.9 percent) and $387 (or 1.5 percent), respectively. The details of the individual elements that make up these costs are presented in Tables 6-1 and 6-7 of Section 6.

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*Appendix C.

Table 7-1
Estimated Reduction in Truck Sales due to Noise Control
(First Year of Each Standard)*

Year of Regulation	Regulatory Level	Type of Truck				Total	Baseline† Projection of Sales (Number of Trucks)
		Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel		
1978	83 dBA	875	296	127	1,729	3,027	428,594
1982	80 dBA	4,759	526	269	3,748	9,032	478,536
1984	80 dBA	4,894	523	277	3,834	9,528	506,758
1984	78 dBA	8,972	883	345	5,598	15,798	506,758
1984	75 dBA	18,079	1,661	530	8,872	29,142	506,758

*Assumes a demand elasticity of -0.7 for all truck types.
†Source, [1].

Table 7-2
Forecast Sales Adjusted for Decrease in Demand

Year of Regulation	Regulatory Level	Type of Truck				Total Number of Trucks
		Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel	
1978	83 dBA	209,393	38,949	3,009	175,966	427,317
1982	80 dBA	215,683	38,250	3,060	212,511	469.504
1984	80 dBA	221,764	38,021	3,152	234,293	497,230
1984	78 dBA	217,686	37,661	3,084	232,530	490,961
1984	75 dBA	208,579	36,883	2,899	229,255	477,616

Assuming that the demand elasticity for all trucks is –0.7, these price increments will result in a reduction in demand of 0.4 percent for medium gasoline trucks, 0.8 percent for heavy gasoline trucks, 4.0 percent for medium diesel trucks, and 1.0 percent for heavy diesel trucks. Table 7-1 shows that adoption of the 83-dBA level would reduce projected truck sales by 2,93? trucks. This reduction is small compared to the baseline sales of 417,325 trucks. Table 7-2 gives the adjusted sales forecast for each category of truck.

It should be noted that the dollar value of sales actually increases, although the number of units sold declines. The increase in dollar sales is the result of the inelastic demand for trucks (i.e., elasticity less than one). Discussion on the impact on trucks and engine manufacturers will present a more detailed discussion of this point.

80-dBA Regulatory Level

With a regulatory level of 80 dBA, prices will increase above 1973 levels by 3.1 percent for medium gasoline, 2.2 percent for heavy gasoline, 11.5 percent for medium diesel, and 2.3 percent for heavy diesel trucks. The price increments (i.e., the differences in cost between an 83-dBA truck and an 80-dBA) will be $145 for medium trucks, $130 for heavy gasoline trucks, $424 for medium diesel trucks, and $233 for heavy diesel trucks. These price increases will result in the demand reductions shown in Table 7-3.

Table 7-3
Percent Demand Reduction due to 80-dBA Regulatory Level*

Type of Truck	Incremental Reduction Due to 83-dBA Standard Percent	Incremental Reduction Due to 80-dBA Standard Percent
Medium gasoline...	0.4	1.7
Heavy gasoline	0.8	0.6
Medium diesel	4.0	4.3
Heavy diesel......	1.0	0.8

* Assumes a demand elasticity of –0.7 for all truck types.

The reductions in demand for heavy gasoline trucks will be about 0.6 percent (third of the reduction for the medium gasoline trucks). Medium diesel trucks will experience a reduced demand of more than 6 times that of the heavy diesel truck market. However, for considerations of impact upon the manufacturing employment or upon the national economy, the medium diesel truck market is the least important because of its small sales. Assuming implementation in 1981, the cumulative reduction in unit sales due to the 80- and 83-dBA regulatory levels would be 4,694 trucks in the medium gasoline market, 527 in the heavy gasoline market, 265 in the medium diesel market, and 3,312 in the heavy market – a total for both markets of 8,798 trucks below present sales levels. Of this total, 2,932 can be attributed to 83-dBA regulatory level and 5,866 to the 80-dBA level. Table 7-2 shows the adjusted sales forecasts.

78-dBA Standard

With a 78-dBA regulatory level, price increases above 1973 levels will be 5.6 percent and 3.3 percent for medium and heavy gasoline trucks and 14.4 percent and 3.4 percent for medium and heavy diesel trucks. The dollar increase in going from 80 to 78 dBA will be $150 for medium gasoline trucks, $125 for heavy gasoline trucks, $209 for medium diesel trucks, and $271 for heavy diesel trucks. The corresponding demand reductions are given in Table 7-4.

Table 7-4
Percent Demand Reduction due to 78-dBA Regulatory Level*

Type of Truck	Incremental Reduction Due to 78-dBA Standard Percent
Medium gasoline. . .	1.8
Heavy gasoline	0.9
Medium diesel	2.0
Heavy diesel.	0.8

* Assumes a demand elasticity of –0.7 for all truck types.

75-dBA Regulatory Level

The incremental cost increase per truck of the 75-dBA regulatory level over the 78-dBA level will be $335 for both medium and heavy gasoline trucks, $565 for medium diesel trucks, and $503 for heavy diesel trucks. Another relevant comparison is the incremental cost between 80 and 75 dBA.

The incremental costs-per-truck of moving from 80 dBA to 75 dBA, then, are $485 for a medium gasoline truck, $460 for a heavy gasoline truck, $774 for a medium diesel truck, and $774 for a heavy diesel truck.

The demand reductions expected to result from the 75-dBA regulatory level are given in Table 7-5. The incremental demand reduction is for going from an 80-dBA level in 1981 to a 75-dBA level in 1983.

Table 7-5
Percent Demand Reduction due to 75-dBA Regulatory Level*

Type of Truck	Incremental Reduction Due to 75-dBA Standard Percent
Medium gasoline. . .	5.9
Heavy gasoline	2.9
Medium diesel	7.6
Heavy diesel.	2.5

* Assumes a demand elasticity of −0.7 for all truck types

As in the case of the other levels considered, the greatest impact will be on medium diesel trucks. While the price increase for heavy diesel trucks is larger in absolute terms than for heavy gasoline trucks, the percentage increase is smaller for heavy diesel than for all types of gasoline trucks. Thus, the demand reduction is smallest for heavy diesel trucks.

Summary

Table 7-6 summarizes the incremental percentage price increases for each of the four regulatory levels considered.

In order to obtain the total percentage price increase for any combination of regulations, simply add the percentage price increases for that combination. For example, the price increases for an 80-, an 83-, and a 78-dBA combination of regulations for heavy diesel trucks is 3.4 percent.

Table 7-6
Incremental Price Increases for 83-, 80-, 78- and 75-dBA Regulatory Levels

Type of Truck	Price Increase (Percent)			
	Present to 83 dBA	83 dBA to 80 dBA	80 dBA to 78 dBA	80 dBA to 75 dBA
Medium gasoline. .	0.6	2.5	2.5	8.3
Heavy gasoline . . .	1.1	1.1	1.1	4.0
Medium diesel . . .	5.8	5.7	2.9	10.6
Heavy diesel.	1.4	0.9	1.1	3.0

Operating Costs

The increase in the initial purchase price of a truck is only one component in the total cost of truck noise control. Noise control will also have an impact on operating costs. Reasons for changes in operating costs and the levels of these changes were dealt with in Section 6 on a per truck basis. Here, briefly considered is the magnitude of cost changes as apportioned over the entire truck population.

The average annual savings in operating costs for the final regulatory level for different regulatory options are given in Table 7.7 for when credit is taken for savings in fuel costs for more efficient fans and fan clutches and for savings in maintenance costs for exhaust gas seals on diesel trucks. The savings in Table 7.7 are computed by taking the operating costs in Table 6-18 for each of the four truck categories and calculating the weighted average savings per truck. The maximum savings occur for options G and E; however, there are still significant savings associated with options C and N.

Total Costs

The total cost impact on truck users is estimated first by a component that represents recovery of the incremental capital invested with interest; and second, one that represents the increased yearly operating costs. Present value computations were utilized in converting estimated incremental investments and operating costs (savings) that occurred through 1991 to a common base year of 1978. These present value figures were then converted to uniform annualized costs by the application of capital recovery costs.* All costs shown in Tables 7-8

* Uniform annualized cost computation represents a method of recovering an initial capital investment over a specified number of years at a specified rate of return by means of uniform-annual payments. (See Appendix E.)

Table 7-7
Savings in Average Operating Expenses with Use of More Efficient Fans and Fan Clutches

Regulatory Option*	Average Saving per Truck Weighted for Distribution of Sales by Truck Category ($)
G	131
E	123
C	70
A	19
N	90

*The options are described in Table 4-1.

and 7-9 assume that there are no technological improvements in methods for noise control. In practice, improvements are likely to occur.

From this point to the end of Section 7 we have adjusted all costs and revenues to 1975 dollars. Tables 1-3 of Appendix D show the new prices used. The factors used for adjustment are based on the Bureau of Labor Statistics' Wholesale Price Index for Truck Prices and Consumer Price Index for Transportation.

Our discussion in this section concentrates on Options A, C, E and N. Calculations were however performed for all options. The figures are given in Appendix E. Capital, Operating and Total Costs for all options can be compared with the revenue figures given in this section.

In Table 7.8, the total annual costs are presented for Options A, C, E and N when credit is taken for the increases in truck prices and savings in fuel and maintenance costs associated with more efficient fans, fan clutches and exhaust gas seals. The highest annual costs are shown for Option A and the lowest for Option E. The annual costs for Options Cand N are similar, with the costs for Option N lower. When credit for the costs and savings for fan treatments and exhaust gas seals is taken, the total annual costs given in Table 7.9 are derived. Savings are shown for all options in every year, except for Option A after 1989.

Table 7-8
Total Annual Costs Without Credit for Costs and Savings for more Efficient Fans, Fan Clutches and Exhaust Gas Seals
(Millions of Dollars)*

Year	Option A	Option C	Option E	Option N
1978	20.5	20.5	20.5	20.5
1979	41.0	41.0	41.0	41.0
1980	61.5	61.5	61.5	61.5
1981	81.9	81.9	81.9	81.9
1982	136.6	136.6	136.6	136.6
1983	190.5	190.5	190.5	190.5
1984	372.6	294.6	243.3	281.5
1985	552.6	397.4	294.8	370.3
1986	730.4	499.0	344.9	456.6
1987	904.4	598.2	393.0	539.7
1988	1,071.2	692.0	436.5	616.6
1989	1,231.8	782.4	478.3	689.6
1990	1,384.8	869.1	518.8	758.7
1991	1,529.8	951.6	557.9	823.5
Uniform Annualized Costs	452	317	225	289

*Table 7-8 is extracted from Appendix E where more detailed information is presented.

Table 7-9
Total Annual Costs With Credit for Costs and Savings for more Efficient Fans, Fan Clutches and Exhaust Gas Seals
(Millions of Dollars)*

Year	Option A	Option C	Option E	Option N
1978....	-118.2	-118.2	-118.2	-118.2
1979....	-227.1	-227.1	-227.1	-227.1
1980....	-325.8	-325.8	-325.8	-325.8
1981....	-414.6	-414.6	-414.6	-414.6
1982....	-481.6	-481.6	-481.6	-481.6
1983....	-539.3	-539.3	-539.3	-539.3
1984....	-466.3	-547.2	-586.7	-560.6
1985....	-385.0	-545.5	-626.4	-573.5
1986....	-297.3	-536.1	-660.8	-580.1
1987....	-206.4	-521.7	-691.6	-582.8
1988....	-119.0	-508.8	-724.3	-587.7
1989....	- 33.9	-495.1	-755.2	-592.5
1990....	- 46.8	-481.8	-784.7	-597.8
1991....	121.0	-471.2	-814.8	-605.8
Uniform Annualized Costs	-307	-446	-523	-475

*Table 7-9 is extracted from Appendix E where more detailed information is presented

IMPACT ON TRUCK AND ENGINE MANUFACTURERS

Two factors of concern in considering the impact on truck manufacturers are the overall level of economic activity in the truck manufacturing industry (e.g., employment and output) and the possible increase in concentration within the industry. In general, the regulation of noise levels of new trucks will not reduce the dollar value of sales (Table 7-12) although the number of units produced will decrease (Table 7-1). Thus, no reduction in employment is anticipated, but rather a probable increase. Labor/output ratios are given in Table 7-10.

Table 7-10
Labor/Output Ratios

SIC Code for Industry	Column 1 $ Value Added per Production Man $	Column 2 $ Value Added per Production Man Hours	Column 3 $ Value Added per Production Man Years
3711: Motor vehicle cars and bodies	$3.46	$20.04	$41,487.32
3712: Truck chassis and trucks	$3.30	$18.94	$38,511.55
3713: Truck and bus bodies	$2.69	$10.06	$19,795.80
3714: Motor vehicle parts and accessories	$2.53	$13.17	$27,577.50

*Source: Census of Manufacturers 1972.

Since revenue dollars are expected to rise in total (due to the increase in prices) additional man-hours are likely to be required. If work is subcontracted to parts and accessories manufacturers who use more man-hours per production dollar, employment is in fact likely to increase more than if additional manufacturing is performed by truck manufacturers. Column 2 of Table 7-10 shows that to generate $18.94 in the parts and accessories industry 1.44 (18.94/13.17) man-hours would be required as opposed to 1 man-hour in the truck chassis industry. Employment is not likely to fall as long as two conditions hold.

1. Elasticity of demand is less than an absolute value of one.

2. Labor/output ratios are at least as high for parts and accessories manufacturers as for chassis and truck manufacturers.

The second concern, the possible increase in industry concentration, also seems unlikely to occur. Small manufacturers appear to be as capable as large manufacturers of meeting the proposed standards. This is particularly true for one small engine manufacturer who is presently producing the quietest diesel engine. Thus, some small manufacturers do not appear to have any cost disadvantage for regulations which will take effect in the more distant future (i.e., 78- or 75-dBA).

Considering the diesel truck market, the changes in market structure brought about by this regulation will most likely be at the level of the engine manufacturer rather than at the level of the truck manufacturer. A key element in the cost of noise control (and thus the price increase in trucks) is engine noise level. As shown in Section 6, noise levels from different engines vary widely. Engines that emit high noise levels will require more extensive treatments, and trucks that use these engines will cost more than trucks using quieter engines. Thus, truck manufacturers will prefer using engines that are inherently quieter.

It should be pointed out that some engine manufacturers also produce trucks, but a number of firms produce either trucks or engines. In the diesel market, Mack, General Motors, * and International Harvester produce both trucks and engines. These three producers account for 35 percent of the medium diesel trucks, and 55 percent of the heavy diesel trucks. Thus, a large part of the output in both the medium and the heavy truck markets is from firms which purchase engines from outside suppliers. It should be noted that General Motors sells engines to other truck manufacturers; all three firms offer trucks which have engines other than the ones they produce. For example, you can buy an International Harvester truck with a Caterpillar engine. Table 7-11 shows the distribution of engine and truck combinations, and Table 7-12 shows the current distribution of output among truck manufacturers.

*General Motors produces Chevrolet and GMC trucks and Detroit Diesel and GMC truck engines.

Table 7-11
Suppliers of Diesel Engines Used by Truck Manufacturers, 1972

Truck Manufacturers	Allis-Chalmers	Cater-pillar	Cummins	Detroit Diesel	GMC	IHC	Mack	Perkings	Scania Vabis	Total
Chevrolet. . . .	–	–	308	3,388	135	–	–	–	–	3,831
Diamond Reo	–	129	2,038	1,040	–	–	–	–	–	3,207
Dodge	–	–	1,046	434	–	–	–	278	–	1,758
FWD	–	1	165	448	–	–	–	–	–	614
Ford	–	9,336	4,759	7,739	–	–	–	–	–	21,834
GMC	–	–	1,255	14,599	609	–	–	–	–	16,463
IHC.	–	747	11,830	14,475	–	2,742	–	628	–	30,476
Mack	22	331	2,612	1,584	–	–	21,121	–	661	26,331
White	44	779	15,513	5,501	–	–	–	–	–	21,857
Others.	–	3,736	8,983	3,999	–	–	–	–	–	16,718
Total	66	15,079	48,509	53,207	744	2,742	21,121	960	661	143,089

Source: reference [1].

Table 7-12
Percent Market Share of New Trucks by Manufacturers, 1972

Truck Manufacturer	Medium Trucks		Heavy Trucks	
	Gasoline	Diesel	Gasoline	Diesel
Chevrolet	23.6%	2.7%	3.8%	2.7%
Diamond Reo. . .	.02	0	2.5	2.3
Dodge	19.8	5.5	8.6	1.1
FWD	*	.2	.7	.4
Ford	28.0	59.7	33.2	13.6
GMC	11.3	8.8	19.4	11.6
IHC	17.2	23.1	29.1	21.2
Mack	0	0	*	19.1
White	0	.06	1.8	15.8
Others	.1	0	.8	12.1

*Less than 0.05 percent.
Source: reference [1].

In the discussion of the impact of the regulation, concentration is on diesel-engine manufacturers rather than truck producers. In the gasoline truck market, firms use primarily their own production engines. In addition, there are few, if any, cost differentials between gasoline truck manufacturers.

Section 6 presented the cost per truck for an 83-, 80-, 78- and 75-dBA regulatory level. These cost estimates were developed for each engine manufacturer. Diesel trucks can be divided into three categories:

1. medium trucks using medium-duty engines,

2. heavy trucks using medium-duty engines, and

3. heavy trucks using heavy-duty engines.

These three categories represent three distinct submarkets. In terms of truck sales, trucks in one category do not generally compete with trucks in another category. For example, heavy trucks used in construction usually have medium duty engines, while line-haul trucks use heavy-duty engines. The selection of engine type in a heavy truck is determined primarily by miles traveled per year.

Presently, there are substantial cost differentials between diesel engine types [4]. The costs of quieting different types will also vary initially. As technology becomes better developed, cost-effective methods will be adopted in preference to relatively ineffective ones. The mix of engines produced in each category will become more cost-effective as competition between manufacturers encourages implementation of better techniques. Over time, differentials between manufacturers of noise control equipment should be reduced. A good example of this behavior was provided by the costs of air pollution equipment, where cost differences between manufacturers were reduced over a period of two or three years.

In addition, though there may be some price differentials (resulting from noise control) among trucks using engines from different manufacturers, the high degree of product loyalty among truck purchasers will minimize any shifts. An additional factor militating against large-scale shifts is that the producer of the quietest heavy-duty diesel engine presently produces very few truck engines, accounting for less than 0.5 percent of current heavy-duty diesel engines for trucks. Thus, a small reduction in demand for engines produced by other manufacturers and a corresponding increase in demand for the quietest engine, would cause a large relative increase in demand for the quiet engine. However, the magnitude of the shift would be small in terms of the entire market.

In the medium-duty engine market, the major disadvantage would be suffered (at the 83-dBA regulatory level) by one manufacturer. This particular manufacturer produces a number of engines which would be used as substitutes for the noisiest engine. Also, given the lead times and this manufacturer's strong position in the market, it seems likely that it can and will reduce the noise level from this engine or develop a new engine to replace it.

In terms of the overall impact on truck manufacturers, Tables 7-1 and 7-2 showed the number of trucks for the baseline and an adjusted sales forecast (with noise control). Although these tables indicated that the number of trucks sold will decrease as a result of higher purchase prices when noise control equipment is added to trucks, the dollar value of sales will actually increase. Table 7-13 gives dollar values for first-year sales for the 83-, 80-, 78-, and 75-dBA regulatory levels and Table 7-14 gives baseline sales. Actual increases in sales are \$39 million in 1978 (with an 83-dBA level); \$64 million in 1982 (with an 80-dBA level); \$68 million in 1984 (with a 80-dBA level); \$100 million (with a 78-dBA level); and \$154 million (with a 75-dBA level) in 1984.

The most probable outcome will be an increase in employment as a result of noise control. If approximately the same amount of labor is required to produce a dollar of output of noise-control equipment as is now required to produce a dollar of output in the truck

Table 7-13
First-Year Sales of Trucks (Millions of 1975 $) under Adjusted Forecast of Demand with Cost of Noise Controls[a]

Year of Regulation	Noise Standard	Type of Truck				Total Sales ($ Billions)
		Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel	
1978 . . .	83-dBA	1,489	554	28	5,534	7.605
1982 . . .	80-dBA	1,572	550	30	6,744	8.896
1984 . . .	80-dBA	1,616	547	31	7,435	9.629
1984 . . .	78-dBA	1,626	547	31	7,456	9.660
1984 . . .	75-dBA	1,642	551	32	7,490	9.715

[a]Adjusted demand computed from baseline figures. See Reference 1.

Table 7-14
Sales of Trucks (Millions of 1975 $) under Baseline Forecase[a] of Demand at Original Cost Without Noise Control in the First Year of the Regulation

Year of Regulation	Type of Truck				Total Sales ($ Billions)
	Medium Gasoline	Heavy Gasoline	Medium Gasoline	Heavy Diesel	
1978 . . .	1,474	552	28	5,512	7.566
1982 . . .	1,558	545	29	6,700	8.832
1984 . . .	1,602	542	30	7,387	9.561

[a]See Reference 1.

industry, then the regulation will stimulate employment. As Table 7-10 shows the output/labor ratio for noise-control equipment is at least the same as the present output/labor ratio for the truck manufacturing industry. Items such as fan clutches, engine enclosures, and exhaust mufflers have physical characteristics similar to other present truck components and are produced in a similar manner.

Each of the proposed levels may have certain unique impacts or potential impacts, and should be considered separately.

Since the proposed 83-dBA regulatory level becomes effective in 1978, the current slump in truck manufacturing may have some relevance to the economic impact. It might be expected that small manufacturers would be particularly affected, as they have less access to capital markets and are less able to bear the cost of new equipment. However, for some of these smaller companies, such as FWD, Auto Car, and Western Star, sales performance was as good or better in 1975 than in 1974[8]. The larger manufacturers such as General Motors and Mack have been hit particularly hard with sales declines.*

For those regulations scheduled to take effect in 1982 and beyond, the current reduction in truck sales affecting the ability of truck manufacturers to finance noise-control investment would not be expected, nor would the slump be expect to persist to 1982. In fact, the economy is now showing signs of recovery. Of course, a short-run cyclincal downturn may occur during any period; this type of event can usually be predicted only one or two quarters in advance.

Thermostatically controlled fans will be introduced to meet the 83-dBA regulation and will also be used under the 80-dBA regulation. Therefore, possible supply problems should be considered. Thermostatically controlled fans are expected to be used in about 50 percent of all truck production (i.e., for most heavy trucks). This corresponds to a demand of about 207,000 thermostatic fans and represents a production rate of about 17,000 fans per month. It is believed that fan manufacturers can increase fan production capacity to meet these demand levels within a lead time of about 1 year.

For redesign and/or manufacturing of special components necessary for the 78- or 75-dBA level, the lead times proposed (i.e., 8 to 10 years) are adequate to ensure a smooth transition to meet these standards.

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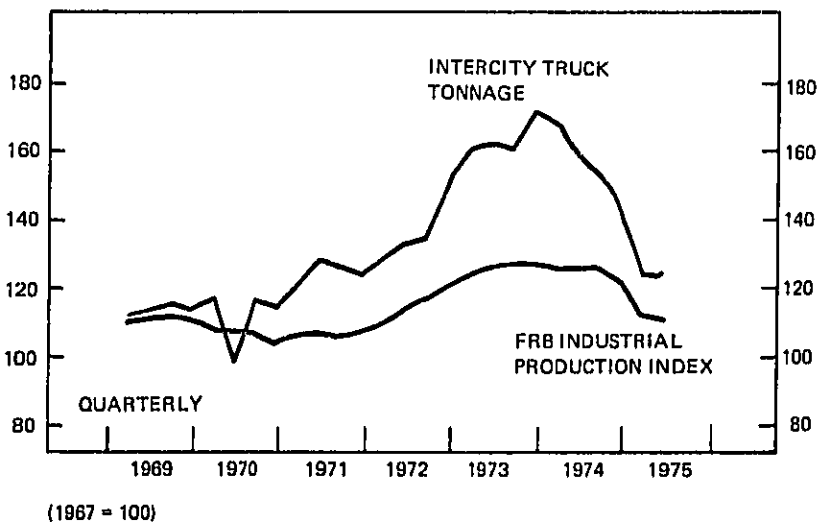
*The less severe decline in sales of small firms reflects the specialized nature of their product. The markets for specialized vehicles have been less severely impacted by the current economic slump.

IMPACT UPON TRUCK-FREIGHT COMPANIES

Current Status of Trucking Industry

Tonnage hauled and earnings for 1975 are expected to fall below the depressed levels of 1974. Production cutbacks and inventory adjustments have led to a sharp decline in truck tonnage since 1973 (Figure 7-1). The volume of freight transportation is closely tied to the

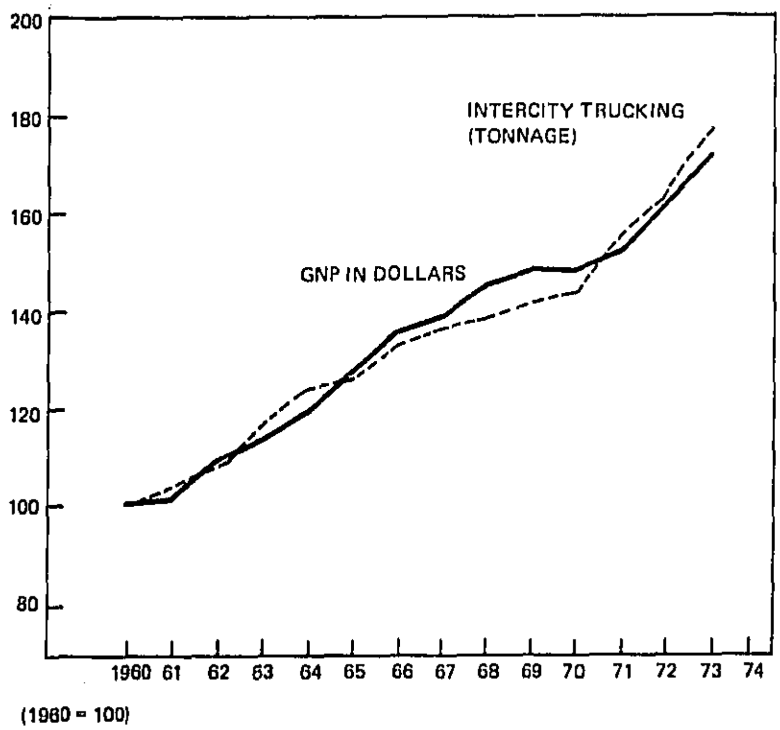


Source: American Trucking Associations

Figure 7-1. Intercity Truck Tonnage

economy (Figure 7-2). Relative to other sectors of the transportation industry, however, trucking has experienced an increase. In 1973, motor carrier revenues accounted for 55.4¢ of every dollar spent for transportation, but this increasing share of transportation business has only partly offset the effects of the economic downturn.

Traffic-related costs represent a substantial percentage of trucking expenditures. When traffic falls, therefore, these costs also fall to some extent. Some increase in costs has been experienced, nonetheless, and rates have been increased to compensate—often with a lag.



Source: Department of Commerce and American Trucking Associations.

Figure 7-2. Relationship Between Trucking and GNF

Recent ICC hearings* indicate an unwillingness to allow rate increases to cover the costs of slack capacity due to the recession.

Rate increases do not necessarily cover all expenses. Increases in labor costs, social security, tolls and other non-labor costs have usually been allowed as the basis for rate increases. Projected non-labor costs are not generally accepted. Such increases may be granted in arrears. Expenses however, cannot always be recouped retroactively. Costs are

*Before the ICC: Justification of Middle Atlantic Conference for General Increases in Rates and Charges. Effective date–July 1 and 8, 1975.

often passes through without markup. Some consideration is beginning to be given to the problems of low rates of return in the industry. The Civil Aeronautics Board's example in allowing rate changes which actually improve profitability has been cited in the ICC hearings*.

Rate increases in truck transportation do not appear to have eroded trucking's market share. Table 7-15 shows the percentage changes in price, ton miles, and market shares for rail and truck since 1969. In 1971-72 and 1972-73 truck prices per ton-mile rose by more than rail prices. In 1971-72 rail prices actually fell. During these two periods, trucking either maintained or increased its market share. Since 1972, this increase has not necessarily been at the expense of rail whose market share was also growing.

Intermodal Competition

The probable extent of a shift away from trucking towards rail varies for different products. A study based on the 1963 Commodity Transportation Survey indicated that the major determinants of modal choice were size and distance of shipment [5]. Shipper group or commodity type was also a key factor, however. Certain commodity groups are likely to consider rail a viable alternative to trucking. Others are likely to find it unacceptable.

Table 7-16 shows the percentages of rail and highway freight by commodity for 1967 and 1972. Water, air, and other types of carriers are excluded to demonstrate the competitive nature of the two modes, thus percentages add to 100.

In paper and allied products; metal cans and miscellaneous fabricated products; electrical products and supplies; motor vehicles and equipment; instruments, photographic equipment, watches and clocks, the share of tonnage going to rail increased between 1967 and 1972. This was probably due in part to the availability of "piggybacking" which has made commodities less susceptible to spoilage and "shrinkage". This is of particular importance for high value goods.

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*Before the ICC: Justification of Middle Atlantic Conference for General Increases in Rates and Changes. Effective date–July 1 and 8, 1975.

Table 7-15
Modal Comparison of Rail and Truck Intercity, 1969-1974

Comparisons	1969	1970	1971	1972	1973	1974
Rail:						
Ton-miles (Billions)	774	768	744	784	858	861
Revenues (Millions)	11,289	11,869	12,730	13,105	14,801	16,936*
Truck:						
Ton-miles (Billions)	404	412	430	470	505	510
Revenues (Millions)	31,383	33,553	37,570	41,690	46,515	50,874*
$ per K ton miles:						
Rail	14.59	15.45	17.11	16.72	17.25	19.67
Truck	77.68	81.44	87.37	88.70	92.11	99.75
Percent of total intercity ton miles (all modes):						
Market Share: Rail	41.03	39.83	38.48	37.77	38.43	38.60
Truck	21.25	21.28	22.18	22.63	22.63	22.90
	1969-70	1970-71	1971-72	1972-73	1973-74	
Percent change:						
Rail price per ton mile	5.90	10.74	(2.28)	3.17	14.03	
Truck price per ton mile	4.84	7.28	1.52	3.84	8.29	
Rail ton-miles	(.78)	(3.13)	5.38	9.44	.35	
Truck ton-miles	1.98	4.37	9.30	7.45	.99	
Rail market share	(2.93)	(3.39)	(1.85)	1.75	.44	
Truck market share	.14	4.23	2.03	.0	1.19	

*Estimated

Sources: Moody's Transportation Manual
M. V. M. A. Truck Facts 1975
Survey of Current Business

Table 7-16
Highway – Rail Distribution by Shipper Group
Percent Distribution Based on Tons

Shipper Group	1967		1972	
	Highway	Rail	Highway	Rail
1. Meat and diary products	72.8	27.2	81.12	18.88
2. Canned and frozen foods and other	39.5	60.5	46.06	53.94
3. Candy, cookies, beverages and tobacco	76.6	23.4	84.52	15.48
4. Textiles and leather products	85.7	14.3	90.18	9.82
5. Apparel and related products	88.9	11.1	90.91	9.09
6. Paper and allied products	48.6	51.4	47.03	52.97
7. Basic chemicals, plastics, synthetics and fibers	37.8	62.2	46.48	53.52
8. Drugs, paints and other chemicals	56.5	43.5	58.96	41.04
9. Petroleum and coal products	69.5	30.5	71.55	28.45
10. Rubber and plastic products	74.0	26.0	75.28	24.72
11. Lumber and wood products except furniture	45.1	54.9	53.41	46.59
12. Furniture, fixture and miscellaneous manufactured products	77.1	22.9	77.57	22.43
13. Stone, clay and glass products	68.0	31.0	76.40	23.60
14. Primary iron and steel products	43.3	56.7	52.25	44.27
15. Primary nonferrous metal products	47.0	53.0	47.40	52.60
16. Fabricated metal products except cans	76.8	23.2	82.29	17.71
17. Metal cans and miscellaneous fabricated metal products	72.2	27.8	62.72	37.28
18. Industrial machinery except electrical	77.7	22.3	79.98	20.02
19. Machinery except electrical and industrial	62.0	38.0	72.85	27.15
20. Communication products and parts	74.5	25.5	85.54	14.46
21. Electrical products and supplies	64.9	35.1	64.43	35.57
22. Motor vehicles and equipment	48.3	51.7	40.46	59.54
23. Transportation equipment except motor vehicles	63.1	36.9	80.14	19.86
24. Instruments, photographic equipment, watches and clocks	85.8	14.5	78.14	21.86

Source: U.S. Bureau of the Census, Census of Transportation, 1967 and 1972 Commodity Transportation Survey

In all shipper groups, other than the five listed, rail reduced and trucking increased its share between 1967 and 1972.

Concentration in the Trucking Industry

The number of I.C.C.-regulated carriers in the United States has declined markedly in recent years—from a total of 3,442 in 1971 to 2,711 in 1974. Most of the decline occurred among special carriers, whose numbers went down by 24.2 percent between 1971 and 1974 (Table 7-17). Within the general-freight carrier market, some substantial shifts occurred.

Table 7-17
Change in Numbers of Carriers 1971 to 1974

Carriers	1971	1974	Change (Percent)
General freight:			
Intercity under $1M......	407	161	-60.4
Intercity over $1M.......	729	791	+ 8.5
Local under $1M	131	64	-51.2
Local over $1M	101	103	+ 2.0
Total	1368	1119	-18.2
Percent of all carriers	39.7	41.3	
Special carriers:			
U.S. common...........	1500	1161	-22.6
U.S. contract	377	330	-12.5
U.S. local..............	197	92	-53.3
Total	2074	1573	-24.2
Percent of all carriers	60.3	58.0	
Grand total, all carriers	3442	2711	-21.2

Source: Trinc's Blue Book 1972 and 1975 (Reference 2).

The total 18 percent numerical decline of this latter group occurred among carriers whose annual revenue is under $1 million. Increases in the numbers of carriers with over $1 million in annual revenue suggest that a number of small carriers grew in size or were merged into larger entities. The declines in the two under-$1-million general freight categories were both greater than 50 percent.

The total number of all carriers both I.C.C. regulated and not, was 15,144 in 1973[6]. This number has probably declined in 1974 and 1975. There were 11,380 carriers with revenues under $300,000 in 1973. Thus, although there are a few very large carriers, there are many small ones. Figure 7-3 shows the distribution of I.C.C.-regulated carriers of general freight. The majority of these have revenues over $1 million but under $10 million.

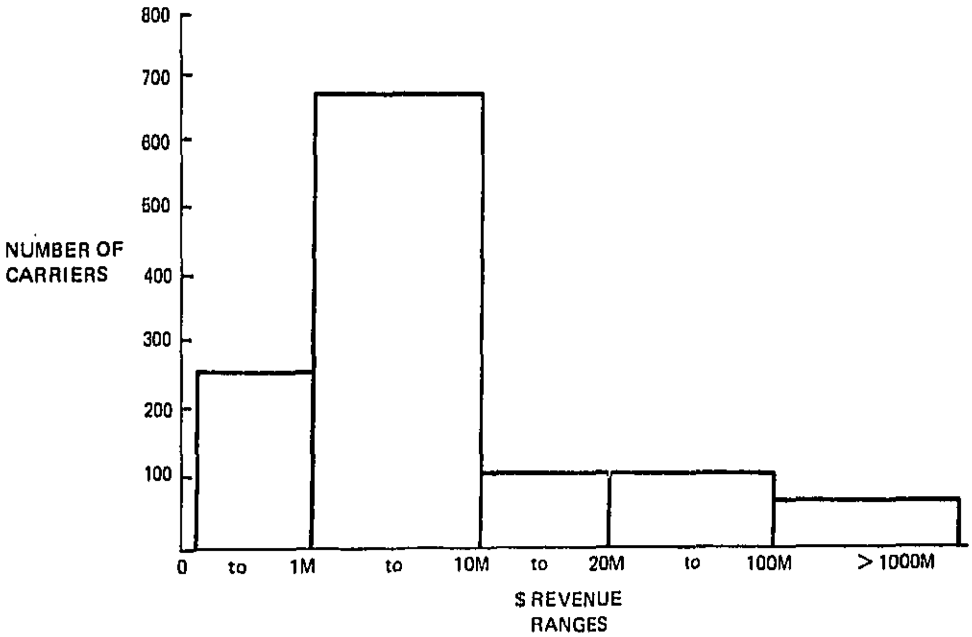

Figure 7.3. Size of I.C.C.-Regulated General Freight Carriers: $\overline{X}$ = 10,597.28.

The I.C.C. regulates all motor carriers holding interstate operating authority. Table 7-18 shows how trucking activity, both private and for-hire, is distributed between all local and inter-city carriers.

Changes in the business and the economic downturn have made it hard for small carriers to operate as many smaller carriers are only marginally profitable. Additional funds have been required for new freight terminals and for computerized routing and billing. Funds for these improvements are not always as accessible to small businesses as to large. New business starts have also been reduced.

Table 7-18
Percentage of Trucking Total

Type of Truck	1965	1970	1980 (Projected)
For-Hire:			
Local	15.2	15.0	15.7
Intercity	32.7	36.2	34.9
Private Trucking:			
Local	34.0	31.5	31.7
Intercity	18.1	17.2	17.7
	100.00	100.00	100.0

Source: Transportation Projections, 1970–1980,
U.S. Department of Transportation

As of January 1, 1974, the classification of carriers was changed so that Class I now includes those whose annual revenues are in excess of $3 million (rather than $1 million). This change reflects both inflation and the trend towards larger entities.

Table 7-19 shows the concentration in each of the six Regional Revenue Bureaus for 1974.

Table 7-19
Percentage of Market Revenues of the Top
Four (4) Carriers Measured by Revenue, 1974

Regional Revenue Bureaus	Revenue of Top 4 Carriers (Percent)
Southern Motor Carriers Conference*	23.04
Rocky Mountain Motor Tariff Bureau	41.25
Middlewest Motor Freight Bureau	15.82
Eastern Central Motor Carriers Association	29.81
Middle Atlantic Conference	14.31
Central & Southern Motor Freight Association	41.01

*1973 data.

Source: Statistics of the 6 Interregional Rate Bureaus,
as established by the Interstate Commerce Commission.

In no region does more than 50 percent of the revenue go to the top four carriers. Concentration is highest in the Rocky Mountain, Central, and Southern regions. It is lowest in the Middlewest. Nowhere does the concentration ratio come close to the Department of Justice definition of high concentration, i.e., four carriers having 75 percent or more of the revenues. Table 7-20 shows how the market share of the top four carriers is distributed.

Table 7-20
Market Share of the Top Four Carriers

Regional Revenue Bureaus	1	2	3	4
Southern Motor Carriers Conference	7.55	6.60	4.49	4.40
Rocky Mountain Motor Tariff Bureau	16.55	9.01	8.09	7.60
Middlewest Motor Freight Bureau	6.08	3.95	2.91	2.88
Eastern Central Motor Carriers Assoc.	12.84	6.07	5.45	5.45
Middle Atlantic Conference	4.22	3.76	3.61	2.72
Central & Southern Motor Freight Assoc.	18.44	8.50	7.77	6.30

Outlook for 1976

As of September 1975 the recession in the trucking industry has apparently bottomed out. The 1974-1975 period saw the most serious reversal in traffic in recent history. This was due to both inventory divestment and the slowdown in production. The trucking industry saw a magnified version of the economy's difficulties. From its peak in November 1974 to the trough in March 1975, truck traffic receded 30 percent. This compares with a decline in total national production of 14 percent from peak to trough. The 1975 truck traffic is expected to be down about 16 to 17 percent from 1974 levels. The 1976 prospects are substantially better. From 1975 levels, truck tonnage is expected to grow 12 to 15 percent in 1976 and revenues to increase by 18 to 22 percent, allowing for an estimated freight rate increase of 8.2 percent. Forthcoming labor negotiations are expected to be followed without delay by an appropriate rate increase. The industry should experience an above-average increase in demand as the economy recovers and inventories are built up. The improved revenue picture should enable many companies to be self-financing for their capital investment in the next few years.

Financial Status of I.C.C.-regulated Carriers

The preceding section indicated a substantial variability in the characteristics of carriers. The following discusses the current status of the I.C.C.-regulated carriers.

Interpretation of Current Status

Table 7-21 shows key financial indicators for the I.C.C. regulated U.S. trucking companies. Financial data for non-I.C.C. regulated companies are not readily available.

- *Operating Revenues* give an idea of the relative size and importance of various sectors. It can be seen that intercity common carriers over-$1-million account for 63 percent of operating revenue for all I.C.C.-regulated companies. If special common carriers are added, we have 91 percent of the total I.C.C.-regulated companies revenue. Local and special contract carriers are thus relatively unimportant.

- *Net Operating Income.** Even when income from operations looks good, a business may be in difficulty, if there are substantial nonoperating or extraordinary expenses, *e.g.*, interest expense or equipment losses. In general, this is a quick indicator of profitability.

Table 7-21
Current Position of I.C.C.-Regulated U.S. Trucking*

	Operating Revenues ($ thousands)	Net Operating† Income ($ thousands)	Number of Power Units	Number of Carriers	Operating Ratio (Percent)	Net Income After Taxes (Percent of Total Operating Revenue)	Current Ratio	Total Assets ($ thousands)	ROI Percent Before Taxes
General freight carriers:									
Intercity Under $1M	121,354	1,875	3,324	161	98.8	1.3	1.15	52,598	3.57
Intercity Over $1M	12,412,015	659,725	185,755	791	94.7	2.9	1.11	5,539,902	11.92
Local Under $1M	44,895	(263)	821	64	101.2	(.6)	1.14	21,478	(1.23)
Local Over $1M	329,219	6,743	3,224	103	99.0	1.5	1.41	185,816	3.63
Special carriers:									
U.S. Common	5,560,939	231,667	106,180	1161	95.9	2.0	1.16	2,358,885	9.82
U.S. Contract	966,254	28,945	18,776	330	97.1	1.3	1.04	424,963	6.81
U.S. Local	95,079	3,683	3,244	92	98.2	2.5	1.31	83,787	4.40
Total special carrier:	6,722,272	264,295	128,200	1573	96.1	1.9	1.14	2,867,635	9.22
Grand total – all carriers	19,669,078	934,085	321,924	2711	95.3	2.5	1.13	8,674,870	10.77

*Source: Trinc's Blue Book (1975)
†See Appendix B for breakdown.

*The definition used is that from Trinc's Blue Book [2]. See Appendix F for detailed breakdown.

- *Power Units* indicates the number of trucks of all types in the carrier industry. This includes light trucks, which represent 10 percent of the trucks used for hire.

- *Carriers* is the number of separate business entities in each category.

- *Operating Ratio* (percent) is a simpler indicator than net operating income of the profitability of incremental revenue. It is calculated by taking operating expenses as a percent of operating revenue. A deficit in net operating income shows up as an operating ratio of greater than 100 percent.

- *Net Income After Taxes (Percent of Total Operating Revenue)* is a general measure of profitability; this includes gains or adjustment to income which do not result directly from operations.

- *Current Assets/Current Liabilities Ratio* is a good indication of the liquidity of a company. If a company has more current assets than current liabilities, it may be "cash rich." The cash situation of those with a ratio less than 1 is generally tight. A ratio less than 1 may reflect good management and an ability to keep debtors from pressing for payment, or it may represent a company in trouble which failed to adjust its expenditures to a decline in revenue.

- *Total Assets* is the sum of all assets. Fixed assets are included at net book value. Book value is a variable measure in the carrier industry. The average life for a truck is 10 years [7]; however, IRS regulations allow trucks to be depreciated faster than this. Therefore, there are a number of fully depreciated trucks generating revenue, and the age of a particular carrier's capital stock will cause this figure to vary. This figure is also affected by the depreciation method used.

- *Return on Investment (ROI): percent (before taxes)* is designed to show the relationship of income to vested capital. The only readily available measure of invested capital is listed in Total Assets. The best available measure of income is Net Operating Income before interest and taxes (see Appendix F for definition). In using ROI as a measure, it is important to remember:

    1 The age of the capital stock and the depreciation method will cause ROI to fluctuate.

    2 ROI is a measure of the *average* return on a group of nonhomogeneous assets, e.g., land, trucks, cash, etc. The returns on each category of assets may be very different.

    3 ROI also measures the return on capital assets acquired over a number of years. This should not be compared directly with the incremental return which is demanded on new capital investment today. Fifteen years ago, 6 percent (after tax) may well have been a reasonable return to expect. Today, 10 percent is more usual.

Analyzing Table 7-21 for each of these variables, one can observe the following:

- Local under-$1-million companies are on the average losing money on operations. Their deficit is 0.6 percent of net income after taxes. Their current ratio, however, is similar to that for U.S. trucking as a whole.

- Special contract carriers typically have a narrow margin between current assets and liabilities, although they are making money on operations.

- Profit margins of trucking companies are characteristically narrow. Total labor costs (including fringe benefits) represent about 60 percent of each dollar of revenue, and scope for increased output per man hour is small. The National Teamster contract expires in March 1976, and, if wage increases are given, higher rates will be needed. Being a regulated industry, rate adjustments may lag cost increases. Despite a number of recent rate increases, a number of which exceeded those of railroads, the overall market share for trucking has continued to rise (Table 7-15). Rate increases have not led to a noticeable fall in traffic.

There is a well-known rule of thumb that a company's current ratio (current assets/current liabilities), should be at least 2:1 and its quick ratio (current assets-inventories/current liabilities), should be at least 1:1. Since inventories are almost negligible for the trucking industry, the current ratio of 1.13:1 is not unreasonable. However, this is not an industry with great liquidity. Delays in approving rate increases therefore have a substantial impact on a carrier's cash position.

Total assets and ROI figures should be used with great care. Fluctuation in these numbers may be only partly due to industry conditions. Taken in aggregate, however, the I.C.C.-regulated industry has a relatively low ROI of 10.77 percent before taxes. Assuming a tax rate of 48 percent, this yields an after tax ROI of 5.6 percent. This is substantially lower than the 10 percent after tax return required for current investment. Municipal bonds, which had been regarded as risk free, yield 8 percent clear of tax, 2 percent is a conservative estimate of the risk premium required for trucking industry funds.

Financial Impact on the Trucking Industry

Assumptions used in assessing impact

1. Initially, it is assumed that all increased costs will be borne by the carrier, rather than passed on as rate increases. This assumption is then relaxed in the discussion of possible rate increases.

2. Trucking industry revenues are assumed to grow at the same rate as GNP.* [Freight activity relates directly to production. As a long run estimate of GNP, 3.5 percent† (real rate adjusted for inflation) seems reasonable despite the decline of recent quarters.]

Table 7-22 projects the revenues, based on these assumptions, for U.S. trucking through 2000. A rate increase that produces a decline in demand could result in a decline in overall revenues. However, it is likely that the demand is highly inelastic** and thus a rate increase would not substantially decrease total revenue. The projections of operating income assume that margins are maintained – i.e., that the operating ratio does not change. §

Revenues and costs are shown in Tables 7-23 and 7-24 for specific years discounted at 10 percent. These tables are computed using Table 7-22 and Appendix E. The use of the discount factor represents the opportunity costs of the funds. However, the percentage which costs represent in a given year is independent of any discounting procedure. Tables 7-25 and 7-26 show the noise control costs as a percentage of revenue and operating income for the years 1981, 1991, and 2000. The costs of any given regulation do not reach a steady percentage of revenue until the entire truck population has come under the given regulation. Where the truck life is 10 years, this will occur 10 years after the regulation is in effect, i.e., in 1992 for Options E and 1994 for Options A, C and N.

It is important to recognize that these percentages are computed for all truck purchasers. The impact on any particular sector is *not* to be found simply by estimating the percentage of trucks purchased by that sector. The truck mix for the sector is critical. Appendix G discusses the procedure for finding the percentage for a given sector. The for-hire sector is shown as an example. The savings and expenses of the regulation are not distributed evenly across all types of truck. Medium-gasoline trucks will experience substantial savings, while medium-diesel trucks will experience greater costs. Thus, savings will be larger than average for agriculture and about average for I.C.C. carriers. The particular mix purchased is thus very critical in assessing the impact on a given sector. Appendix G shows how this can be computed.

7.4.2 Rate Increases for ICC Regulated Carriers

Three questions must be asked concerning rate increases for I.C.C. regulated carriers to cover noise control costs.

1. When will increases be permitted by the ICC?

2. What is the economic impact of a lag in rate increases?

3. How much rate relief will the ICC permit to offset noise control costs?

*There is some evidence that they may grow faster as they become an increasing percentage of the transportation sector.
†3.5 percent is the most conservative percentage used for projections by Department of Transportation in "Transportation 1970-1980 Projections," Office of Systems Analysis and Information (revised March 1973)
**See earlier discussion of intermodal freight competition and Tables 7-15 and 7-16.
§The operating ratio for I.C.C. carriers is assumed to be typical of the industry as a whole.

Table 7-22
Revenue Projections for Trucking (Millions of Dollars)

Type of Trucking	1965 (Actual)	1970 (Actual)	1980* (Projected)	1990* (Estimated)	2000* (Estimated)
1971 ($)					
For Hire:					
Local	5641.979	6875.718	10370.944	14629.253	20635.667
Intercity	12131.258	16571.536	23140.074	32641.388	46043.941
Private Trucking:					
Local	12603.318	14412.456	21019.614	29650.267	41824.666
Intercity	6716.214	7875.583	11756.650	16583.93	23393.291
Total	37092.769	45735.293	66287.282	93504.838	131897.56
1975 ($)**					
For Hire:					
Local	7017.984	8552.616	12900.282	18197.137	25668.881
Intercity	15089.914	20613.178	28783.637	40602.198	57273.46
Private Trucking:					
Local	15677.103	17927.466	26146.024	36881.581	52025.158
Intercity	8354.211	9793.335	14623.944	20628.535	29098.611
Total	46139.212	56886.535	82453.887	116309.45	164066.11

*1990 and 2000 figures are computed as projection from the D.O.T. projected 1980 figures, assuming 3.5 percent real growth in G.N.P. This is the most conservative figure used in the D.O.T. study.

**1975 $ were arrived at using the Department of Labor statistics commodity price index for transportation.

Source: Transportation Projections 1970-1980, U.S. Department of Transportation.

Table 7-23
Revenue Discounted at 10 Percent* to 1977 (Millions of 1975 Dollars)

Type of Trucking	1981	1991	2000*
For Hire:			
Local	10031.4	5455.5	2866.65
Intercity	22382.5	12172.6	6396.19
Private Trucks:			
Local	20331.4	11057.2	5819.07
Intercity	11371.7	6184.5	3249.68
Total	64117.0	34869.9	18322.59

*This rate is used as the cost of capital and opportunity cost for all calculations. It may be high for an industry such as I.C.C. carriers, whose margins are 4.75 percent and whose ROI is 5.6 percent.

Table 7-24
Costs for Particular Years Discounted at 10 Percent* to 1977 (Millions of 1975 Dollars)

Options	1981	1991	2000*
Option A with savings**	(311.5)	35.0	61.8
Option C with savings	(311.5)	(136.5)	(64.3)
Option E with savings	(311.5)	(236.0)	(142.1)
Option N with savings	(311.5)	(175.5)	(103.8)
Option A without savings	61.6	443.1	317.8
Option C without savings	61.6	275.6	193.1
Option E without savings	61.6	161.6	108.8
Option N without savings	61.6	238.5	156.6

*The impact of all regulations has reached a steady state by 2000. Changes are due primarily to growth in the truck population and the variations in the demand for each type of truck.

**Includes costs and savings for more efficient fans, fan clutches and exhaust gas seals.

Analysis of past ICC procedures indicates a variation from "a simultaneous rate increase" to "an 8-week lag." There is only limited information on the economic effects of a lag in freight rate increases. It is likely in 1976 that a 7 percent rate increase will be allowed in May for labor costs, and a .5 percent increase for fuel costs in June. It is estimated that a delay of 5 weeks in these rate increases will reduce second quarter operating ratios by 2.8 percent. This pressure on margins is of a short-term nature and for the year as a whole, the impact is

Table 7-25
Projected Noise Control Costs in Selected Years as a Percentage of Revenue

Options	1981	1991	2000
Option A with savings	(.486)	.100	.337
Option C with savings	(.486)	(.391)	(.351)
Option E with savings	(.486)	(.677)	(.776)
Option N with savings	(.486)	(.503)	(.566)
Option A without savings . .	.096	1.271	1.734
Option C without savings . .	.096	.790	1.054
Option E without savings . .	.096	.463	.594
Option N without savings . .	.096	.684	.855

Table 7-26
Projected Noise Control Costs in Selected Years as a Percentage of Operating Income*

Options	1981	1991	2000
Option A with savings	(10.23)	2.10	7.09
Option C with savings	(10.23)	(8.23)	(7.39)
Option E with savings	(10.23)	(14.25)	(16.34)
Option N with savings	(10.23)	(10.59)	(11.92)
Option A without savings . .	2.02	26.76	36.50
Option C without savings . .	2.02	16.63	22.19
Option E without savings . .	2.02	9.75	12.50
Option N without savings . .	2.02	14.40	18.00

*It is assumed that operating income is 4.75 percent of revenue and that the costs are passed on.

much smaller. Nonetheless, it is important that the rate increases coincide, as nearly as possible, with cost increases. This is particularly true at a time when cash is tight.

The answer to the third question is equally difficult. The percentage by which rates would have to be raised just to cover such costs (assuming there is no loss of market share) is easily computed as:

$$\frac{\text{Annualized Cost of Noise Controls} \times 100}{\text{Annualized Revenue}} = \begin{array}{l}\text{Costs as}\\ \text{percentage}\\ \text{of revenue}\end{array}$$

These are shown in Table 7-25 for 1981, 1991 and 2000. These percentages do not allow for any markup on the incremental costs of trucking services. For this reason, trucker's margins will still be eroded.

Example for ICC Regulated Carriers

If on costs of 19.2 billion suppose an increase of 2 percent is experienced by truckers. If this is passed on completely and no substitution occurs, revenues will become $20.54 billion and operating income will still be $957.44 million. Although this is 4.75 percent of $20.16 billion, it is only 4.66 percent of $20.54 billion. Margins are thus eroded because the cost base is increased. If no markup is allowed, the carriers will, in effect, be asked to put money into noise-control equipment with no return; if a markup is allowed by the ICC to preserve margins, then the inflationary effect of the noise-control equipment will be greater. To preserve existing margins, it would be necessary to multiply the above equation by 1.0499, thereby maintaining a 4.75 percent margin.

Possible Rate Increases for ICC Regulated Carriers

In this section, the assumption that there will be no rate increases to cover increased costs is relaxed. Until 1973, labor costs provided the basis for freight rate increases. Non-labor costs were generally offset by productivity increases. If productivity increases were not completely offset by other costs, rates were raised to offset only part of a wage increase. Since late 1973 however, because of rapid increases in non-labor costs, (e.g., fuel) there have been three non-labor based rate increases. As the discussion earlier indicates, the I.C.C. has traditionally allowed historical non-labor cost increases but not projected ones. Such cost increases eventually are often allowed to be passed through as rate increases without markup.

I.C.C. regulated carriers may have operating margins which are greater or less than the aggregate. If a 4.75 percent markup is allowed by the I.C.C., those whose existing margins are less than 4.75 percent will become more profitable, and vice versa, since the rates are set without regard to individual carriers' characteristics.

Impact on Particular Segments of the Carrier Industry

The impact on the for-hire sector in aggregate is shown in Appendix G. Table 7-21 showed the status of various segments of the I.C.C. regulated industry. It is important, however, to appreciate that there is substantial variation between different carriers in the industry. This may be due to scale, geographical location, route structure, types of freight, etc. Table 7-27 shows mean and standard deviation of operating ratios for I.C.C. regulated companies. As can be seen, the operating ratio gets less favorable as companies get smaller. An operating ratio greater than 100 indicates a company which is losing money on everyday business. If the distribution were normal one would expect substantially more companies to have an operating ratio greater than 100 than turns out to be the case. One explanation is that companies in this

Table 7.27
Operating Ratios: Means and Standard Deviations
for ICC Regulated Companies*

	Mean Operating Ratio	Standard Deviation	Expected Probability of an Operating Ratio > 100+	Actual Percent With Operating Ratio > 100
Class I (over 100M)...	94.8	5.84	0.19	0.045
Class II (20 to 100M)..	95.5	4.95	0.18	0.093
Class III (1 to 20M)	96.2	5.57	0.25	0.185
Class IV (Under 1M)....	99.0	6.76	0.44	0.370

*1974 Statistics, Source: Trinc's Blue Book (1975) [2].
+Based on a normal distribution of operating ratios

position may already have stopped operations and are no longer reporting to the I.C.C. It should be remembered also that there are other factors (e.g., ability to decline unprofitable business) that make it likely that the distribution is skewed to the favorable side of the mean. Companies with a deficit from operations are likely to remain in business only for a limited time. There are strong indications that in 1975 carriers' margins were lower than indicated here.

Table 7-28 shows the current position for some selected companies* indicating that there is substantial variation from the averages shown in Table 7-21. It is most important, therefore, that concern not just with the aggregate impact on all trucking, but with the specific impact on individual groups is given. Appendix G shows how this can be done for an industry group. The substantial variation between I.C.C. regulated carriers will cause any regulation to be nonhomogeneous in its impact. Although the aggregate impact on an industry is important, it is also critical to observe which segments of that industry will be affected to a greater or lesser degree than the average.

*These companies were selected as representative of types within each group rather than by a segmented random sampling procedure. A statistical check was run to ascertain the representativeness of the companies selected. This check used a revenue-based weighting scheme. Because of the weight given to Class I and the nonstatistical nature of the sample, Table 7-28 is compatible with a total population having an operating ratio of 91 percent and a current ratio of approximately 1.18. These figures indicate that Table 7-28 represents a somewhat more favorable situation than is actually present. The true population has an operating ratio of 95.4 percent and a current ratio of 1.13 (Table 7-21) and comparison with Table 7-27 also indicates this. Table 7-28 should therefore be used with caution.

Table 7-28 contains information similar to that in Table 7-21, but for four classes within the the industry. Comparison of the two tables shows substantial deviations from the average. Two of the companies shown are already running a deficit; net operating income is negative, and the operating ratio is over 100. Any additional financial burden could cause financial distress to companies in this position. Even if these companies could raise the financing for noise controls, they may not be able to support the payments. It is important to observe that these companies are medium or small and privately owned. It is this type of carrier which may experience hardship. Table 7-21 shows that, taken together, local general freight carriers under $1-million are in deficit. This group is probably the most vulnerable to increased costs of noise control, even if able to pass these increased costs on via increased rates.

Computed returns on investment described for Table 7-21 is also shown in Table 7-28 and should be used with great care. The age and mix of capital equipment varies greatly from one company to another. As can be seen, ROI fluctuates a great deal. The ability to expend the necessary funds for noise control equipment will depend both on the economic outlook for the industry, and the existing financial position of any particular carrier. The short-term outlook for the industry is rapidly improving (outlook for 1976). Even companies whose condition appeared poor in 1974 may be able to provide substantial internal funds for investment by 1978. A good indicator is a substantial improvement in operating ratios.

If outside financing is required, the ability to borrow money will depend on a number of factors:

- Existing leverage,
- Timing of present debt retirement,
- Access to money markets, e.g., stock market for public companies,
- Other sectors' demands on the money markets,
- Prevailing interest rates, and
- Certainty of future profitability ensuring repayment.

These factors differ substantially for individual companies. The small and medium private companies may have the most difficulty in raising funds. Smaller, newer companies are usually found in Classes III and IV and as shown earlier concentration is increasing. If new entrants are discouraged or their growth is inhibited, this is likely to continue.

Table 7-28
Current* Sample Position of U.S. General Freight Trucking Companies

Revenue Class	Operating Revenues ($ thousand)	Net Operating† Income ($ thousand)	No. of Power Units	Operating Ratio (percent)	Net Income After Taxes (Percent of Total Operating Revenue)	Current Ratio	Total Assets ($ thousand)	ROI percent Before Taxes
I. (Over 100 M)								
A. Consolidated Freightways	426,175	33,833	5,019	92.1	4.6	0.85	221,814	15.25
B. Roadway Express	504,375	60,500	2,324	88.0	7.0	1.63	243,901	24.81
C. Yellow Freight	351,385	43,789	4,736	87.5	6.9	1.09	209,879	20.86
D. Lee Way	113,315	8,548	593	92.5	3.8	1.17	63,895	13.38
E. Smith's Transfer	126,295	10,584	2,255	91.6	3.8	.87	81,781	12.94
II. (20 to 100 M)								
A. Hall's Mtr. Transit Company	73,204	7,334	1,115	90.0	2.2	.72	44,691	16.41
B. Gordon's	63,734	3,534	889	94.5	2.8	1.41	34,869	10.14
C. Mid-American	36,088	281	607	99.2	.1	1.67	18,225	1.54
D. Milne Truck Lines	28,287	1,922	489	93.2	5.4	1.01	8,286	23.20
III. (1 to 20 M)								
A. Link Trucking	1,019	107	29	89.5	7.0	1.22	544	19.67
B. Pic-Walsh Freight	10,653	(574)	16	105.4	10.7§	3.05	3,969	(14.46)
C. Suwak Trucking	9,011	113	163	98.5	.9	1.79	1,617	8.23
IV. (Under 1 M)								
A. M&G Transportation	562	(21)	7	103.7	(3.2)	.55	182	(11.54)
B. Heding Truck Service	688	78	25	88.6	6.4	.84	285	27.37
C. Heartland Express	563	17	10	96.9	10.1	2.57	1,122	1.52

*1974 Statistics, Source: Trinc's Blue Book (1975) [2].
†See Appendix B for breakdown.
§A special tax credit causes this number to be positive despite the deficit on operating income.

Impact on Users of Transportation Services

The impact of the noise control program on end users can be measured by the price increases that would result if truck freight rates are increased. Table 7-29 shows both direct and indirect truck transportation inputs for the commodities listed. The first column shows the cents of truck transportation per dollar of output for each commodity for both for-hire and private trucking. For example, commodity 8, food and drugs, requires 5.7¢ of truck transportation per dollar of sales. The 5.7¢ reflects all truck transportation inputs for raw materials, intermediate inputs, and the final product. The second column shows the relative importance of trucking in each sector. The four right-hand columns show the change in selling price, which results from Options A, C, E and N in 1991 and 2000. The rate used was computed from the increase (decrease) in total costs as a percentage of revenue. Savings result from Options C, E and N through the year 2000. The complete effect of an option will not be felt until 10 years after its initiation, when the entire truck population will have turned over. The figures for 1991 price increases should be viewed accordingly. By 2000, the entire population will be subject to the option under consideration. These figures therefore indicate the level at which costs will reach a steady percentage.

It is important to note that the percentage used is an aggregate figure. A more precise figure for each commodity can be arrived at by using the procedure to compute the exact percentage cost increase for each sector as described in Appendix G.

Table 7-29 assumes no shifts to other forms of transportation due to the price increase.

Impact on truck purchases

Truck price increases and operating cost increases will affect the private trucking sector as well as the for-hire sector. Table 7-29 presents the price increases that anticipated in 35 sectors of the economy and included both for-hire and private trucking.

To assess the relative impacts within the private trucking sector, the distribution of future truck purchases by end users must be considered. It is assumed that distribution of future purchases of truck type by end-user category will be in proportion to the present distribution of truck ownership. Table 7-30, presenting the 1972 distribution of ownership by truck type, can be interpreted as the best estimate of distribution of future truck purchases.

For medium diesel trucks, the operating and capital cost increases are the largest. Excluding the for-hire sector already considered, the largest purchasers of medium diesel trucks are the construction and service sectors. These two account for about 39 percent of current ownership, and estimates will account for 39 percent of future purchases. While these sectors will experience cost increases in trucking services, the dollar value of trucking services

Table 7-29
Truck Transportation Costs per Dollar of Final Demand in Various Industries
(Fan Savings Are Included As Rates Would Be Adjusted to Allow for These)

Industries	Current† (1972) Cents per $1 Demand	Trucking† as a Percentage of Transportation $ for All Modes	Increase (Decrease) in Cents per Dollar Demand Due to Noise Control							
			1991 Option A	1991 Option C	1991 Option E	1991 Option N	2000 Option A	2000 Option C	2000 Option E	2000 Option N
1. Agriculture	7.1	74.7	.0071	(.0278)	(.0481)	(.0357)	.0239	(.0249)	(.0551)	(.0402)
2. Iron ore mining	4.7	17.2	.0047	(.0184)	(.0318)	(.0236)	.0158	(.0165)	(.0365)	(.0266)
3. Nonferrous mining	9.7	59.5	.0097	(.0379)	(.0657)	(.0488)	.0327	(.0341)	(.0753)	(.0549)
4. Coal mining	8.3	27.5	.0083	(.0324)	(.0562)	(.0417)	.0280	(.0291)	(.0644)	(.0470)
5. Miscellaneous mining	59.7	77.8	.0597	(.2334)	(.4042)	(.3003)	.2011	(.2095)	(.4633)	(.3379)
6. Construction	4.4	62.0	.0044	(.0172)	(.0298)	(.0221)	.0148	(.0154)	(.0341)	(.0249)
7. Ordnance	3.0	63.8	.0030	(.0117)	(.0203)	(.0151)	.0101	(.0105)	(.0233)	(.0170)
8. Food and drugs	5.7	67.1	.0057	(.0223)	(.0386)	(.0287)	.0192	(.0200)	(.0442)	(.0323)
9. Textiles and apparel	4.2	77.8	.0042	(.0164)	(.0284)	(.0211)	.0142	(.0147)	(.0326)	(.0238)
10. Lumber and products	5.2	38.5	.0052	(.0203)	(.0352)	(.0262)	.0175	(.0182)	(.0404)	(.0294)
11. Furniture	4.0	59.7	.0040	(.0156)	(.0271)	(.0201)	.0135	(.0140)	(.0310)	(.0226)
12. Paper and paper products	4.9	46.7	.0049	(.0192)	(.0332)	(.0246)	.0165	(.0172)	(.0380)	(.0277)
13. Printing	2.8	63.6	.0028	(.0109)	(.0190)	(.0141)	.0094	(.0098)	(.0217)	(.0158)
14. Chemicals	6.1	56.5	.0061	(.0238)	(.0413)	(.0307)	.0206	(.0214)	(.0473)	(.0345)
15. Plastic, paints and rubber	4.3	64.2	.0043	(.0168)	(.0291)	(.0216)	.0145	(.0151)	(.0334)	(.0243)
16. Petro and products	4.5	47.9	.0045	(.0176)	(.0305)	(.0226)	.0152	(.0158)	(.0349)	(.0255)
17. Stone, clay, glass products	8.4	65.6	.0084	(.0328)	(.0569)	(.0422)	.0283	(.0295)	(.0652)	(.0475)
18. Iron and steel	3.6	43.4	.0036	(.0141)	(.0244)	(.0181)	.0121	(.0126)	(.0280)	(.0204)
19. Nonferrous metal	3.3	52.4	.0033	(.0129)	(.0223)	(.0166)	.0111	(.0116)	(.0256)	(.0187)
20. Fabricated metal	3.0	57.7	.0030	(.0117)	(.0203)	(.0151)	.0101	(.0105)	(.0233)	(.0170)
21. Farm, Construction machinery	3.7	53.6	.0037	(.0145)	(.0250)	(.0186)	.0125	(.0130)	(.0287)	(.0209)
22. Industrial machinery	3.3	60.0	.0033	(.0129)	(.0223)	(.0166)	.0111	(.0116)	(.0256)	(.0187)
23. Electrical machinery	2.4	61.5	.0024	(.0094)	(.0162)	(.0121)	.0081	(.0084)	(.0186)	(.0136)
24. Motor vehicles	3.5	51.5	.0035	(.0137)	(.0237)	(.0176)	.0118	(.0123)	(.0272)	(.0198)
25. Aircraft	1.7	60.7	.0017	(.0066)	(.0115)	(.0086)	.0057	(.0060)	(.0132)	(.0096)
26. Other transportation equipment	3.5	57.4	.0035	(.0137)	(.0237)	(.0176)	.0118	(.0123)	(.0272)	(.0198)
27. Scientific optical institute	4.7	87.0	.0047	(.0184)	(.0318)	(.0236)	.0158	(.0165)	(.0365)	(.0266)
28. Communications	.8	72.7	.0008	(.0031)	(.0054)	(.0040)	.0027	(.0028)	(.0062)	(.0045)
29. Utilities	2.4	39.3	.0024	(.0094)	(.0162)	(.0121)	.0081	(.0084)	(.0186)	(.0336)
30. Services	3.6	83.7	.0036	(.0141)	(.0244)	(.0181)	.0121	(.0126)	(.0279)	(.0204)
31. Auto repairs	2.1	61.8	.0021	(.0082)	(.0142)	(.0106)	.0071	(.0074)	(.0163)	(.0119)
32. Government enterprises	3.5	38.5	.0035	(.0137)	(.0237)	(.0176)	.0118	(.0123)	(.0272)	(.0198)
33. Bus, travel, gifts	5.9	68.6	.0059	(.0231)	(.0399)	(.0297)	.0199	(.0207)	(.0458)	(.0334)
34. Miscellaneous manufacturing	9.4	74.0	.0094	(.0368)	(.0636)	(.0473)	.0317	(.0330)	(.0729)	(.0532)
35. Scrap sales	1.8	10.8	.0018	(.0070)	(.0122)	(.0090)	.0061	(.0063)	(.0140)	(.0102)
Percent increase used			.100	(.391)	(.677)	(.503)	.337	(.351)	(.776)	(.566)

†Source for these columns is 1972 National Transportation Report [3].
Note: The four right-hand columns indicate the increase (decrease) in cents per $1 demand due to noise control regulations.

Table 7-30
Percent of Size Class in Each Industry Category

Industries	Medium Gasoline	Medium Diesel	Heavy Gasoline	Heavy Diesel
Agriculture	36.57	9.33	16.89	4.45
Forestry and lumbering	1.89	1.19	3.65	3.54
Mining	.82	1.09	1.67	1.87
Construction	1.22	24.95	21.07	15.91
Manufacturing	3.68	7.93	6.73	10.17
Wholesale and retail	22.41	2.48	21.43	14.67
For Hire	7.19	27.99	17.77	45.12
Personal transportation	9.43	.21	1.63	.05
Utilities	3.19	.43	2.89	.53
Services	10.33	14.23	3.77	1.48
All other	3.27	10.18	2.52	2.22
Total	100	100	100	100

Source: Computer tapes for 1972 census of transportation, truck inventory, and user survey.

consumed by these sectors is small. Table 7-29 shows that the direct and indirect purchasers account for only 4.4 cents per dollar of final demand in construction and 3.6 cents per dollar of final demand in the service sector.* Negligible impact is anticipated because of the small proportion of trucking costs to total costs.

Including the for-hire sector along with the two mentioned above, these three sectors account for 67 percent of medium diesel truck ownership (and thus future purchases).

The price increases per truck, ranging from $42 at 83 dBA to $800 at 75 dBA for medium gasoline trucks and $151 at 83 dBA to $866 at 75 dBA for heavy gasoline trucks, are offset (fully or in part) by operating cost savings. These operating cost savings include fuel savings from treatment of fan noise. The major users of heavy gasoline trucks are wholesale and retail

*Note the cents per dollar of final demand include both direct and indirect trucking services. The large volume of medium diesel trucks referred to in these industries is used in direct trucking services; thus, the impact would be even smaller than these figures would indicate.

trade (21 percent), agriculture (17 percent), and construction (21 percent). Of these three sectors, agriculture is the largest user of truck transportation, as measured by the truck transportation costs per dollar of final demand. Again, no significant cost increases in these sectors are anticipated particularly given the small price increases relative to the large operating cost savings.

Agriculture, wholesale and the retail trade account for almost 60 percent of the medium gasoline truck ownership.

The for-hire sector has been considered separately, and this sector accounts for 45 percent of heavy diesel trucks. The other major users are construction (16 percent), wholesale and retail (15 percent), and manufacturing (10 percent) (Table 7-30).

The mining sectors have substantial truck transportation costs. However, although a relatively small number of trucks is owned by that sector, costs per dollar of final demand are 4.7¢ for iron ore mining, 9.7¢ for nonferrous mining, 8.3¢ for coal mining and 59.7¢ for miscelleneous mining.

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Section 8
ENFORCEMENT

GENERAL

Enforcement of new product noise emission standards applicable to new medium and heavy trucks will be accomplished through production verification testing of vehicle configurations, assembly process testing using selective enforcement auditing of production vehicles and in-use compliance programs. The predominant portion of any production verification testing and assembly process vehicle testing will be carried out by the manufacturer and audited or confirmed by EPA personnel as necessary.

Any test used for production verification testing and any test used for assembly process testing of production vehicles should be the same test or else correlative so that compliance may be accurately determined. A measurement methodology used both for production verification testing and assembly process testing of medium and heavy trucks is a modified version of the SAE standard test procedure J366b.

PRODUCT VERIFICATION

Production verification is the testing of early production models by a manufacturer or by EPA to verify that a manufacturer has developed the necessary noise attenuation technology and is capable to applying the technology in a manufacturing process.

Production verification does not involve any formal EPA approval or issuance of certificates subsequent to manufacturer testing, nor is any extensive testing required by EPA. A vehicle configuration must undergo production verification prior to or soon after its distribution into commerce.

Like configurations may be grouped into a category as defined in the regulations. A vehicle model would be considered to have been production verified after the manufacturer has shown (based on the application of the noise measurement testing methodology) that a configuration or configurations of that model conform to the standard. Production verification testing of all configurations produced by a manufacturer may not be required if a manufacturer can show that the noise levels of some configurations in a category are consistently higher than others in a category. In such a case, the noisiest configuration would be the only configuration requiring verification. Manufacturers must reverify whenever they implement engineering changes to their products that are likely to adversely affect noise emissions. Additionally, some further testing on a continuing or other periodic basis of production products will be necessary to assure that all products manufactured conform to the standards.

Product verification provides EPA with confidence that production models will conform to the standards and also limits the possibility that non-comforming vehicles will be distributed in commerce. If the possibility exists that subsequent models may not conform to the standard, assembly process vehicle testing may be made a part of the enforcement strategy in order to determine whether production vehicles continue to actually conform to the standard.

ASSEMBLY PROCESS TESTING

Assembly process testing of production vehicles is a method where vehicles are tested upon completion of assembly to determine whether they conform to applicable standards. For this determination, only representative samples of newly-produced vehicles need be tested and inferences can be drawn regarding the conformity (with the standard) of other newly assembled vehicles.

Sample testing will involve the auditing of production vehicles on some random basis.

Any sampling strategy adopted by EPA does not attempt to impose a quality control or quality assurance scheme upon a manufacturer but would merely audit the conformity of his products and provide a deterrent to the distribution in commerce of non-conforming products.

Without some justification to the contrary, 100 percent testing is unnecessary, since sample testing can yield the desired result. At this time, 100 percent testing is not proposed as a primary enforcement tool; however, 100 percent testing may be required should an audit show that a manufacturer is in violation of the regulation by introducing in commerce vehicles exceeding the standards.

ENFORCEMENT ACTION

The prohibitions in the Act would be violated in the following instances:

- The manufacturer fails to properly verify the conformance of production vehicles,

- On the basis of assembly process testing or other information, it is determined that non-conforming production vehicles are knowingly being distributed into commerce, or

- The manufacturer fails to comply with an Administrator's order specifying appropriate relief where non-conformity is determined.

REMEDIES

In addition to the criminal penalties, fines, and imprisonment, associated with violations of the prohibitions of the Act, the Administrator has the option of issuing an order specifying such relief as he determines necessary to protect the public health and welfare. Such orders could require that a manufacturer recall products distributed into commerce not in conformity with the regulations whether or not the manufacturer had knowledge of the non-conformity. Recall orders will be issued in situations where assembly process testing demonstrates that vehicles of a particular configuration have been distributed in commerce not conforming with the applicable emission standards.

The Administrator may also issue an order requiring the manufacturer to cease distribution in commerce of vehicles where the requirements of production verification have not been met.

Any orders would be issued only after manufacturers had been afforded notice and an opportunity for a hearing.

LABELING

The label will provide notice to buyers and users that the product is sold in conformity with the regulations and that the vehicle is equipped with noise attenuation devices, which should not be removed or rendered inoperative, as prohibited under Federal law. The label also states that the use of a product which has been "tampered with" is prohibited.

IN-USE COMPLIANCE

If the goal of protecting the public health and welfare is to be fully achieved, the noise levels of vehicles (which cannot be exceeded at the time of sale) must not increase during the useful life of the vehicle except possibly minimal allowance for degradation which cannot be prevented by reasonable maintenance and repair. The standard, therefore, should incorporate an in-use standard that must not be exceeded during the useful life. However, little data is available to determine the useful life of vehicles or what amount of degradation can be expected during their useful life. Thus, EPA has chosen not to promulgate a useful life standard at this time, but has reserved this option until sufficient data is available to impose such a standard. The delay in promulgating this requirement should not be construed as a deemphasis of this important requirement, but merely as a means to assure that an accurate and fair useful life requirement may be imposed.

The manufacturer is required (by Section 6(d) (1) of the Act) to warrant to the first purchaser and each subsequent purchaser that the vehicle was designed, built, and equipped to conform at the time of sale to the Federal noise emission standards. Thus, the manufacturer is required to remedy all defects in design, assembly, or in any part or system, which at the time of retail sale caused the Federal noise emission standard to be exceeded. Although the warranty covers only date-of-sale nonconformity, the consumer may make a claim under the warranty at any time during the life of the product, as long as he can establish noncompliance on the date of sale.

Recall is the appropriate remedy (under Section 11(d) (1)) to require the manufacturer to repair or replace a class of vehicles which fails to conform to Federal standards at the time of sale. Such recall may be used, for example, when products in use are discovered with defects relating back to the date of sale which would cause noncompliance.

Tampering with (i.e., removing or rendering inoperative) the noise control devices and elements of design is prohibited under Section 20(2) (A) of the Act. The use of a product after it has been tampered with is also prohibited.

Finally, manufacturers can be required (under Section 6 (c) (1)) to provide instructions to purchasers specifying the maintenance, use, and repair necessary to minimize or eliminate any possible degradation from the initial noise emission levels.

Section 9
ENVIRONMENTAL EFFECTS

Whenever action is taken to control one form of environmental pollution, there are possible spinoffs affecting other environmental factors or natural resource. This section evaluates the effects of truck noise control on air and water pollution, solid waste disposal, energy and natural resource consumption, and land-use.

The principal sources of truck power train noise are the fan, engine, and exhaust. Fan noise control involves the use of large, slower-turning fans, and fan clutches that disengage the fan entirely when cooling requirements for the engine are satisfied. Engine noise control is achieved by vibration-isolating the engine and employing engine barriers or enclosures. Exhaust noise is controlled through the use of more effective mufflers.

AIR

The major potential effect on air pollution from the noise control measures described above would be an increase in engine exhaust emissions as a result of an increase in exhaust system backpressure [1]. Truck exhaust mufflers have been designed and tested that adequately reduce exhaust noise without exceeding engine manufacturers backpressure specifications. Accordingly, no increase in air pollution is to be expected from noise control related to exhaust mufflers. Air intake systems modifications, should they be necessary, are not expected to result in any change in vehicle performance or increased exhaust emissions.

WATER AND SOLID WASTE

There are no significant impacts that would apparently result from truck noise control on either water quality or solid waste disposal.

ENERGY AND NATURAL RESOURCE CONSUMPTION

There are three factors where noise controls affect energy consumption. The first and major factor is the use of fans that can be disengaged when not required. Bender et al [1] developed the following estimates of fuel savings in gallons per mile per unit of accessory horsepower (Table 9-1).

Table 9-1
Fuel Savings, Gallons Per Mile Per Unit of Accessory Horsepower

Engine Type	Truck Category	
	Medium	Heavy
Gasoline	0.0035	0.0019
Diesel	.0019	.0010

Also, the following annual mileages by truck category apply* (Table 9-2).

Table 9-2
Annual Mileage, Gallons Per Mile Per Unit of Accessory Horsepower

Engine Type	Truck Category	
	Medium	Heavy
Gasoline	10,000	18,000
Diesel	21,000	54,000

Finally, the number of trucks that are predicted to be in use in 1990 [2] are shown in Table 9-3.

*Data reduced from U.S. Bureau of Census, 1973.

Table 9-3

Trucks in Use in 1991

Truck Type	Model Years	Estimated Population in 1990
Medium Gasoline	1978 - 1981	376.2×10^3
Medium Gasoline	1982 - 1983	277.3×10^3
Medium Gasoline	1984 - 1991	$1,497.4\times10^3$
Heavy Gasoline	1978 - 1991	354.0×10^3
Medium Diesel	1978 - 1981	5.3×10^3
Medium Diesel	1982 - 1983	3.7×10^3
Medium Diesel	1984 - 1991	24.3×10^3
Heavy Diesel	1978 - 1991	$2,469.2\times10^3$

Table 9-4

Decrease in Accessory Power Requirements

Truck Type	Regulatory Levels	Power Savings (hp)
Medium Gasoline	83dBA	2.5
Medium Gasoline	80dBA	4.5
Medium Gasoline	78 and 75dBA	6.0
Heavy Gasoline	83, 80, 78 and 75 dBA	15.0
Medium Diesel	83dBA	5.0
Medium Diesel	80dBA	9.0
Medium Diesel	78 and 75dBA	12.0
Heavy Diesel	83, 80, 78 and 75dBA	15.0

Combining the data in Tables 9-1, 9-2 and 9-3 as well as the estimated power savings given in Table 9-4 (also see Table 6-8) shows that under regulatory options A, C and N approximately 2.59 billion gallons of fuel would have been saved by 1991, and under regulatory option E, 2.50 billion gallons.

The second energy effect factor might involve decreases in engine efficiency as a result of increased exhaust system backpressure. Since exhaust systems can generally be made to meet engine manufacturers backpressure specifications, any effect on fuel consumption in this area is expected to be minor (see Section 6).

A third energy effect factor on fuel consumption is the increased truck-rolling resistance attributable to the weight of noise control materials varies from a few pounds for larger mufflers to potentially several hundred pounds for an engine enclosure. Estimates of increases in fuel consumption attributed to increases in weight for noise treatment given in Section 6 show that the added weight has a small effect on fuel consumption.

Effects on the consumption of other natural resources are expected to be small. As indicated, no more than the addition of several hundred pounds per truck are likely to be required for noise treatment. This is a small fraction of the roughly 25,000 to 30,000 lbs per tractor/trailer vehicle.

LAND-USE

The expected impact of this Federal new truck regulation on land-use would reduce marginal capital damages on property bordering highways and streets. In a recent report, Nelson indicated that "traffic noise has a negative and statistically significant effect on property value" [3].

Nelson found that for suburban areas, marginal capital damages were $58 per property per dBA above the residual level (L_{10} - L_{90}). These results were based only on individual property sales in close proximity to major highways.

REFERENCES

[1] BENDER, E. K., W. N. PATTERSON and G. E. FAX. The technology and costs of quieting medium and heavy trucks, BBN Report 2710. Bolt Beranak and Newman, Cambridge, Mass. (October 30, 1974).

[2] MILLER, D. C. Equations used for truck population models, BBN memo to Charles T. Molloy, EPA/ONAC (May 23, 1974).

[3] NELSON, J. P. Effect of mobile-source air and noise pollution on residential property value, Report No. DOT-OS-40094. Department of Transportation, Office of University Research, Washington, D.C. 20590 (January 1975) p.7-21.

Appendix A-1
INTRODUCTION TO DOCKET ANALYSIS

This analysis is intended to serve as a review of the public comments which were made regarding the New Medium and Heavy Truck Proposed Regulation, published in the *Federal Register* on October 30, 1974.

The analysis is structured as follows:

In the Summary of Comments (Section A-2), each issue is identified by a number or series of numbers. The individual comments are grouped together by contributor. The contributors are also grouped into the major categories of (1) truck manufacturer, (2) manufacturers related to the truck industry, (3) truck users, (4) private citizens, (5) State and local governments, and (6) trade organizations.

Issues are identified and discussed in Sections A-3 through A-11, as outlined below. A discussion on the actions taken in response to public comments is presented for each issue.

Section Number	Docket Analysis Comment Categories
A-1	Introduction
A-2	Summary of Comments
A-3	Benefits to Public Health and Welfare. Discusses the comments related to the impact made by the proposed regulation on the community noise environment.
A-4	Technology. Discusses the comments on the noise control technology necessary to produce trucks that comply with the proposed regulations.
A-5	Costs of Compliance. Examines the criticisms made of the costs associated with producing trucks that comply with the proposed regulations.
A-6	Costs Versus Benefits. Discusses comments on the justification of the costs of the proposed regulations relative to the benefits to be derived, and the methods of comparing costs and benefits.

Section Number	Docket Analysis Comment Categories
A-7	Economic Impact. Issues on the economic impact of the proposed regulations are discussed.
A-8	Testing. This section discusses criticisms of the proposed test procedure.
A-9	Classification. Briefly discusses comments regarding the vehicles to which the regulation should or should not be applicable.
A-10	Enforcement. Examines comments on the enforcement of the proposed regulations.
A-11	Miscellaneous Comments.

Appendix A-2
SUMMARY OF COMMENTS

Comments were made on the Proposed Noise Emission Standards on New Medium and Heavy Trucks (Federal Register, 30 October 1974, p. 38338) in the form of written responses in Docket ONAC 74-1 and in Public Hearings held on 19-20 February 1975 in Arlington, Va. and 27 February 1975 in San Francisco, Calif. Summaries of the comments which fall into the general categories of public health and welfare, available technology, costs of compliance, costs vs benefits, economic impact, compliance testing or vehicle classification are given here. The comment summaries are catalogued according to contributor, and the contributors grouped into truck manufacturers, manufacturers related to the truck industry, truck users, private citizens, governments (local, State or federal agencies), and trade organizations.

Within each group, the contributors are listed in alphabetical order by the name of the organization, State or local jurisdiction, or citizen. The general category into which the comment is placed is given in parentheses after each comment summary along with references to the original comment. Numbers which begin with the letter "T" (e.g., T076) refer to written Docket submissions. References to the Official Transcript of the Public Hearings in Arlington, Va. and in SanFrancisco are given by PHW and PHSF, respectively. Written submissions in response to questions or requests for additional information at the Hearings are referenced by numbers beginning with "Th" (e.g., Th039).

A-2.1 TRUCK MANUFACTURERS

A-2.1.1 Chrysler Corporation

A-2.1.1.1 Meeting the regulated 75-dBA regulatory level is not technically feasible. The Freightliner DOT Quiet Truck is a 75-dBA truck (not 72-dBA as claimed by EPA) and thus will not comply with the not-to-exceed 75-dBA regulation (Technology, p. 4–5 of T087).

A-2.1.1.2 Medium diesel trucks are the most difficult to quiet since they have very high engine noise levels due to their high-speed, light-weight engine design. No prototype medium diesel truck has been built to demonstrate the availability of technology for meeting the 75-dBA regulatory level (Technology, p.4 of T087).

A-2.1.1.3 It is not possible to determine the acceptable design ranges on the parameters for devices and elements which are known to control noise over the useful life of trucks (Technology, p. 2-210 of PHW).

A-2.1.1.4 EPA underestimated the increase in the costs per truck required to meet regulatory levels. To comply with the 83-dBA level would cost about $500 more per truck and for the 80-dBA, $1200 more per truck. No estimate could be made for the 75-dBA regulatory level (Costs of Compliance, p.6 of T087).

A-2.1.1.5 Noise abatement equipment would cause an increase in annual service labor costs of $800 per truck for the 80-dBA regulatory level (Costs of Compliance, p.7 of T087).

A-2.1.1.6 The deceleration test should be required only on trucks equipped with engine brakes. (Testing, p. 9 of T087 and p. 2-208 of PHW).

A-2.1.1.7 The round-off procedure and the number of tests to be used are not adequately described in the proposed test procedures. (Testing, p. 9 of T087).

A-2.1.1.8 Motor homes should be excluded from the regulation. (Classification, p. 8 of T087).

A-2.1.2 Crane Carrier Company

The regulations would have a greater economic impact on the smaller company, particularly those who build specialized vehicles. The costs for a test facility would be $250,000 and the operating costs would be $80,000 per year. These costs must be spread out over fewer trucks, resulting in higher increases in costs for trucks from the smaller manufacturer. The smaller company cannot compete with the larger ones for the technical talent required to design and produce compliant vehicles. Customers can find ways to do without specialized vehicles. Therefore, an increase in prices could have a greater impact on the manufacturer of specialized vehicles (Economic Impact, T116).

A-2.1.3 Ford Motor Company

A-2.1.3.1 The 1-dBA increase in community noise level every 5 years caused by the predicted increase in truck population given by EPA is too high. Predictions of future truck populations are too high (Health & Welfare, p. 1 of T119 and p. 3-199 of PHW).

A-2.1.3.2 The contributions to community noise from tires and regulated trucks should be assessed separately (Health & Welfare, p. 2 of T119).

A-2.1.3.3 Costs-benefits analyses for more regulation options, such as 83-dBA from 1977 to 2000, need to be made (Health & Welfare, p. 1 of T119).

A-2.1.3.4 Regulations in which 10 percent of the tested vehicles are allowed to be 2 dBA above the regulatory level will produce substantially all of the intended noise reduction (Health & Welfare, p. 3-197 of PHW).

A-2.1.3.5 "Off-the-shelf" hardware does not exist which will produce the noise reductions necessary to comply with 80- or 75-dBA regulatory levels, meet reliability requirements, and not reduce truck performance and fuel economy (Technology, p. 7 of T119 and p. 3-198 of PHW).

A-2.1.3.6 The DOT Quiet Trucks were prototypes of limited quantity involved in linehaul service which is probably not the most severe type of operation and therefore do not adequately demonstrate that technology is available to build reliable trucks which comply with the 75-dBA regulation (Technology, p. 7 of T119).

A-2.1.3.7 Vehicle testing indicates that truck noise levels approaching 77-dBA which is needed to comply with the 80-dBA regulation cannot be reached (Technology, p. 3-213 of PHW).

A-2.1.3.8 Design targets need to be at least 3 dBA below not-to-exceed regulatory levels to assure compliance of most trucks (Technology, p. 3-209 of PHW).

A-2.1.3.9 High backpressure in exhaust systems is associated with high noise reduction and reduced engine performance (Technology, p. 8 of T119).

A-2.1.3.10 Some of the noisier engines are no longer usable where an 83-dBA regulation is in effect (Technology, p. 4 of T119).

A-2.1.3.11 Many of the heavy diesel Ford trucks require a fan clutch, larger mufflers, and engine noise shields to meet 83-dBA regulatory level (Technology, p. 4 of T119 and p. 3-211 of PHW).

A-2.1.3.12 Design changes which will probably be required to meet the 80-dBA regulation are full encapsulation for diesel engines, noise shields for gasoline engines, treatment of air intake systems for diesel trucks, fan clutches, larger radiators and fans, double wall exhaust pipes, wrapped mufflers, internal engine modifications and tire redesign (Technology, pp. 3-212-4 of PHW).

A-2.1.3.13 Many gasoline trucks will require modifications to the cooling system, including the addition of fan clutches, in order to comply with the 83-dBA regulation (Technology, p. 4 of T119 and p. 3-211 of PHW).

A-2.1.3.14 EPA underestimated the increase in the costs per truck required to meet regulatory levels. To meet the 83-dBA regulation, the cost increases will be $163 for medium-heavy gas trucks, $194 for extra-heavy gas trucks, $514 for mid-range diesel trucks, and $973 for premium diesel trucks. For the 80-dBA regulation, the cost increases will be $700 for medium-heavy gas trucks, $900 for extra-heavy gas trucks, $1800 for mid-range diesel trucks and $2500 for premium diesel trucks. These cost estimates include design and development costs and costs associated with EPA's requirement to document noise control hardware, which were not included in the EPA estimates (Costs of Compliance, p. 9 of T119 and p. 3-214 of PHW).

A-2.1.3.15 If 10 percent of the tested vehicles are allowed to exceed the regulated levels by 2 dBA, the increased costs per truck will be reduced from a range of $163–973 to a range of $62–385 for the 83-dBA regulation (Costs of Compliance, p. 3-202 of PHW).

A-2.1.3.16 The noise regulations on trucks will result in only 3-dBA reduction in community noise levels by 1990 at a cumulative cost of over 3 billion dollars. This noise reduction will not be cost effective (Costs vs. Benefits, p. 1 of T119).

A-2.1.3.17 A trade-off analysis needs to be performed on quieting trucks versus using noise abatement along highways, such as barriers, building insulation, and control of vehicle traffic (Costs vs. Benefits, p. 2 of T119).

A-2.1.3.18 The effect of the Interstate Motor Carriers regulation should be assessed before regulations on new trucks are promulgated (Costs vs. Benefits, p. 4 of T119 and p. 3-201 of PHW).

A-2.1.3.19 The 75-dBA regulation will reduce the overall noise from an individual truck at highway speeds by only about 3.5 dBA. A non-sensitive observer requires 8-dB to just detect an intensity difference of a pure tone. This implies that the truck noise reduction will not be noticeable or cost effective (Costs vs. Benefits, p. 7 of T119).

A-2.1.3.20 The regulations will cause an added inflationary burden on the automobile and trucking industry at a time when it is economically depressed (Economic Impact, p. 3-196 of PHW).

A-2.1.3.21 The present supply of quiet engines is not enough to meet current demands resulting from state and local noise regulations and therefore the future supply of quiet diesel engines may be inadequate to meet the EPA proposed regulations (Economic Impact, p. 8 of T119 and p. 3-198 of PHW).

A-2.1.3.22 The 80-dBA regulatory level will force manufacturers to reduce the number of truck models (Economic Impact, p. 1 of Exhibit II of Th039).

A-2.2.3.23 The round-off procedure and the number of tests to be used are not adequately described in the proposed test procedures. (Testing, p. 11 of T119).

A-2.1.3.24 In order for the regulation to have a consistent impact on manufacturers, they should be effective on calendar years instead of model years. (Miscellaneous, p. 10 of T119).

A-2.1.4 Freightliner Corporation

A-2.1.4.1 The 77-dBA tire noise level used by EPA in assessing benefits to the public welfare is for new ribbed tires on a smooth surface and is 5- to 9-dBA lower than half-worn ribbed tires on typical road surfaces. The tire noise from a loaded tractor and trailer at 55 mph with half-worn ribbed tires is about 84 dBA. Using this level for tire noise, the 75-dBA regulation will result in only a 3- to 6-dBA reduction in total truck noise at 55 mph. Since a linehaul truck spends around 70 percent of its operating time at speeds over 50 mph, the benefits to the public welfare of the regulations will be small (Health & Welfare, p. 5 of T103 and pp. 617-622 of PHSF).

A-2.1.4.2 Engine quieting kits reduce diesel engine noise by only about 2 dBA, not up to 4 dBA as claimed by EPA (Technology, p. 6 of T103).

A-2.1.4.3 Design targets need to be 2- to 3 dBA below not-to-exceed regulatory levels in order to comply with the proposed regulations (Technology, p. 627 of PHSF).

A-2.1.4.4 The tires on the final configuration of the Freightliner DOT Quiet Truck were not suitable for highway use (Technology, p. 635 of PHSF).

A-2.1.4.5 The Freightliner DOT Quiet Truck has a larger than normal engine compartment and radiator frontal area. Typical heavy diesel trucks have less room, which will make it impossible to bring all trucks into compliance with the proposed 75-dBA regulation (Technology, p. 636 of PHSF).

A-2.1.4.6 The noise treatment to meet the 75-dBA regulatory level will increase the weight of the truck by about 700 lbs. This will result in a loss of about $1000 per year per truck in revenue for the bulk hauler (Costs of Compliance, p. 2 of T103).

A-2.1.4.7 EPA underestimated the increase in the costs per truck required to meet the proposed regulations. To comply with the 83-dBA regulatory level, the truck price increase will be $456 per truck, for the 80-dBA level, $500 to $700 per truck, and for the 75-dBA level, $1 000 to $1 200 per truck (Costs of Compliance, p. 2-3 of T103).

A-2.1.4.8 Fuel savings from fan clutches should not be included in estimating changes in operating costs caused by noise regulations, since the energy shortage will force their use in the absence of any noise regulations. The number of Freightliner trucks ordered with fan clutches has increased from 1 percent to 11 percent. In addition, the proposed test for compliance does not allow fan clutches to be off during testing, which removes the advantage of using fan clutches in complying with the proposed regulations (Costs of Compliance, p. 4 of T103 and pp. 623-4 of PHSF).

A-2.1.4.9 The proposed 75-dBA regulatory level would severely limit the truck configurations that could be manufactured (Economic Impact, p. 637 of PHSF).

A-2.1.4.10 The proposed regulations add to inflation (Economic Impact, p. 620 of PHSF).

A-2.1.4.11 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative. (Testing, p. 10 of T103).

A.2.1.5 General Motors

A.2.1.5.1 Projections of changes in equivalent noise levels for urban freeways (55 mph) and streets (35 mph) which should result from promulgation of the EPA proposed truck noise regulations and promulgation of the GM proposed regulation of 83 dBA in 1977 show that the inclusion of the 80 dBA and 75 dBA regulatory levels produce little additional reduction in the traffic noise levels. The maximum differences in the equivalent noise levels are about 0.7 dBA at 55 mph and 2.3 dBA at 35 mph. These reductions result from a decrease in regulatory levels of 8-dBA. The differences between the equivalent levels for 86 dBA and 83-dBA regulatory levels are 0.8 dBA for 55 mph and 1.9 dBA for 35 mph, which result from a decrease in regulatory levels of 3 dBA. The most significant reductions result by reducing regulatory levels to 83 dBA with decreased reductions in equivalent levels for regulatory levels below 83 dBA. Therefore, only the 83-dBA regulation should be promulgated (Health & Welfare, pp. VI-1 to VI-23 of T076 and pp. 40–46 of Th038).

A-2.1.5.2 Comparisons of EPA specified noise levels, which just intrude on given activities, with predictions of noise levels versus distance from individual trucks regulated at 83, 80 and 75 dBA indicate that regulating trucks at 80 or 75 dBA will have little effect in changing the number of activities intruded upon at distances greater than 70 feet. Therefore, only the 83-dBA regulation should be promulgated, since the 80 and 75-dBA regulatory levels will produce little benefit to the public health and welfare (Health & Welfare, pp. VI-24 to VI-48 of T076).

A-2.1.5.3 Predictions of the distances at which the noise levels from an individual unregulated and an individual 83-dBA regulated truck exceed the noise levels from a continuous flow of light vehicles by 10 dB at 55 mph indicate that the 83-dBA regulated truck does not intrude over the background traffic noise 98 percent of the time. Therefore the 83-dBA regulation is sufficient to reduce the intrusion of an individual truck most of the time, and the 80 and 75-dBA regulations are not necessary (Health & Welfare, pp. VI-48 to VI-51 of T076).

A-2.1.5.4 The differences in the noise levels measured by SAE J366b for the existing trucks and 83-dBA regulated trucks will be large enough to indicate that regulatory levels below 83-dBA should not be established. The 50 percentile level was reduced by 7.1-dBA and the 0.1 percentile level by 15.3-dBA (Health & Welfare, pp. VI-51 to VI-53 of T076).

A-2.1.5.5 The differences in roadside noise levels between one truck which complies with the 83 dBA regulation (80.5 dBA) and one which complies with the 80 dBA regulation (78.2 dBA) are 0.5 dBA at 125 feet for urban acceleration, 1.6 dBA at 125 feet for 35 mph cruise, and 0.3 dBA at 150 feet for 55 mph cruise. Both trucks were equipped with quiet ribbed tires. These differences are small enough to indicate that the 80 dBA regulation will bring little additional benefit over the 83 dBA regulation (Health & Welfare, p. 12 of Th004 and p. 2-46 of PHW).

A-2.1.5.6 EPA should develop estimates of benfits for a regulatory program which includes all of the following necessary elements: new truck regulations, interstate carrier regulations including state and local enforcement of identical regulations, regulations on tire noise, and elimination of modified and poorly maintained light vehicles (Health & Welfare, p. 54 of Th038).

A-2.1.5.7 Design targets need to be 2 to 3 dBA below the not-to-exceed regulatory levels in order to comply with proposed regulations (Technology, p. V-5 of T076).

A-2.1.5.8 In order to comply with the 83-dBA regulatory level, many heavy diesel trucks will require double wall muffler and exhaust pipes, and engine noise barriers. In addition, to bring most heavy diesel trucks into compliance with the 80-dBA level, modified engines with barrel-shaped, tight clearance pistons, fan clutches, full underpans, and engine compartment absorptive material will be needed. A larger radiator or a remote cooling system, totally encapsulated turbocharged engines and transmissions, air cleaner silencers and larger mufflers with premufflers will have to be added to many 80-dBA regulated trucks in order to comply with the 75-dBA regulatory level. Engine side shield will be required on gasoline trucks to meet the 75-dBA regulation (Technology, pp. V-26-28 of T076).

A-2.1.5.9 The Freightliner DOT Quiet Truck is not a good demonstration of the available technology to meet the 75-dBA regulation, because it had a special COE sleeper cab with a larger engine compartment than available on most production heavy diesel trucks (Technology, P. V-3 of T076).

A-2.1.5.10 Piston slap is the major single source of noise in diesel engines and significant engine noise reductions are not likely to result unless piston slap is reduced (Technology, p V-10 of T076).

A-2.1.5.11 The technology to manufacture engine noise barriers which are easy to install and remove, satisfy durability requirements and provide sufficient attenuation is not available (Technology, p. V-11-12 of T076).

A-2.1.5.12 It will be necessary to turbocharge all diesel engines to reduce exhaust noise enough to meet the 75-dBA regulation (Technology, p. V-13 of T076).

A-2.1.5.13 A fully encapsulated engine is required to meet the 75-dBA regulation. This will require the use of a remote cooling system in some cabs, since sufficient space for large enough radiators is not available (Technology, p. V-13-14 of T076).

A-2.1.5.14 The durability of packed mufflers, tight clearance pistons, and absorptive materials in engine compartments are not known (Technology, p. V-23 of T076).

A-2.1.5.15 The technology is not available to mass-produce trucks to comply with the 75-dBA regulation since technology applications upon which production manufacturing may be based for trucks to comply with the 75-dBA regulation have not been demonstrated to be feasible (Technology, pp. 2-18-19 of PHW and p. 57 and 62 of Th038).

A-2.1.5.16 Tire noise needs to be reduced so that it does not mask the reduction of noise from other truck sources, such as engine, exhaust, and fan. However, it is not possible with available technology to reduce tire noise levels much below the levels of the quietest available tires (Technology, pp. 2-44 and 2-69 of PHW).

A-2.1.5.17 Tire and aerodynamic noise (65-73 dBA), axle noise (up to 78 dBA), truck frame radiation (up to 70 dBA), truck cab radiation (up to 65 dBA), and transmission noise (up to 77 dBA) must be treated in addition to engine, cooling, exhaust and intake systems, in order to comply with the 75 dBA regulation (Technology, pp. 59-61 of Th038).

A-2.1.5.18 The durability and noise reduction effectiveness of new engine mounting systems necessary to comply with the 75-dBA regulation have not been determined (Technology, p. 62 of Th038).

A-2.1.5.19 The encapsulation of engines will cause increases in engine compartment temperatures from about 100°F to 200°F which may affect the durability of some engine mounted components and create a fire hazard (Technology, p. V-10 and V-23).

A-2.1.5.20 Costs for compliance testing were not included in the estimated costs to the customer of the truck. The test facility required by EPA will cost $286,000. In addition, a $500,000 acoustically treated chassis dynamometer facility will be required for development testing (Costs of Compliance, p. VII-3 of T076).

A-2.1.5.21 The estimations of customer price increases per truck were based on the regulatory levels and not the design or median levels, and are therefore too low (Costs of Compliance, p. VII-4 of T076).

A-2.1.5.22 The decrease in costs of noise abatement due to future improvements in noise control technology should not be included in cost estimates (Costs of Compliance, p. VII-4 of T076).

A-2.1.5.23 EPA's costs estimates are outdated (Costs of Compliance, p. VII-5 of T076).

A-2.1.5.24 The fan clutch was included in the GM estimates of increases in purchase prices of the truck, but the fuel savings were not included because there are not enough real data on fuel savings over a large enough range of different operating conditions (Costs of Compliance, p. VII-8 of T076).

A-2.1.5.25 The estimated average increases in prices for diesel trucks are $365 to comply with 83-dBA regulatory level, $1090 for the 80-dBA level, and $4450 for the 75 dBA. For gasoline trucks, the average increases in truck price will be $25 to meet the 83-dBA regulation, $130 for 80-dBA and $350 for 75 dBA. These price increase estimates include increased costs due to development and testing, manufacturing, tooling, compliance testing, and dealer and customer services associated with noise abatement equipment. Costs for six models were weighted by sales volume before averaging. The figure for the 83-dBA level is based on manufacturer's suggested retail prices for "Quiet Truck Packages" used to comply with local 83-dBA regulations (Costs of Compliance, pp. VII-12-13 of T076, p. 2-20 of PHW and pp. 12-15 of Th038).

A-2.1.5.26 The estimated average increases in annual maintenance costs per year per diesel truck are $179 to comply with 83-dBA regulatory level, $304 for the 80-dBA level and $305 for the 75-dBA level. These estimates include increased labor costs for ordinary maintenance caused by the addition of noise abatement equipment, and increased costs for replacement parts to assure continued compliance. Costs for six models are weighted by sales volume in computing the average maintenance cost increases (Costs of Compliance, pp. VI-12-13 of T076 and pp. 13-20 of Th038).

A-2.1.5.27 For one of GM's truck models, a 6 percent reduction in cargo volume would result in complying with the 75-dBA regulation (Costs of Compliance, p. VII-7 of T076).

A-2.1.5.28 At 35 mph, the adoption of the 83-dBA regulation will yield 80 percent of the benefit (8-dBA reduction for the 83-dBA regulation relative to 10.1-dBA for the 75-dBA regulation) for 32 percent of the total costs ($5.2 billion of the $16.2 billion for adoption of the EPA proposed regulations). At 55 mph, 95 percent of the benefits (5.9-dBA of the total 6.2-dBA) result from 32 percent of the costs. Therefore, it is not cost-effective to spend an additional $11 billion for such a small increase in benefits (Costs vs. Benefits, pp. VIII-3-4 of T076).

A-2.1.5.29 The results of the analyses of benefits versus costs given by the Department of Transportation (2.5.4.4) and the Council on Wage and Price Stability (2.5.6.1) are incorrect, mostly because the estimates of savings are too high. Their estimates are too high because their assumptions, given below, are incorrect.

1. All trucks are operated 70,000 miles per year.

2. The average power savings with fans off is 19.5 hp for all medium and heavy trucks.

3. Fan clutches will be used on all new regulated trucks and the resulting saving can be credited to the noise emission regulations.

4. The price increase for trucks which comply with the 75-dBA regulation is $1075 (Cost vs. Benefits, Th052).

A-2.1.5.30 Possible shifts in buying habits caused by noise regulations need to be considered (Economic Impact, p. VII 7 of T076).

A-2.1.5.31 The cumulative costs caused by the EPA proposed noise regulations will be $16.2 billion by 1990. If only the 83-dBA regulatory level is adopted, the cumulative costs will be $5.2 billion. Thus, the national economy will be seriously affected by the EPA proposed 80 and 75-dBA regulations. The cumulative cost estimates include projections of vehicle sales, average customer costs per truck and average maintenance costs per truck (Economic Impact, pp. VII-14-15 of T076).

A-2.1.5.32 Environmental regulations contribute to inflation (Economic Impact, VII-1 of T076).

A-2.1.5.33 An Inflation Impact Statement is required (Economic Impact, pp. 2-20 of PHW).

A-2.1.5.34 The proposed test procedure allows excessive variability and should include test site correction factors. (Testing, p. IV-5 of T076).

A-2.1.5.35 The proposed regulation provides no provisions for correcting measured noise levels to standard conditions of temperature, barometric pressure, etc. (Testing, p. IV-5 of T076).

A-2.1.5.36 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative. (Testing, p. IV-4-5 of T076).

A-2.1.6 International Harvester Company

A-2.1.6.1 At speeds above 40 mph, tire noise overshadows the engine-related noise for trucks regulated at 83 dBA, making regulations below 83 dBA completely ineffective except in a few areas (Health & Welfare, p. 7 of T113).

A-2.1.6.2 Community noise modeling has not progressed to the extent that truck noise can be adequately correlated to community noise levels. MVMA is presently sponsoring an effort to provide an adequate model (Health & Welfare, p. 7 of T113).

A-2.1.6.3 EPA has not established that truck noise makes a significant contribution to environmental noise levels, or derived a relation between environmental noise levels and annoyance. In addition, EPA has not developed a relation between truck noise levels measured according to the test procedure in the proposed regulations and the levels necessary to protect public health and welfare (Health & Welfare, p. 26 of T113 and p. 3-124 of PHW).

A-2.1.6.4 The noise generated by trucks do not cause hearing damage, but may produce annoyance which is difficult to measure objectively (Health & Welfare, p. 3-126 of PHW).

A-2.1.6.5 The manufacturer is forced to design 2 to 3 dBA below the regulatory levels in order to comply with the proposed regulations (Technology, pp. 4-5 and 28 of T113 and p. 3-122 of PHW).

A-2.1.6.6 The technology to meet the 75-dBA regulatory level is not currently available for any truck. The fundamental design criteria was compromised in the Freightliner

DOT Quiet Truck and therefore it does not represent available technology. The cooling was not adequate and the truck was unique in that it had a small engine in a chassis designed for larger engines (Technology, pp. 6 and 35 of T113).

A-2.1.6.7 The technology to meet the 80-dBA regulatory level does not exist for a full truck line, because a 2-3/4 year lead time is required to redesign each truck model and a full set of reliability tests is needed on each truck model (Technology, pp. 31 and 33 of T113).

A-2.1.6.8 Extensive redesigns of the cooling, exhaust and air-intake systems and the addition of engine panels were required for International Harvester DOT Quiet Truck to comply with the 83-dBA regulation (Technology, pp. 28-30 of T113).

A-2.1.6.9 The noise levels given in Table 2, Volume 5, page 11, of the HRBDG for truck engine, exhaust and fan noise for a 55–65 mph cruising condition are higher than SAE J366b levels which should be maximum levels. Such discrepancies cast doubt on the validity of these levels in HRBDG and, in turn, on the EPA background document (Technology, p. 13 of Th041).

A-2.1.6.10 The estimated increases in purchase price due to the addition of noise abatement equipment are $583 for a heavy diesel truck to comply with the 83-dBA regulatory level and $2150 for the 80 dBA level. These estimates are 3 to 4 times greater than EPA's estimates partly because EPA did not take into account the need to design trucks 2 to 3 dBA below the regulatory levels (Costs of Compliance, pp. 30-32 of T113).

A-2.1.6.11 The added costs increase at a faster rate as the levels of truck noise are reduced to lower levels. Down to the regulatory level of 83 dBA the costs increase at a rate of approximately $70/dBA and below the regulatory level of 83 dBA at about $750/dBA (Costs of Compliance, p. 3–125 of PHW).

A-2.1.6.12 The projected initial price increase ($2150 per truck) far outweighs any benefit to public health and welfare (Costs vs. Benefits, p. 35 of T113).

A-2.1.6.13 The 80-dBA regulation should be adopted no sooner than 1983 and the regulations re-evaluated in 1979 (Costs vs. Benefits, p. 6 of T113).

A-2.1.6.14 An Inflation Impact Statement is required (Economic Impact, p. 3–118 of PHW).

A-2.1.6.15 Since truck manufacturers are currently being forced to eliminate some truck configurations to meet local 83-dBA regulations, the EPA proposed regulations should reduce the number of truck configurations which can be offered. A list of truck-engine combinations dropped because of the California 83-dBA regulation was given (Economic Impact, p. 3-143 of PHW and p. 17–18 of Th041).

A-2.1.6.16 Increased demand for quiet engines may result in shortages (Economic Impact, p. 18 of Th041).

A-2.1.6.17 The test procedure should be improved. (Testing, pp. 40-1 of T113).

A-2.1.6.18 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative. (Testing, p. 46 of T113).

A-2.1.6.19 The deceleration test should only be required on vehicles equipped with engine brakes. (Testing, p. 45 of T113).

A-2.1.6.20 The instrumentation required for compliance testing should be more precisely specified. (Testing, p. 51 of T113).

A-2.1.7 Mack Trucks, Inc.

A-2.1.7.1 The 75-dBA regulated truck would not produce enough noise to serve as a warning to pedestrians, and thus would constitute a safety hazard (Health & Welfare, p. 3 of T113).

A-2.1.7.2 Compliance with 86 and 83-dBA local regulations has already produced drastic reductions in overall noise levels. An adoption of the 80-dBA regulation should be considered after obtaining more experience with 83-dBA regulated trucks. The 75-dBA regulation should be postponed indefinitely (Health & Welfare, p. 3 of T113).

A-2.1.7.3 Truck noise can produce annoyance but does not affect hearing loss (Health & Welfare, p. 3-5 of PHW).

A-2.1.7.4 Tire noise at higher speeds will reduce the benefits from regulations on truck noise levels which are lower than 83-dBA (Health & Welfare, p. 3-6 of PHW).

A-2.1.7.5 Design targets need to be 2 to 3-dBA below the regulatory levels in order to comply with proposed regulations (Technology, p. 1 of T102 and p. 3-7 of PHW).

A-2.1.7.6 It is impossible to determine the design noise level for the 80 or 75-dBA regulatory level which compensate for deterioration over the life of the truck (Technology, p. 2 of T102).

A-2.1.7.7 The 80-dBA regulation may require encapsulation of some power plants and removal of the noisier engines. The 75-dBA regulation will require the elimination of a majority of vehicle configurations, and the encapsulation of engines in trucks of the remaining configurations (Technology, pp. 1-2 of T102).

A-2.1.7.8 Results from the DOT Quiet Truck Program can not be considered adequate grounds for determining that the technology for meeting the 75-dBA regulation is available since COE trucks are usually quieter than similarly equipped conventional trucks (Technology, p. 2 of T102).

A-2.1.7.9 Because of the elimination of some engines and truck configurations which will be caused by the 80 and 75-dBA regulations, the user may be forced to use a truck that does not fulfill his requirements which may increase his operating costs. Some present engine-truck models can not be marketed in California, where an 83-dBA regulation is in effect (Economic Impact, p. 2 of T102, pp. 3–9 of PHW, and pp. 17–18 of Th041).

A-2.1.7.10 Federal regulatory agencies should consider the cumulative increase in costs of all regulations on trucks, such as the Federal Motor Carrier Safety Regulations on truck brakes and interior noise levels, and the EPA's regulations on smoke and gaseous emissions, the regulations passby noise levels for interstate motor carriers and the proposed, new truck noise regulations (Economic Impact, pp. 8–9 of T102 and pp. 3–14 of PHW).

A-2.1.7.11 A stationary compliance test would be desirable. (Testing p. 3-10 of PHW).

A-2.1.7.12 The proposed test procedure allows excessive variability and should include test site correction factors. (Testing, p. 7 of T102).

A-2.1.7.13 The round-off procedures and the number of tests to be used are not adequately described in the proposed test procedures. (Testing, p. 6 of T102).

A-2.1.8 Oshkosh Truck Corporation

A-2.1.8.1 New technology will be required to economically produce trucks to meet the 75-dBA regulation (Technology, T125).

A-2.1.8.2 In order to comply with the proposed noise regulations, heavy truck manufacturers will be largely dependent on the ability of engine manufacturers to produce quiet engines (Economic Impact, T125).

A-2.1.9 Paccar Inc.

A-2.1.9.1 Design targets need to be at least 2 dBA below the regulatory levels in order to comply with the proposed regulations (Technology, p. 4 of T126, pp. 443 and 465 of PHSF, and p. 2 of Th036).

A-2.1.9.2 The degradation of the performance of noise reduction hardware and change in noise levels from engines with age is not known (Technology, p. 444 of PHSF).

A-2.1.9.3 Technology is not available to comply with the proposed regulations (Technology, p. 442 of PHSF).

A-2.1.9.4 The estimated increases in the prices per truck to meet the 83-dBA regulation will be $210-400, to meet the 80-dBA regulation, $700, and to meet the 75-dBA regulation, $1400 (Costs of Compliance, pp. 442 and 465 of PHSF).

A-2.1.9.5 The cost of compliance testing was not considered in assessing the costs of compliance for the proposed regulations. The cost of an adequate test facility could be $147,000 to $346,000. Independent testing services may cost nearly $1800 per truck for manufacturers who custom-build trucks if testing is required on almost all trucks (Costs of Compliance, p. 3 of T126 and p. 443 of PHSF).

A-2.1.9.6 The proposed regulations should not claim credit for the savings due to fan clutches, since they will be widely used without the regulations (Costs of Compliance, p. 444 of PHSF).

A-2.1.9.7 Medium trucks impact an estimated 34.6 million people whereas heavy trucks impact an estimated 2.7 million people. Therefore, regulating medium and heavy trucks separately could be used to increase the ratio of the public welfare benefits to costs of compliance (Costs vs. Benefits, p. 1 of Th036).

A-2.1.9.8 The proposed regulations are inflationary (Economic Impact, p. 446 of PHSF).

A-2.1.9.9 Cumulative effect of federal regulations to date have added approximately $2550 to customer costs per truck. These added costs have been a major contributor to the recent economic downturn. Therefore, in assessing the economic impact of the EPA proposed regulations on new truck noise emissions, the cumulative effect of all federal regulations on trucks should be considered (Economic Impact, p. 441 of PHSF).

A-2.1.10 **White Motor Corporation**

A-2.1.10.1 The responsibility for determining the benefits to the public health and welfare of the proposed truck noise regulations rests with EPA. EPA has not substantiated the benefits from the regulatory levels below 83 dBA. Therefore, the regulatory levels below 83 dBA should be removed from the regulations (Health & Welfare, p. II–12 of T085 and pp. 2–138 of PHW).

A-2.1.10.2 Heavy trucks typically operate above 35 mph where tire noise will reduce the benefits derived from the proposed regulations (Health & Welfare, pp. 2–142 of PHSF).

A-2.1.10.3 There are no data available to determine the deterioration of the performance of noise abatement equipment (Technology, p. VI-3 of T085 and pp. 3–161 and 3–166 of PHSF).

A-2.1.10.4 Other noise sources in trucks which have yet to be measured or treated will need treatment in order to comply with the lower regulatory levels (Technology, p. 2–161 of PHSF).

A-2.1.10.5 The truck owner, whose truck is weight limited, may lose $600 annually because of weight increases caused by the 83-dBA regulation and $1600 annually for the 80-dBA regulation (Costs of Compliance, p. 2–141 of PHSF).

A-2.1.10.6 EPA's estimated increases in truck prices are too low. Estimated increases in the prices of heavy diesel trucks will be $261 to meet the 83-dBA regulation and $1307 to meet the 80-dBA regulation. Quieting kits to bring a Freightliner conventional truck into compliance with local 83-dBA regulations cost $636. The above estimation of price increases include manufacturing costs only and do not include any costs for testing required by EPA, allowances for R&D, engineering, inflation, or excise taxes (Costs of Compliance, pp. 2–139–40 of PHW).

A-2.1.10.7 The truck price increases at a faster rate as the levels of the truck noise are reduced. Reducing the truck noise level to 81 dBA costs $37/dBA, whereas reducing the truck noise level from 81 to 78 dBA costs $349/dBA (Costs of Compliance, p. 3-140 of PHW).

A-2.1.10.8 An Inflation Impact Statement is required (Economic Impact, p. III–1 of T085).

A-2.1.10.9 The proposed regulations will contribute to inflation (Economic Impact, p. 2–142 of PHSF).

A-2.1.10.10 The proposed test procedures should be improved. (Testing, p. V-1 of T085).

A-2.1.10.11 A stationary test would be desirable. (Testing, p. V-8 of T085).

A-2.1.10.12 The proposed test procedure allows excessive variability and should include test site correction factors. (Testing, p. V-3 of T085).

A-2.1.10.13 The proposed regulation contains no provisions for correcting measured noise levels to standard conditions of temperature, barometric pressure, etc. (Testing, pp. V-2-3 of T085).

A-2.1.10.14 Testing should take place with the engine coolant at operating temperature. (Testing, p. V-2 of T085)

A-2.1.10.15 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative. (Testing, p. V-7 of T085).

A-2.1.10.16 The instrumentation required for compliance testing should be more precisely specified. (Testing, p. VII-9 of T085).

A-2.2 MANUFACTURERS RELATED TO THE TRUCK INDUSTRY

A-2.2.1 Cummins Engine Company, Inc.

A-2.2.1.1 There are little data on the change in engine noise levels with the age of the engine (Technology, p. 2 of T124).

A-2.2.1.2 Engine noise depends on engine power as well as engine type and design (Technology, p. 3 of T124).

A-2.2.1.3 The average level of truck fan noise in 83.3 dBA which is higher than indicated by EPA (Technology, p. 4 of T124).

A-2.2.1.4 Transmission noise averages 75.5 dBA and chassis noise (coast-by at 30 mph) averages 70 dBA. Therefore, noise from the transmission and chassis may become significant as the total vehicle noise level is reduced to comply with the 75-dBA regulatory level (Technology, p. 4 of T124).

A-2.2.1.5 The costs for testing will be higher than estimated by EPA. For example, the test site will cost approximately $150,000 (Costs of Compliance, p. 5 of T124).

A-2.2.2 Donaldson Company, Inc.

A-2.2.2.1 Truck noise can produce annoyance, but does not affect hearing loss. There is no accurate technique for objectively evaluating annoyance (Health & Welfare, p. 272–3 of PHSF).

A-2.2.2.2 The greatest annoyance comes from a small minority of the noisiest trucks. Reduction in the noise levels from these trucks by the Interstate Motor Carriers will result in a significant reduction in traffic noise. (Health & Welfare, p. 274 of PHSF).

A-2.2.2.3 Tire noise levels at highway speeds frequently exceed 80 dBA at 50 feet. Therefore, regulatory levels below 83 dBA would not produce significant benefits, since technology to reduce tire noise does not exist (Health & Welfare, p. 275 of PHSF).

A-2.2.2.4 Design targets need to be 2–5 dBA below the regulatory levels in order to comply with the proposed regulations (Technology, p. 277 of PHSF).

A-2.2.2.5 Even with partial engine enclosures which were open in front and back, two of the three DOT Quiet Trucks could not be quieted to below 75 dBA. Therefore, it is not clear that the technology is available to comply with the 75 dBA regulation (Technology, p. 275 of PHSF).

A-2.2.2.6 Many engines will require partial enclosures to meet the 80-dBA regulation and all will require enclosures to meet the 75-dBA regulation (Technology, p. 275 of PHSF).

A-2.2.2.7 Engine enclosures will result in reduced payload capacities, loss in fuel economy, and increased maintenance costs (Costs of Compliance, p. 275 of PHSF).

A-2.2.2.8 EPA's estimates of increased truck prices are understated by at least 25 percent (Costs of Compliance, p. 276 of PHSF).

A-2.2.2.9 The 80 and 75-dBA regulations should be postponed until experience with the 83-dBA regulation can be used to better assess the benefits and costs of the lower regulatory levels (Costs vs. Benefits, p. 273 of PHSF).

A-2.2.2.10 The small manufacturer of trucks with special equipment would be subjected to an unreasonable economic burden (Economic Impact, p. 276 of PHSF).

A-2.2.3 B.F. Goodrich

A-2.2.3.1 Tire noise will be a factor in complying with the 75-dBA regulation. Therefore, the regulatory levels below 83-dBA should not be adopted until more information is available on the control of tire noise (Technology, p. 4 of Th030).

A-2.2.3.2 Measuring in the "fast" response could result in levels 1–2-dBA lower than that measured under "slow" response. "Slow" response should be utilized. (Testing, p. 2 of Th030).

A-2.2.4 Koehring Company

A-2.2.4.1 The proposed regulations will add absolutely nothing to the health and welfare of the public (Health & Welfare, p. 374 and 384 of PHSF).

A-2.2.4.2 Facilities required for testing for compliance will cost between $500,000 and $1,000,000 (Costs of Compliance, p. 373 of PHSF).

A-2.2.4.3 The estimated costs for transporting one special purpose construction [illegible] by rail, which required disassembling and reassembling, and testing according to the proposed test procedures ranged from $2935 to $11,380 (Costs of Compliance, pp. 377–82 of PHSF).

A-2.2.4.4 The need for testing facilities for the federal brake safety regulation encouraged one large truck manufacturer to close one plant and move production to another plant where test facilities were available. This had a significant economic impact on the area where the plant was closed. Economic impact factors such as this should be considered before the proposed regulations are promulgated (Economic Impact, p. 371 of PHSF).

A-2.2.4.5 The proposed regulations could put some manufacturers out of business business (Economic Impact, p. 374 of PHSF).

A-2.2.5 Rexnord

A-2.2.5.1 Mounting a mixer on a truck chassis does not materially affect the truck's noise emissions (Technology, p. 5 of T021).

A-2.2.6 Schwitzer Engineering Components

A-2.2.6.1 The technology does not appear to be available to comply with the 75-dBA regulation (Technology, p. 2-174 of PHW).

A-2.2.6.2 Tire noise at high speeds can not be reduced below about 80-dBA. Therefore, reducing truck power plant noise to levels below 80-dBA will not produce enough benefits to justify the additional costs (Costs vs. Benefits, p. 2-174 of PHW).

A-2.2.6.3 The costs will be enormous if the 75-dBA regulation is established and then must be postponed (Economic Impact, p. 2–175 of PHW).

A-2.2.6.4 The present high unemployment in the trucking industry and increasing vehicle costs will increase the economic impact of the proposed regulations (Economic Impact, p. 2–174 of PHW).

A-2.2.6.5 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan drive in its normal automatic mode (Testing, p. 2 of T081).

A-2.2.6.6 The round-off procedure and the number of tests to be used is not adequately described in the proposed test procedures (Testing, p. 1 of T081).

A-2.2.7 Walker Manufacturing

A-2.2.7.1 The technology for exhaust systems would permit shorter lead times in the proposed regulations (Technology, T053).

A-2.2.8 Horton Manufacturing Company, Inc.

A-2.2.8.1 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative (Testing, T054).

A-2.2.9 Bendix Heavy Vehicle Systems Group

A-2.2.9.1 Vehicles equipped with thermostatically controlled fan drives should be tested with the fan inoperative (Testing, T088).

A-2.2.11 Buckeye Equipment Company

A-2.2.11.1 The availability of enough acoustical consultants may be inadequate for all manufacturers to be able to comply with these regulations. (Miscellaneous, T023).

A-2.3 TRUCK USERS

A-2.3.1 American Trucking Associations, Inc.

A-2.3.1.1 At speeds below 35 mph, tire noise will make a significant contribution to the overall noise levels from trucks regulated at 80-dBA and below. Therefore, tire noise will reduce the benefits derived from the proposed regulations. (Health & Welfare, p. 7 of T108 and p. 3-47 of PHW).

A-2.3.1.2 A comprehensive study of the technology of quieting tires, and the effect of quieting tires on safety and costs of operation must be completed before the regulations should be adopted. For example, the use of tire labeling as a tool for the truck manufacturer and user for selecting quiet tires should be considered. Within the available technology for tires, there is a practical floor to tire noise below which it is impractical to produce a tire of any tread configuration that would be acceptable and safe in normal truck service (Technology, p. 7 of T108 and p. 3-47 of PHW).

A-2.3.1.3 The truck manufacturers will be forced to design for noise levels 2 to 3-dBA below the regulatory levels in order to comply with the proposed regulations (Technology, p. 4 of T108).

A-2.3.1.4 Major engine redesigns will probably be required in order to obtain any worthwhile reduction in engine noise (Technology, p. 4 of T108).

A-2.3.1.5 The regulations may force the use of turbocharged engines in place of naturally aspirated engines in some trucks. The projection of increases in costs needs to include the increased costs of using turbocharged engines in place of naturally aspirated engines (Costs of Compliance, p. 4 of T108).

A-2.3.1.6 The cost of modifications to truck cabs, resulting from redesign of cooling systems required to reduce noise, should be included in the projections of increased truck costs (Cost of Compliance, p. 5 of T108).

A-2.3.1.7 The price increases associated with quieting trucks rises exponentially as the noise levels are reduced (Costs of Compliance, p. 9 of T108).

A-2.3.1.8 EPA's estimates of increases in truck prices are low (Costs of Compliance, p. 3-48 of PHW).

A-2.3.1.9 The estimates of fuel savings presented by the Department of Transportation are too high (Costs of Compliance, Th010).

A-2.3.1.10 The regulations may force engines to be redesigned with closer tolerances and combustion modifications. The cost of the increases in failure rates of these redesigned engines needs to be included in the economic analysis (Costs of Compliance, p. 4 of T108).

A-2.3.1.11 The increase in weight due to noise treatment will affect bulk haulers the most. This point was dismissed by EPA (Costs of Compliance, p. 3-49 of PHW).

A-2.3.1.12 The cost of quieting new trucks rises exponentially as the noise levels are reduced, yet the benefits to the public are reduced to a point of little or no return. A more careful study of cost/benefit ratios needs to be made before the regulations are adopted (Costs vs. Benefits, p. 9 of T108 and p. 3-44 of PHW).

A-2.3.1.13 The adoption of the lower regulatory levels should be postponed until after experience with the 83-dBA regulation can be obtained and used to assess better the costs and benefits of the lower regulated levels (Costs vs. Benefits, p. 3-52 of PHW).

A-2.3.1.14 Federal regulations have increased the price of linehaul tractors by 14 percent over the increase due to inflation. Federal regulations have contributed to the present recession. The cumulative effect of federal regulations will put the small trucker out of business (Economic Impact, p. 3-50-1 of PHW).

A-2.3.1.15 The trucking industry was not adequately represented during the development of the proposed regulations (Miscellaneous, p. 3 of T108).

A-2.3.2 Construction Machinery Company

A-2.3.2.1 If the mixer mounter must comply with the proposed regulations, the entire sales distribution pattern would be disrupted completely, resulting in two or three large dealers servicing the entire country (Economic Impact, T015).

A-2.3.3 **Gifford-Hill Company**

A-2.3.3.1 An Inflation Impact Statement is required (Economic Impact, T067).

A-2.3.4 **W.S. Hatch Company**

A-2.3.4.1 The regulations should not be promulgated until equipment that can be used in complying with the regulations can be developed (Technology, Th042).

A-2.3.4.2 The EPA estimates of increases in prices and weights of trucks indicate that bulk haulers will be seriously impacted economically (Costs of Compliance, Th042).

A-2.3.5 **Overdrive Magazine**

A-2.3.5.1 The increases in weight for noise treatment will result in lost revenues to the general freight operator of $8 to 69 per year for the 83-dBA regulatory level and $170 per year for the 75-dBA regulatory level. For the bulk hauler, the losses will be $51 to 445 per year for the 83-dBA level and $1000 per year for the 75-dBA level (Costs of Compliance, p. 574 of PHSF).

A-2.3.5.2 The costs of the research and development needed to comply with the proposed regulations should be borne by the entire public (Economic Impact p. 569 of PHSF).

A-2.3.5.3 An analysis of the results of current federal regulations affecting the trucking industry should be conducted before adopting any new regulations (Economic Impact, p. 570 of PHSF).

A-2.3.5.4 Because of increases in truck costs, projected profits for truckers will be lower, making it more difficult to obtain necessary loans to buy trucks. This will force many truckers out of the truck business (Economic Impact, p. 570–1 of PHSF).

A-2.3.5.5 An economic impact statement, which goes into more depth than provided into the Background Document, must be prepared (Economic Impact, p. 572–3 of PHSF).

A-2.3.5.6 There is no analysis of the economic impact that the proposed regulations will have on the independent trucker (Economic Impact, p. 576 of PHSF).

A-2.3.6 **PROD (Professional Drivers)**

A-2.3.6.1 Noise from trucks sometimes masks warning signals, such as those from sirens from emergency vehicles. Quieter trucks would permit people to hear such signals, thereby contributing to public safety (Health & Welfare, p. 2-246 of PHSF).

A-2.3.6.2 The estimated costs given by EPA apply to prototype vehicles. Under full production, the added costs per truck will be lower (Costs of Compliance, p. 2–238 of PHW).

A-2.3.6.3 After promulgation of the proposed regulations on new trucks, the in-use regulations on interstate carriers should be modified to bring the noise levels from old trucks closer to those of new trucks (Costs vs. Benefits, p. 2–256–7 of PHW).

A-2.3.7 **Regular Common Carrier Conference**

A-2.3.7.1 The manufacturer's estimates of increases in annual operating costs may be higher than the EPA estimates because the manufacturer considered the increase in needed maintenance as the truck ages (Costs of Compliance, p. 1 of Th031).

A-2.3.7.2 The costs of repairs which could be caused by failures of fan clutches should be considered in estimating operating costs. For example, if the fan clutch bearing fails, the fan may come off and damage the radiator (Costs of Compliance, p. 2 of Th031).

A-2.3.7.3 Operators cannot afford the current increases in truck prices. The proposed regulations will increase truck prices even more, which will make the situation more difficult for truck users (Economic Impact, p. 3 of Th031).

A-2.3.7.4 The cumulative increase in prices of new trucks caused by federal regulations on trucks, such as those on brakes, interior noise levels and exterior noise levels, will prevent truckers from buying the new trucks they need, which will have a serious economic impact on them (Economic Impact, p. 4 of Th031).

A-2.4 **PRIVATE CITIZENS**

A-2.4.1 **B.L. Atkins**

A-2.4.1.1 By moving too quickly with truck regulations, EPA is contributing to inflation (Economic Impact, T004).

A-2.4.2 Lawrence Auerbach

A-2.4.2.1 The current regulations, as well as future regulations, should be firmly and effectively enforced (Costs vs. Benefits, T080).

A-2.4.3 Citizens Against Noise

A-2.4.3.1 Noise from trucks disturbs sleep and can affect health (Health & Welfare, p. 3-82 of PHSF and Th037).

A-2.4.3.2 The technology is available to produce quieter tires (Technology, Th037).

A-2.4.3.3 The proposed regulations are too lenient. Truck noise levels should be reduced to automobile noise levels (Costs vs. Benefits, p. 3-79 and 3-83 of PHW).

A-2.4.3.4. Regulations should be adopted to force operators to retrofit all trucks so that the noise from all trucks is reduced (Costs vs. Benefits, p. 3-80 of PHW).

A-2.4.3.5 Regulations should be adopted which prevent trucks from operating at night (8:00 p.m. to 8:00 a.m.) (Costs vs. Benefits, p. 3-80-1 of PHW).

A-2.4.4 Friends of the Earth and Sierra Club

A-2.4.4.1 Technology is available to allow the 80-dBA regulatory level to be advanced one year (Technology, Th029).

A-2.4.4.2 Research in this country as well as in England and Germany has clearly shown that the 75-dBA regulation can be attained with available technology (Technology, Th029).

A-2.4.5 Alan Parker

A-2.4.5.1 The 83 and 80-dBA regulations should be made effective in 1976 and 1980, respectively (Health & Welfare, T050).

A-2.4.6 George Wilson

A-2.4.6.1 Manufacturing trucks to comply with the 75-dBA regulatory level is technically feasible (Technology, p. 499 of PHSF).

A-2.4.6.2 In comments before promulgation of the California regulations, General Motors indicated that they would have no problem in meeting the 86, 83 and 80-dBA California regulations (Technology, p. 500 of PHSF).

The following citizens expressed their support of the proposed regulations: Harold Blau (T002), Robert C. Puff, Jr. (T010), D. L. Bristol (T043), Stephen Richter (T049), P. J. Coorey (T051), Lawrence Auerbach (T080), and Thomas F. Scanlan (T098).

A-2.5 GOVERNMENTAL AGENCIES (STATE, LOCAL AND FEDERAL AGENCIES)

A-2.5.1 California Highway Patrol

A-2.5.1.1 Regulations on operational noise levels should be adopted to insure that truck noise levels do not increase with age (Costs vs. Benefits, p. 511-2 of PHSF).

A-2.5.2 City of Chicago, Department of Environmental Control

A-2.5.2.1 The results from the DOT Quiet Truck Program indicate that the 75-dBA regulation can be met (Technology, p. 2–262 of PHW and p. 485–6 of PHSF).

A-2.5.2.2 The lead times should be reduced so that the 75-dBA regulation becomes effective in 1980 (Costs vs. Benefits, p. 2–262 of PHW and p. 486 of PHSF).

A-2.5.3 Delaware

A-2.5.3.1 The technology of reducing tire noise was not addressed (Technology, T095).

A-2.5.3.2 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T095).

A-2.5.3.3 There should be some provisions for the noise reduction of old trucks (Costs vs. Benefits, T095).

A-2.5.3.4 The savings in costs for highway noise barriers and extra noise insulation of buildings, and the increase in property values caused by the noise reduction for the new truck regulations should be included in the economic analysis (Economic Impact, T095).

A-2.5.3.5 Trucks in different GVWR categories should be regulated to different noise levels. (Classification, T095).

A-2.5.4 Department of Transportation

A-2.5.4.1 Regulations on tire noise of 83 dBA in 1977 and 80 dBA in 1981 for a 50 mph coast-by should be adopted concurrently with the proposed new truck regulations (Health & Welfare, p. 6 of T104 and p. 3-287 of PHW).

A-2.5.4.2 Since buses are usually operated in densely populated areas and are frequently accelerating such that they generate higher levels than assumed by EPA (73-dBA at 50 feet), they should be included in the truck regulations (Health & Welfare, pp. 7-8 of T104 and p. 3-289 of PHW).

A-2.5.4.3 The benefits of the proposed regulations on new truck noise emissions should be identified separately from the benefits from regulations on other highway noise sources, such as truck tires. At 55 mph, the reduction in traffic noise levels will be 0.2, 0.5 and 0.7-dBA for the 83, 80 and 75-dBA proposed regulations on trucks when there are no regulations on tire noise, and 3.5, 4.1 and 4.6 dBA for the 83, 80 and 75-dBA regulations with regulations on tire noise which reduces all tire noise levels to those of the quietest tires known today. At 27 mph, the reductions in traffic noise levels will be 1.7, 3.1 and 4.5 dBA for the 83, 80 and 75-dBA proposed regulations on trucks when there are no regulations on tire noise, and 2.2, 3.7 and 5.2 dBA with regulations on tire noise. (Health & Welfare, p. 3-29 of PHW).

A-2.5.4.4 Cooling system radiator shutters should not be referred to as noise reduction equipment, since closing the shutters increases the noise by about 2 dBA (Technology, p. 1 of T104 and p. 3-282 of PHW).

A-2.5.4.5 In all of the trucks in the DOT Quiet Truck Program, the cooling system noise was greater than 80 dBA. This suggests that many truck cooling systems generate noise levels in excess of 80 dBA (Technology, p. 2 of T104 and p. 3-283 of PHW).

A-2.5.4.6 Given equal flow rates, the design of the cooling fan has little effect on its noise generation (Technology, p. 2 of T104 and p. 3-283 of PHW).

A-2.5.4.7 Exhaust sheil noise is high enough on many trucks that it will require treatment to meet the 83-dBA regulation. On the International Harvester DOT Quiet Truck the pipe shell noise was 82 dBA and the muffler shell noise was 74 dBA, whereas the exhaust discharge noise was 76 dBA and noise due to exhaust leaks was 72-dBA (Technology, pp. 3-4 of T104 and p. 3-285 of PHW).

A-2.5.4.8 Mufflers are available to reduce exhaust outlet noise of all popular truck diesel engines to 75 dBA. In many cases, the 75-dBA level can be reached without series mufflers (Technology, p. 4 of T104 and p. 3-285 of PHW).

A-2.5.4.9 There is no fundamental difference in the noise control technology for trucks and buses (Technology p. 7 of T104 and p. 3-289 of PHW).

A-2.5.4.10 The manufacturing design levels would be about 4 dBA below the regulatory levels which includes 2 dBA to account for variation of the levels for identical trucks and 2 dBA to account for design tolerances (Technology, p. 10 of T104, p. 3-296 of PHW and p. B-3, Information Brief, 10 April 1975).

A-2.5.4.11 Sufficient information does not exist to assure that all trucks can be quieted to a 75-dBA noise level (Technology, p. 7 of T104 and p. 3-297 of PHW).

A-2.5.4.12 Reduction of cooling system noise to a level of 65 dBA which is needed to reduce most truck noise levels to 75 dBA will require radiators to be larger than those available today. It may be possible to include large enough radiators on COE trucks, but it will not be practical on conventional trucks because of the need for visibility (Technology, p. 2-283 of PHW).

A-2.5.4.13 The data on engine, exhaust and fan noise levels, taken from the Highway Research Board Design Guide for nominal highway operations, are higher than SAE J366b test levels. These data appear to be about 5 dBA too high since engine-related highway noise levels should be at least 2 dBA below levels measured according to SAE J366b test procedures (Technology, p. 3-291 of PHW).

A-2.5.4.14 The tire noise level of 77 dBA at 55 mph, assumed by EPA in making predictions of the benefits of the proposed regulations, is too low. Such a level is not attainable by any tire known today (Technology, p. 3-292 of PHW).

A-2.5.4.15 The fact that the noise levels of the International Harvester DOT Quiet Truck decreased slightly with age can be partly attributed to thorough maintenance procedures (Technology, p. 3-298 of PHW).

A-2.5.4.16 EPA's estimates of costs for noise abatement treatment are lower than the costs quoted in the DOT Quiet Truck Program. Freightliner achieved 72–74 dBA at a cost of $1400, International Harvester, 78 dBA for $1390 and 80 dBA for $516 and White Motors Corp., 79–81 dBA for $260 and 77–79 dBA for $1307 (Costs of Compliance, p. 10 of T104 and p. 3–296 of PHW).

A-2.5.4.17 The monetary estimate associated with reductions in urban traffic noise is about $20/person/dB. Using this figure along with estimates of the number of people exposed to urban street or freeway traffic noise and the reductions in traffic noise for different regulatory options, monetary estimates for the benefits were computed. Estimates of costs/savings associated with each regulatory option were made assuming credit for fuel savings from disengaged fan clutches. Comparing estimates of costs/savings and monetary estimates of benefits show that the costs for the proposed regulations are greater than the benefits. Savings are predicted to result with the regulatory options which do not have the 75-dBA regulatory level. (Costs vs. Benefits, DOT Information Brief, April 10, 1975, pp. 5–7).

A-2.5.4.18 EPA should consider the different benefits of using vertical and horizontal exhaust systems. For example, lower exhaust noise levels are achievable more easily with vertical systems than with horizontal due to apparent image source enhancement of the horizontal systems. Technology is more advanced for vertical systems. The gases from underframe systems are more aggravating and create splash and spray visibility problems. The lower exhaust outlet noise levels of underframe systems make roadside barriers more effective. Underframe systems present more difficult packaging problems. The noise radiated vertically is 2-dBA higher for vertical systems (Costs vs. Benefits, pp. 4–5 of T104 and p. 3–286–7 of PHW).

A-2.5.4.19 The total cost impact of the proposed regulations can not be determined from the estimates given by EPA since production tolerances were not included in the design levels used to estimate the costs (Economic Impact, p. 10 of T104 and p. 3-296 of PHW).

A-2.5.4.20 Special purpose equipment should be covered under the regulations (Classification, p. 9 of T104).

A-2.5.4.21 Buses should be included in the regulations (Classification, p. 7 of T104).

A.2.5.5 City of Des Plaines, Illinois

A-2.5.5.1 The proposed regulations should be more stringent so that they conform with the local regulations in Chicago and California (Costs vs. Benefits, p. 658 of PHSF).

A-2.5.6 Council on Wage and Price Stability

A-2.5.6.1 The analysis of the increasing marginal costs and decreasing marginal benefits strongly indicate a lack of justification 75-dBA regulatory level. The GM estimates of truck price increases and operating costs for medium trucks and the DOT estimates for heavy trucks were used. Benefits included estimates of changes in property values and fuel consumption with fan clutches. The costs and benefits were cumulated to the year 2000 and discounted at a rate of 10 percent to a 1975 present value (Cost vs. Benefits, Th051).

A-2.5.7 District of Columbia

A-2.5.7.1 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T063).

A-2.5.8 Federal Highway Administration, Ohio

A-2.5.8.1 An Environmental Impact Statement is required (Health & Welfare, T066).

A-2.5.8.2 The assessment of increases in annual operating costs should take into account replacement parts and labor costs to maintain a truck in compliance (Costs of Compliance, T066).

A-2.5.8.3 The costs of testing facilities and manpower, and production delays due to testing should be determined (Costs of Compliance, T066).

A-2.5.8.4 The effect of truck noise treatments on fuel consumption should be determined (Costs of Compliance, T066).

A-2.5.8.5 An assessment of a "do-nothing" alternative to the regulations should be addressed (Costs vs. Benefits, T066).

A-2.5.8.6 The effect that increases in transportation costs have on the costs of customer retail goods should be determined (Economic Impact, T066).

A-2.5.8.7 The effect that differences in cost increases for gasoline and diesel trucks will have on buyer patterns should be determined (Economic Impact, T066).

A-2.5.9 State of Illinois, Environmental Protection Agency

A-2.5.9.1 The 75-dBA regulation is needed to reduce intrusions from noise emissions from trucks (Health & Welfare, p. 310 of PHSF).

A-2.5.9.2 The 75-dBA regulation will not reduce roadside truck noise levels to levels similar to the roadside levels of automobiles, as indicated in the Preamble to the Proposed Regulations. The 75-dBA regulated truck will typically be around 10 dBA noisier than the average automobile (Health & Welfare, p. 311 of PHSF).

A-2.5.9.3 A label on the vehicle should state the noise level produced at the time of manufacture, GVWR and model year. (Miscellaneous, p. 309 of PHSF)

A-2.5.10 Indiana

A-2.5.10.1 The exhaust system should be required to be located beneath the truck body (Costs vs. Benefits, T093).

A-2.5.11 Louisiana

A-2.5.11.1 The impact of training testing personnel and of production delays for testing should be assessed (Costs of Compliance, T127).

A-2.5.11.2 Prior to promulgation, the economic impact of the regulation should be revised and re-evaluated to terms of the existing economic stiuation (Economic Impact, T127).

A-2.5.12 Los Angeles County

A-2.5.12.1 An effort to regulate noise from buses should be initiated (Health & Welfare, T105).

A-2.5.12.2 The California regulation of 70-dBA in 1987 should be included in EPA's regulations (Costs vs. Benefits, T105).

A-2.5.13 Mississippi

A-2.5.13.1 The effect of the regulations on public health should be assessed (Health & Welfare, T073).

A-2.5.13.2 The effect of the regulations on highway safety should be considered (Health & Welfare, T073).

A-2.5.13.3 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T073).

A-2.5.13.4 The economic analysis should consider the effect of the noise regulations on the costs of highway projects (e.g., savings in required highway noise barriers) and on property values (Economic Impact, T073).

A-2.5.14 Minnesota

A-2.5.14.1 Complementary regulations on tires on all vehicles at normal highway speeds should be considered (Health & Welfare, T086).

A-2.5.14.2 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T086).

A-2.5.14.3 States must rely on highway noise treatments until the regulations on trucks become effective. (Miscellaneous, T086)

A-2.5.15 New Mexico

A-2.5.15.1 The proposed new truck regulations are in excess of the 70-dBA L_{10} FHWA standards for residential, hospital and school areas. Therefore, truck regulations which are more in keeping with 70-dBA at 50 feet should be adopted (Health & Welfare, T045).

A-2.5.15.2 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T045).

A-2.5.15.3 Noise abatement walls along highways cost about $100/foot. Therefore, the effect of the new truck regulations on the need for highway noise barriers should be considered (Economic Impact, T045).

A-2.5.16 New York State

A-2.5.16.1 Since tire noise dominates at high speeds, regulations on tire noise should be considered (Health & Welfare, T082 and Th027).

A-2.5.16.2 The regulations should include buses (Health & Welfare, T082 and Th027).

A-2.5.16.3 Special purpose equipment should be covered under the regulation. (Miscellaneous, T046)

A-2.5.16.4 The regulation should include a high speed noise level standard. (Miscellaneous, T082)

A-2.5.17 National Organization to Insure Sound Controlled Environment (NOISE)

A-2.5.17.1 The predicted rate of increase in truck population of 4.3 percent per year used in predicting benefits to the public welfare is too high (Health & Welfare, p. 3-312-3 of PHW).

A-2.5.17.2 The regulations should be enforced at speeds below 50 mph instead of below 35 mph, since tire noise does not become a factor for speeds below 50 mph (Health & Welfare, p. 3-311 of PHW).

A-2.5.18 San Diego County

A-2.5.18.1 Buses and vehicles over 6000 lbs. GVWR should be included in the regulations (Health & Welfare, T097).

A-2.5.18.2 The regulatory levels should be at least as low as the California regulated levels of 83 dBA in 1974, 80-dBA in 1977, and 70 dBA in 1987 (Costs vs. Benefits, T097).

A-2.5.19 San Francisco, Noise Control Task Force

A-2.5.19.1 Commercial trucks are capable of obtaining 80-dBA noise levels at reasonable costs, now. The noise level from a bus was reduced from 90 to 81 dBA by retrofitting noise treatment at a cost of $600 (Costs of Compliance, p. 416-7 of PHSF).

A-2.5.19.2 The proposed regulations are too lenient (Costs vs. Benefits, p. 414 of PHSF).

A-2.5.20 Texas

A-2.5.20.1 Lower regulatory levels with shorter lead times should be considered (Costs vs. Benefits, T042).

A-2.5.20.2 The economic impact on the state and local governments of providing highway noise abatement treatment during the period before the EPA regulations become effective should be addressed (Economic Impact, T042).

A-2.5.21 Virginia

A-2.5.21.1 The height of exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations (Costs vs. Benefits, T022).

A-2.5.21.2 States must rely on highway noise treatment until the regulations on trucks become effective (Miscellaneous, T022).

A-2.6 TRADE AND MANUFACTURING ORGANIZATIONS

A-2.6.1 American Road Builders Association

A-2.6.1.1 Studies which prove that there are harmful effects directly attributed to noise from new trucks need to be conducted before the regulations are adopted (Health & Welfare, T114).

A-2.6.1.2 By the time the regulations become effective, inflation will have increased the costs of compliance (Costs of Compliance, Th035).

A-2.6.2 Associated General Contractors of Colorado

A-2.6.2.1 The EPA projections of truck price increases are totally unrealistic (Costs of Compliance, T060).

A-2.6.2.2 A tremendous reduction of noise can be accomplished by enforcement of existing regulations (Costs vs. Benefits, T060).

A-2.6.2.3 The costs to all elements of the total economy, such as agency costs to enforce the regulations, manufacturer's costs, increased costs to the small businessman and costs to the consumer, should be included in the costs projections (Economic Impact, T060).

A-2.6.2.4 The present state of the inflated economy should be considered in the analysis of the economic impact of the regulations (Economic Impact, T060).

A-2.6.2.5 Trucks in different GVWR categories should be regulated to different levels (Classification, T060).

A-2.6.3 Automotive Exhaust Systems Manufacturers Committee

A-2.6.3.1 It is not technically feasible to determine the useful life of an exhaust system, since there are no data on the driving habits of the vehicle owner. These data are critical in determining the extent and speed of deterioration of exhaust systems (Technology, p. 9 of T112).

A-2.6.4 Chamber of Commerce

A-2.6.4.1 EPA's estimate of 70 million people who are affected by traffic noise is too high. It should be around 3-6 million (Health & Welfare, p. 2-104 of PHW).

A-2.6.4.2 The technology is not available to comply with the proposed regulations. (Technology, p. 2-104 of PHW).

A-2.6.4.3 EPA's estimates of the increases in truck prices are too low (Costs of Compliance, pp. 2-105 and 2-111 of PHW).

A-2.6.4.4 The effects of the 83-dBA regulation should be assessed before lower levels are set (Costs vs. Benefits, p. 2-114 of PHW).

A-2.6.4.5 The proposed regulations will cause trucks to be priced beyond reach (Economic Impact, p. 2-103 of PHW).

A-2.6.4.6 The proposed regulations will have an inflationary impact on consumer goods (Economic Impact, p. 2-104 of PHW).

A-2.6.4.7 The proposed regulations will help to drive the small trucker out of business (Economic Impact, p. 2-106 of PHW).

A-2.6.4.8 The economic impact study is outdated (Economic Impact, p. 2-110-1 of PHW).

A-2.6.4.9 The cumulative economic impact of all federal regulations on trucks should be considered (Economic Impact, p. 2-118 of PHW).

A-2.6.5 Construction Industry Manufacturers' Association

A-2.6.5.1 Small manufacturers of custom-built specialty construction trucks do not have the financial resources for the testing required in the proposed regulations (Costs of Compliance, p. 357 of PHSF).

A-2.6.6 Motor Vehicle Manufacturers' Association

A-2.6.6.1 EPA has not defined what is the "impact" that the regulations are intended to relieve, or what is meant by "relief." Does relief refer to avoiding hearing loss or reduction in annoyance? (Health & Welfare, p. 3 of T099).

A-2.6.6.2 EPA has not met the statutory requirement which requires that the regulatory levels be attainable with available technology (Technology, pp. 5-6 of T099).

A-2.6.6.3 The total increase in costs to users of attaining the 1990 level of benefits is $2 to 3 billion higher than estimated by EPA since EPA failed to take into account all of the costs incurred in the intervening years (Economic Impact, p. 4 of T099).

A-2.6.6.4 An Inflation Impact Statement is required (Economic Impact, p. 2 of T099):

A-2.6.7 National Solid Wastes Management Association

A-2.6.7.1 Mounting a truck body could affect the noise emission characteristics of a truck (Technology, p. 2-87-8 of PHW).

A-2.6.7.2 The economic impact on small companies engaged in solid wastes collection and disposal services caused by increased prices and maintenance expenditures for equipment should be carefully considered (Economic Impact, T111).

A-2.6.7.3 Second-stage manufacturers of solid waste disposal trucks cannot afford the costs of testing for compliance to the proposed regulations (Economic Impact, p. 2-92 of PHW).

A-2.6.8 Recreation Vehicle Industry Association

A-2.6.8.1 Motor homes have not been identified as a major source of noise. In fact, motor homes are substantially quieter than medium and heavy duty trucks (Health & Welfare, T120).

A-2.6.8.2 The regulations would have a devastating economic impact on the motor home manufacturers and substantially restrict competition within the industry (Economic Impact, T120).

A-2.6.8.3 Motor homes should be excluded from the Regulation (Classification, T120).

Appendix A-3
BENEFITS TO PUBLIC HEALTH AND WELFARE

A-3.1 BENEFITS TO PUBLIC HEALTH

A-3.1.1 Hearing Damage

Identification: The State of Mississippi (A-2.5.13.1)* commented that the effects on public health of the regulations on new truck noise emissions should be assessed. International Harvester Company (A-2.1.6.4), Mack Trucks, Inc. (A-2.1.7.3), and the Donaldson Company (A-2.2.2.1), asserted that outdoor noise from trucks does not cause damage to hearing, but produces only annoyance. Citizens Against Noise (2.4.3.1) claimed that noise from trucks disturbs sleep which can affect public health.

Discussion: In the assessment made by EPA of the impact of truck noise on hearing damage, it was concluded that truck noise has little impact on hearing loss. EPA has identified an 8-hour equivalent noise level of 75 dBA as requisite to protect the public from hearing damage with an adequate margin of safety [1]. Most people presently impacted by traffic noise are exposed to equivalent levels less than 75 dBA. Note, however, that this is highly dependent upon individuals' exposure to non-traffic noise situations, i.e., workplace, recreational, etc. It is conceivable that exposure to traffic noise (even less than 75 dBA) combined with hazardous or near-hazardous workplace/recreational noise may, in fact, be hazardous. In the aggregate, however, most of the benefits from the regulations on new medium and heavy truck noise emissions will be derived from the reduction of annoyance caused by truck noise. In estimating the benefits to public health and welfare, EPA has focused attention on the reduction in the number of people disturbed or impacted by noise from trucks. Even here it must be recognized that basic annoyance may adversely affect health by causing general stress, fatigue, etc.

The annoyance associated with sleep disturbance by single truck passbys and the reduction in the present levels of annoyance by the regulations on new truck noise emissions has been treated by EPA. However, little information exists on the impact on public health caused by the disturbance of sleep by truck noise.

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* Number refers to paragraph number in Section A-2, SUMMARY OF COMMENTS.

Action in Response to Public Comment: The benefits of the new truck noise emissions regulations have been treated in terms of the reduction in annoyance caused by truck noise.

A-3.1.2 Safety

Identification: The State of Mississippi (A-2.5.13.2) suggested that the effect of the regulations on highway safety should be considered. Mack Trucks, Inc. (A-2.1.7.1) commented that the 75 dBA regulated truck would not produce enough noise to serve as a warning to pedestrians. On the other hand, PROD (A-2.3.6.1) points out that the noise from unregulated trucks masks the warning signals from emergency vehicles. Thus, the reduction of truck noise is expected to increase the detection of warning signals, thereby contributing to public safety.

Discussion: EPA agrees with PROD that an increase in the detectability of warning signals should result from the reduction in overall traffic noise attributable to the reduction in truck noise. It is not likely that the new truck regulations will produce a significant safety hazard, as implied by Mack Trucks. Horns will probably provide most of the audible warnings to pedestrians of impending danger. However, in the absence of the use of a horn, the 75 dBA regulated truck will still be about 5 dBA noisier than unregulated automobiles. This should be more than sufficient to provide warning to pedestrians close enough to be in danger.

Actions in Response to Public Comment: No further action has been taken.

A-3.2 BENEFITS TO PUBLIC WELFARE

A-3.2.1 Need for Additional Study

Identification: The American Road Builders Association (A-2.6.1.1) suggested that there is a need for studies which prove that there are harmful effects directly attributed to noise from trucks. White Motor Corporation (A-2.1.10.1) commented that the benefits to public welfare for the new truck regulations have not been assessed. The American Trucking Associations, Inc. (A-2.3.1.10) pointed out that a more careful study of the benefits needs to be conducted before the proposed regulations are adopted. According to the Motor Vehicle Manufacturers Association, (A-2.6.6.1) definitions of "impact" on and "relief" to public welfare have not been presented.

International Harvester, Inc. (A-2.1.6.2) and the Donaldson Company (A-2.2.2.1) indicated that modeling techniques have not been developed which are sufficient for accurate predictions of benefits from motor vehicle noise regulations. International Harvester (A-2.1.6.3) added that EPA has not shown a relation between regulated truck noise levels and noise levels necessary to protect public health and welfare. General Motors Corp. (GM) (A-2.1.5.6) suggested that the effects of the Interstate Motor Carrier regulations, regulations on tire noise and elimination of modified or poorly maintained light vehicles should be considered in assessing benefits. The benefits of the regulations on new truck noise emissions should be identified separately from the benefits for regulations on other sources of traffic noise, according to the Department of Transportation (DOT) (A-2.5.4.3).

Ford Motor Company (A-2.1.3.3) commented that estimates of benefits should be given for other regulatory programs. The Federal Highway Administration (A-2.5.8.5) suggested that an assessment of the impact on the public welfare with no regulations on new trucks be given.

Discussion: The equivalent number of people impacted by urban traffic noise is estimated by EPA to be 37.3 million. Regulating only medium and heavy trucks to 75 dBA can reduce this number by 13.1 million [2]. This indicates that medium and heavy trucks do have a significant noise impact on people and that their regulation will bring appreciable relief.

Predictions of the benefits from several regulatory programs on noise emissions from new medium and heavy trucks have been made [2]. Estimates of the reductions in the average noise levels for urban street traffic (average speed-27 mph) and freeway traffic (average speed-55 mph) are given. The effect of these reductions on people is assessed. The concept of equivalent number of people impacted is defined and used in making these assessments. The word "relief" is used to indicate a reduction in the number of people impacted by noise.

In revising the benefit predictions in response to public comment, predictions are given for a wide range of possible regulations so that benefits from the final regulations can be evaluated relative to more lenient and more stringent regulations. The regulatory programs added in revising the predictions include the regulatory alternatives suggested by the Ford Motor Company and the Federal Highway Administration. To provide additional insight into the benefits will probably result from the new truck regulations alone and when supported by other regulations, predictions are given with and without a 4 dBA reduction in noise levels from road vehicles other than medium and heavy trucks. Since average noise levels are sometimes a poor indicator of annoyance from individual truck passby noise, estimates of the amount of activity interference produced in different situations are given for trucks regulated at different levels.

In all of the revised predictions, relations between regulatory levels and typical truck passby levels were developed using published truck noise measurement data, where available. The typical truck passby noise levels, individually or in averages with passby levels from other vehicles, were compared to levels specified by EPA as necessary to protect public health and welfare. Therefore, relations between regulated truck noise levels and levels necessary to protect public health and welfare have been developed.

The effects of the Interstate Motor Carrier regulations and the elimination of the more noisy vehicles were included in revising the estimates of the benefits to public health and welfare. Truck tire noise levels were also considered.

Sophisticated modeling techniques are not available to accurately represent all possible situations where people are impacted by noise. Even if such techniques were available, employment in all possible situations would result in an overwhelming amount of data for analyses. Therefore, simple modeling techniques representing typical scenarios were employed by EPA. These techniques are believed to be adequate for use, by EPA, in justifying the selection of the final regulatory levels on a nationwide basis.

Action in Response to Public Comment: Some of the public comments were employed for improving estimates of the benefits to the public health and welfare of new medium and heavy truck noise emission regulations. The revised estimates are sufficient for use in supporting the selection of the final regulatory levels. Additional studies have not been conducted.

A-3.2.2 Accuracy of EPA Predictions

Identification: The Ford Motor Company (A-2.1.3) and N.O.I.S.E. (A-2.5.17.1) commented that the truck population growth rates used in the EPA predictions of benefits to the public welfare are too high. According to the Chamber of Commerce (A-2.6.4.1), the EPA estimate of 70 million people affected by traffic noise is too high. The number should be around 3 to 6 million. Koehring Company (A-2.2.4.1) implied that, since there will be no benefits from the new truck regulations, the EPA predictions are incorrect. The State of Illinois (A-2.5.9.2) commented that the 75 dBA regulated truck will not be as quiet as a typical automobile as indicated by EPA, but will be about 10 dBA noisier.

General Motors (A-2.1.5.1) and the Department of Transportation (A-2.5.4.3) both presented predictions of the reductions in average noise levels in urban street and freeway traffic for the different regulatory programs. Estimates of the annoyances produced by the noise from individual passbys of truck regulated at different levels were also given by General Motors (A-2.5.1.2).

Discussion: Changes in the traffic noise levels, due to different future growth rates of trucks, will effect all of the estimates of average traffic noise reductions for the different regulatory programs on new truck nearly equally, as long as the traffic mix of trucks and other vehicles remains constant, as assumed by EPA in estimating benefits. In other words, comparison of the traffic noise reductions estimated by EPA for different regulatory programs are not sensitive to the assumed truck population growth rate. In addition, the future population growth rates of traffic vehicles cannot be accurately predicted. For these reasons, EPA used a zero population growth rate in reviewing the estimates of traffic noise reductions. By assuming a zero growth rate, the EPA estimates of reductions in the equivalent number of people impacted (P_{eq}) will be lower (i.e., more conversative) than estimates made by assuming a positive growth rate.

The number of people exposed to an outdoor noise level with an L_{dn} greater than 55 dBA where the dominant source of noise is urban street traffic is given by EPA as 93.4 million people [3]. The L_{dn} = 55 dB has been identified by EPA as the outdoor noise level requisite to protect the public from interference with outdoor activities and general annoyance [1]. Therefore, the estimate of 3 to 6 million people affected by traffic noise, particularly urban street traffic, referenced by the Chamber of Commerce appears to be quite low.

In all of the estimates of benefits given by EPA, General Motors and the Department of Transportation, definite reductions in the average traffic noise levels and the number of people impacted by traffic noise are indicated. Therefore, the comment by the Koehring Company that no benefits will accrue by regulating truck noise emissions is incorrect.

Typical roadside noise level for a 75 dBA regulated truck will be approximately 71 dBA cruising at 27 mph and 81 dBA, as measured at 50 ft. [2]. Noise emissions for existing automobiles are 65 dBA and 75 dBA, respectively as measured at the same distance [2]. Therefore, the 75 dBA regulated truck will be noisier than existing automobiles, as indicated by the State of Illinois. However, it will be noisier by about only 6 dBA.

For two regulatory programs, the predictions of reductions in the average traffic noise given by General Motors and the Department of Transportation are compared to the EPA predictions in Figure A-3.1 for urban street traffic and in Figure A-3.2 for freeway traffic. In all predictions, the effect of reductions in non-truck vehicle noise levels of about 4 dBA and the Interstate Motor Carrier Regulations are included. DOT and EPA assumed that all trucks will be equipped with only ribbed tires in making the predictions given in Figures A-3.1 and A-3.2. GM assumed a reduction in tire noise of about 3.5 dBA from 1975 to 1993. In order to make comparisons, the curves in Figures A-3.1 and A-3.2 for the GM predictions are plots of the differences in the curves given by GM with and without noise emission regulations.

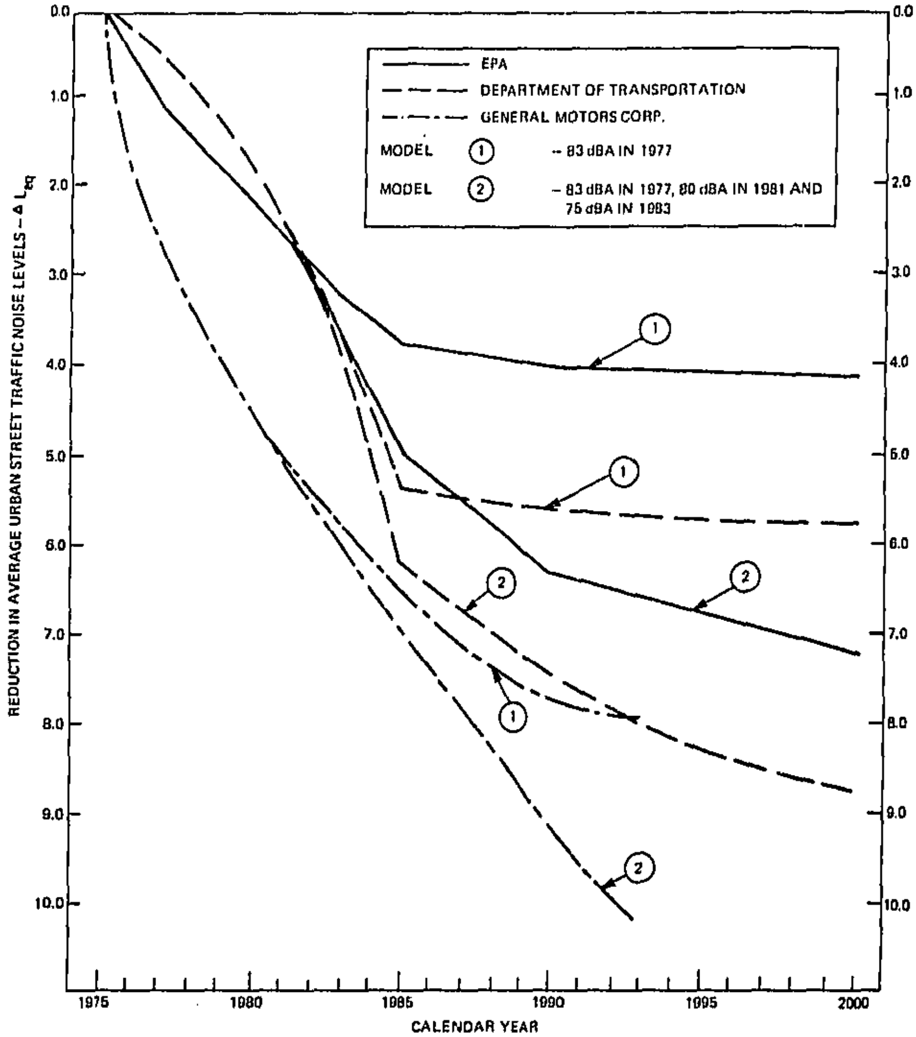

Figure A-3.1. Comparison of EPA, GM, and DOT Estimates of Average Urban Street Traffic Noise Reductions Due to New Truck Regulations

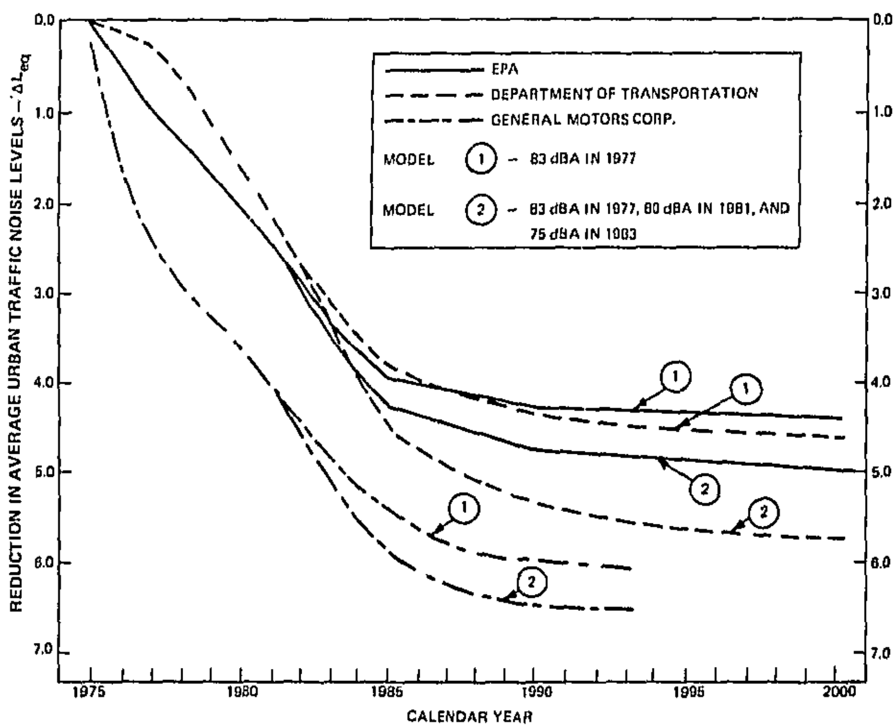

Table A-3.2. Comparison of EPA, GM, and DOT Estimates of Average Freeway Traffic Noise Reductions Due to New Truck Regulations

The DOT and GM estimates of reductions in the average urban street traffic noise are higher than the EPA estimates, with the estimates from GM the most optimistic. EPA included the effects of noise from buses and motorcycles in their estimates of the noise reductions. GM and DOT did not consider these vehicles in their model. This partially explains the higher estimated benefits predicted by GM and DOT. Because buses and motorcycles are noisier than automobiles, they tend to limit the potential reductions in urban street traffic noise levels afforded by regulations on new medium and heavy trucks. Comparison of estimates from EPA with those from DOT and GM clearly indicate the necessity of future noise emission regulations on buses and motorcycles.

The DOT and EPA estimates of the reductions in average freeway traffic noise levels are nearly identical. The estimates of benefits from GM are higher than the DOT and EPA predictions. A partial explanation for this may be the assumed lower truck tire noise emission levels used by GM. GM assumed a tire noise emission level of 78.5 dBA for 1981 and subsequent years, while EPA used a level of 81 dBA for 1977 and subsequent years.

In assessing the benefits to public health and welfare, EPA used the predictions of reductions in average traffic noise levels to estimate the changes in the extensiveness and severity of impact for several regulatory programs. The P_{eq} is a better indicator of the benefits to public welfare since it takes into account the number of people who benefit from traffic noise reductions and the extent to which they are benefited (See Section 4). Therefore, the selection of the final regulatory levels should be based more on the estimates of P_{eq} than on decibel reductions in the average traffic noise levels.

EPA and GM have estimated the maximum distances from individual truck passbys at which disruption of various activity occurs in different situations. Comparisons of these estimates are shown in Figures A-3.3 through A-3.6. The estimates from GM are lower than those from EPA for the following reasons:

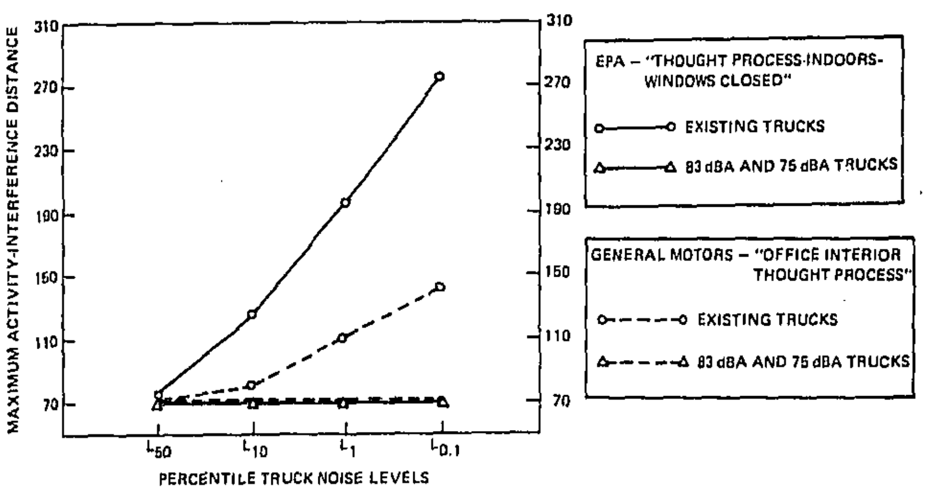

Figure A-3.3. Comparison of EPA and GM Predictions of Maximum Activity-Interference Distances for Thought Process Indoors

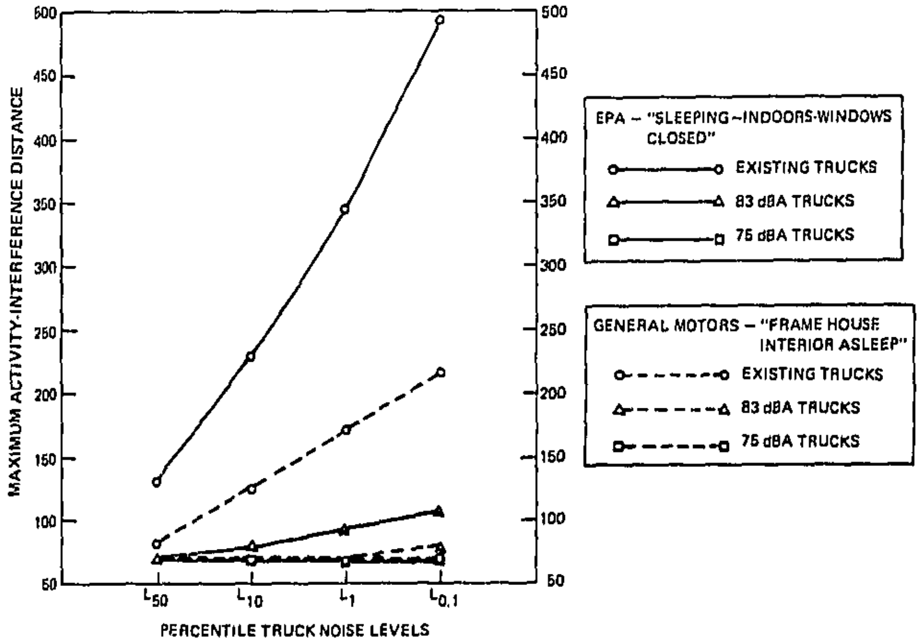

Figure A-3.4. Comparison of EPA and GM Predictions of Maximum Activity-Interference Distances for Sleeping Indoors

- EPA used noise levels for accelerating trucks while GM conservatively used levels for trucks at constant speed, and

- The noise reduction factors assumed by GM for indoor situations are much higher than those used in revised EPA estimates.

The noise levels from accelerating trucks are higher than the levels from cruising trucks. Therefore, accelerating trucks are capable of producing greater activity interference than trucks cruising at constant speed.

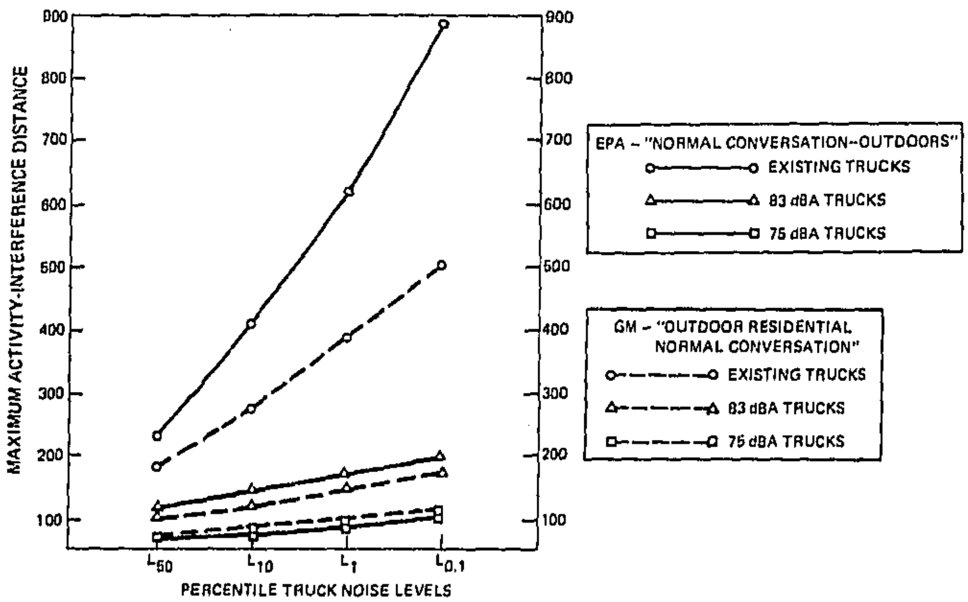

Figure A-3.5. Comparison of EPA and GM Predictions of Maximum Activity-Interference Distances for Normal Conversation Outdoors

GM used noise reduction factors of 35 to 29 dBA taken from data given in the first background document on the new truck regulations. A noise reduction factor of 25 dBA was also given in the first background document as an approximate national average for houses with windows closed. This factor appears more reasonable and was therefore incorporated in the revised estimates of activity interference.

Action in Response to Public Comments: EPA estimates of the benefits to the public welfare have been revised. The selection of the final regulatory levels is based more on the estimates of the reduction in the extensiveness and magnitude of annoyance and activity interference as measured by P_{eq} and maximum annoyance distances, than on estimates of the

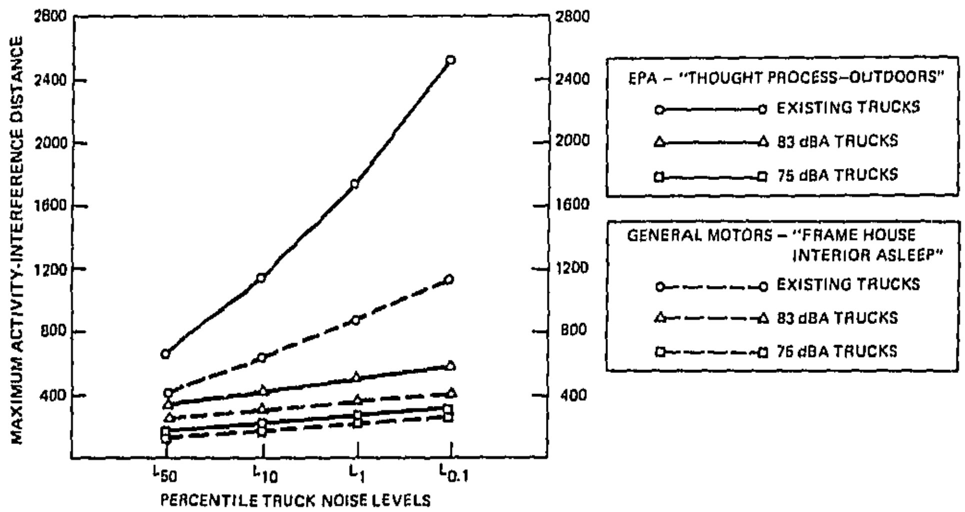

Figure A-3.6. Comparison of EPA and GM Predictions of Maximum Activity-Interference Distances for Thought Process Outdoors

changes in the traffic noise levels. EPA estimates of the benefits to public health and welfare are believed to be more than sufficient to support the selection of the final regulatory levels.

A-3.2.3 Needed Benefits

Identification: The State of Illinois (A-2.5.9.1) commented that a 75-dBA regulation is needed to reduce intrusions from noise emissions from trucks. According to the State of New Mexico (A-2.5.15.1), the new truck regulations should be similar to the 70 dBA L_{10} Federal Highway Administration standard for residential, hospital and school areas.

Discussion: Estimates of annoyance or intrusion from truck noise emissions demonstrate that regulating trucks to a level of 75 dBA will not assure that people won't still be annoyed with truck noise or that all activity disruption will be removed. In order to remove all annoyance and activity disruptions caused by trucks, regulatory levels below 75 dBA would be required. However, other considerations preclude lowering the regulatory levels below 75 dBA at this time. For example, technology has not been demonstrated that will reduce truck noise levels low enough to comply with not-to-exceed regulatory levels below 75 dBA.

Action in Response to Public Comments: No further action has been taken.

A-3.2.4 Benefits from More Lenient Regulations

Identification: Ford Motor Co. (A-2.1.3.4) claimed that substantially all of the intended noise reductions will result if 10 percent of the tested vehicles are allowed to exceed the regulation level by 2 dBA. According to Mack Trucks (A-2.1.7.2) drastic reductions in traffic noise levels will result from the 83-dBA regulation. Donaldson Company (A-2.2.2.2) commented that the greatest annoyance comes from a small minority of the noisiest trucks which will be controlled by the Interstate Motor Carriers Regulations.

General Motors Corporation asserted that the overwhelming amount of the benefits to be derived from noise emission regulations on trucks will come from the combination of the enforcement of the Interstate Motor Carriers Regulations and the 83-dBA regulation on new trucks. In support of this assertion, General Motors presented the following data.

1. Predictions of the average noise reductions from urban street and freeway traffic for five regulatory programs (A-2.1.5.1);

2. Predictions of the maximum intrusion distances for different activity/location situations for single passbys of existing trucks and trucks regulated at 83, 80, and 75 dBA (A-2.1.5.2);

3. Predictions of the distances at which the noise from an unregulated truck and a truck regulated at 83 dBA will be equal to and 10 dBA greater than the noise from a continuous line of freely-flowing traffic at 55 mph (A-2.1.5.3);

4. Predictions of the differences in typical low speed roadside levels for unregulated trucks and trucks regulated at 83 dBA (A-2.1.5.4); and

5. Comparison of SAE J366b measured levels and levels measured under different typical operating conditions for the same trucks (A-2.1.5.5).

Discussion: Predictions of reductions in the average noise levels for urban street traffic are given in Figure A-3.7 for the regulations proposed by EPA with nearly all trucks measured at levels below the regulated levels (nearly 100 percent compliance) and with 10 percent of the trucks allowed to exceed the regulatory level (90 percent compliance) as suggested by Ford Motor Company. Shown in Figure A-3.8 are predictions of the equivalent number of people impacted (P_{eq}) computed using the reductions in traffic noise levels given in Figure A-3.7. These predictions were computed following procedures given in Reference 2 and Section 4. Using a standard deviation of 0.5 dBA for the tested truck levels and a 1.0 dBA factor to account for measurement instrumentation and site variations, the median tested level was assumed to be 1.5 dBA below the regulatory levels for 90 percent compliance and 2.5 dBA for nearly 100 percent compliance.

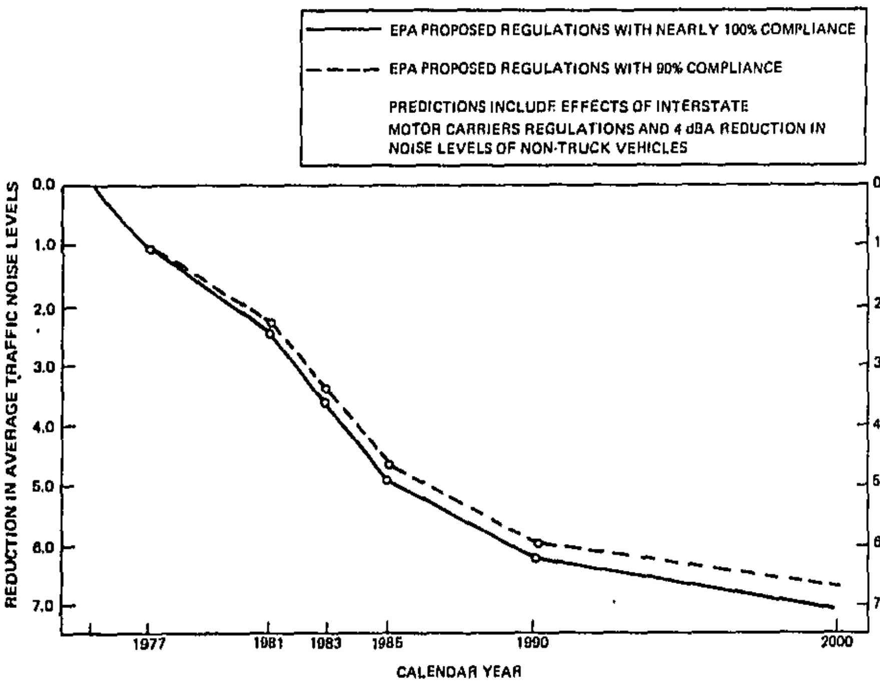

Figure A-3.7. Predictions of Average Traffic Noise Reductions for 100 Percent and 90 Percent Compliance to the EPA Proposed Regulations

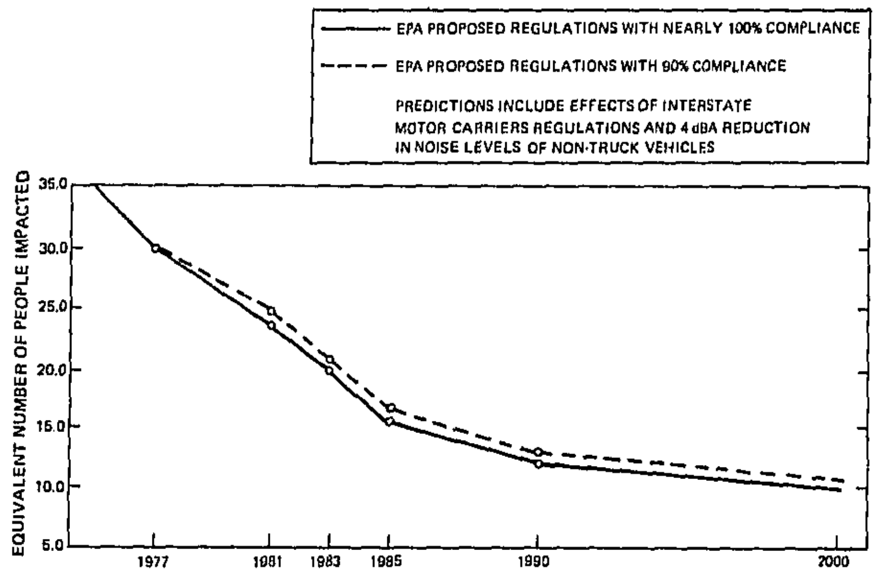

Figure A-3.8. Predictions of P_{eq} for 100 Percent and 90 Percent Compliance to the EPA Proposed Regulations

Observation of the predictions in Figures A-3.7 and A-3.8 confirm the comments made by Ford Motor Company that only small losses in the benefits would result if 10 percent of the trucks are allowed to exceed the regulated level of 2 dBA. However, there is a provision in the selective enforcement auditing in the proposed regulations that allows 6.8 percent of the sampled vehicles to exceed the regulated level (Section 205.57-3(b) of Federal Register Volume 39, No 210, Part II, p. 38358). Changing this to 10 percent of the sampled vehicles is under consideration by EPA.

Comparison of the revised EPA predictions of the noise reductions for urban street traffic [2] are given in Figure A-3.9 with (1) no regulations on new trucks, (2) an 83-dBA regulation in 1977, and (3) the regulations proposed by EPA. All predictions include the benefits of the Interstate Motor Carrier Regulations as well as a 4-dBA reduction in non-truck vehicle noise levels. These predictions do not substantiate the comment from the Donaldson Company that the Interstate Motor Carrier Regulations will eliminate most annoyance from truck noise by removing the noisiest of the existing trucks. (Results in Figures A-3.3 through A-3.6 also fail to confirm the comment made by Donaldson.) The claim that most of the reduction in traffic noise will result from the 83-dBA regulation made by

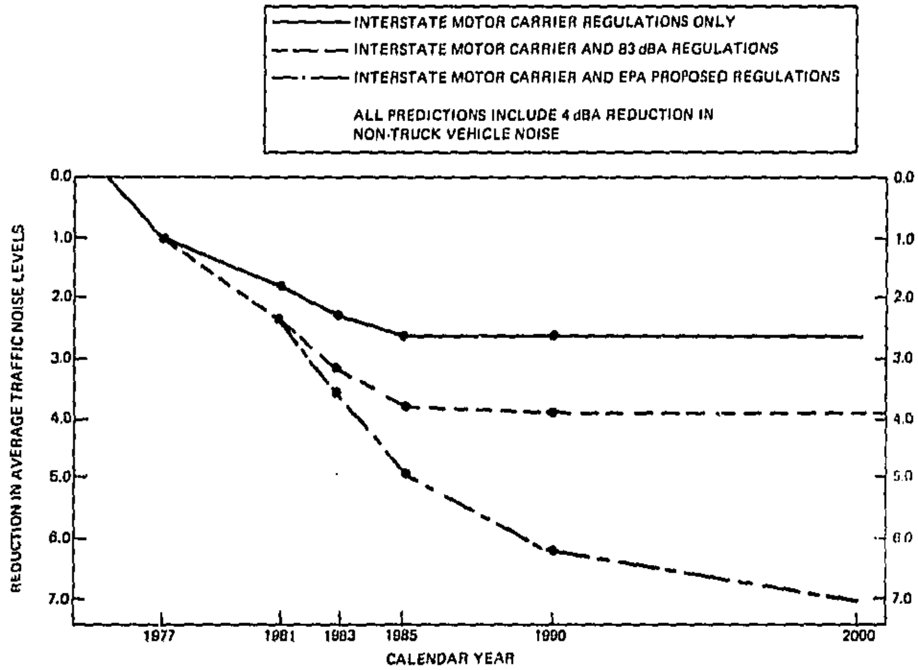

Figure A-3.9. Predictions of Average Traffic Noise Reductions with Regulations on New Medium and Heavy Trucks

General Motors Corporation and Mack Truck Inc. is also contrary to results given in Figure A-3.9. Figure A-3.10 shows that appreciable benefits in terms of reductions in population impacted will be derived by regulating new medium and heavy trucks to levels below 83 dBA.

The estimates of the average noise reductions for urban street and freeway traffic furnished by General Motors are higher than the estimates given by EPA. (See Figures A-3.1 and A-3.2.) Emphasis will be placed in this discussion on the estimates for urban street traffic, since tire noise will dominate in freeway traffic and tire noise is not addressed in the proposed regulations. For urban street traffic noise, the differences between the EPA estimates in noise levels for the proposed regulations and the 83-dBA regulation are nearly equivalent to the corresponding differences in the GM estimates. However, because the overall reductions estimated by GM are larger than the EPA estimates, it visually appears that more benefits will be derived from the 83-dBA regulation. Although EPA and GM use similar methods and traffic population figures, differences in the EPA and GM estimates may be attributed primarily to differences in the equivalent noise levels assumed by EPA and GM

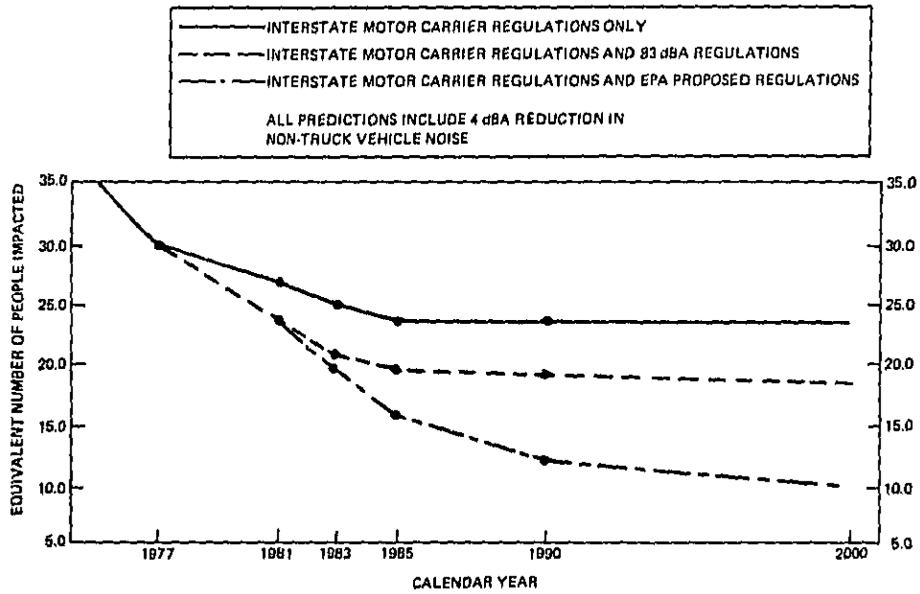

Figure A-3.10. Predictions of P_{eq} with Regulations on New Medium and Heavy Trucks

for each type of vehicle. The noise emission levels by vehicle type which were assumed by EPA and GM are tabulated in Table A-3.1. The following may be observed.

1. In the revised predictions of benefits, EPA considered the effect of motorcycles and buses. Since motorcycles and buses are in general noisier than automobiles, adding these sources will raise the overall traffic noise levels which, in turn, will increase the masking of benefits derived from regulating new medium and heavy trucks. Considering the noise from motorcycles and buses in the environmental will both provide a better representation of existing conditions and improve the accuracy of the anticipated traffic noise reductions.

2. The reductions in vehicle noise levels furnished by GM for regulated vehicles (12.7 dBA for trucks and 6.5 dBA for automobiles) are higher than these reductions in noise emissions given by EPA (9.7 dBA for trucks and 5.1 dBA for automobiles). The principal reason for these differences is that the noise emission levels from existing trucks and automobiles furnished by GM are about 5 dBA higher than the levels used by EPA. Based upon an EPA survey of truck noise emission levels [14]. Different levels were used by EPA for medium and heavy trucks. The equivalent noise levels used by GM for medium and heavy trucks is

Table A-3.1
Average Noise Levels Used in EPA and GM Estimates of
Noise Reductions in Urban Street Traffic

Urban Street Traffic	Average Noise Level		Total Population Mix	
	EPA	GM	EPA	GM
Trucks:	(dBA)	(dBA)	7.0%	7.0%
Existing	81.0*	86.0		
Interstate Motor Carrier	79.6*	84.7		
83 dBA New Truck Regulation	77.6	78.5		
80 dBA New Truck Regulation	75.1	75.8		
75 dBA New Truck Regulation	71.3	73.3		
Automobiles and Light Trucks:			91.5%	93.0%
Untreated	66.6	70.5		
Treated	61.5	63.5		
Buses:			0.5%	0.0%
Untreated	80.6	–		
Treated	75.5	–		
Motorcycles:			1.0%	0.0%
Untreated	83.6	–		
Treated	78.5	–		

*Represent weighted averages of the levels for medium and heavy trucks

nearly equal to the level used by EPA for heavy trucks (86.6 dBA). Considering medium and heavy trucks separately, as done by EPA, yields a more accurate representation of real traffic situations since most medium trucks are powered by gasoline engines, and therefore are quieter than most heavy trucks, many of which are diesel-powered. The noise emission level for existing light vehicles used by GM is based upon results from one survey taken in California [5]. On the other hand, the median level used by EPA for light vehicles in urban street traffic is based on results from the same survey plus results from five other surveys [2]. Hence, the levels used by EPA are believed to be more accurate.

In view of the above, it appears that the projections of anticipated reductions in average traffic noise levels given by EPA are more accurate than those of GM. In addition, the higher estimates given by GM tend to diminish the relative magnitude of the additional benefits to be derived from regulating trucks at levels below 83 dBA.

Reductions in the average traffic noise levels do not adequately measure the benefits to the public welfare. A more useful measure of the benefits is the reduction in equivalent number of people impacted (P_{eq}). This is because the P_{eq} considers both the number of people exposed to traffic noise and the magnitude or severity of individual impact. For this reason, more emphasis should be placed on P_{eq} as a measure of benefits than on the average traffic noise reduction.

According to predictions of the P_{eq} given by EPA (See Section 4), the difference between the total P_{eq} for the regulation proposed by GM (83 dBA in 1977) and for the regulations proposed by EPA is 6.8 million in 1990 for people exposed to urban street or freeway traffic. Greater differences will occur if the reductions in non-truck vehicle noise levels are higher than 4 dBA. Based upon these estimates, it appears that the overwhelming amount of the benefits will not be derived from the combination of the 83-dBA regulation and the Interstate Motor Carrier Regulations.

General Motors also predicted the maximum distances to which noise from single truck passbys will intrude on people engaged in a given activity. Some of the GM predictions are shown in Figures A-3.3 through A-3.6 along with EPA estimates of maximum intrusion distances for the same activity and location. Both sets of predictions indicate that the reductions in intrusion with decreases in regulatory levels diminish for levels below 83 dBA. Observation of the levels for unregulated and regulated trucks given in Table A-3.2 show that the largest reduction in typical roadside noise levels will occur for the 83 dBA regulation, which implies that the greatest reduction in intrusion will result from the 83 dBA regulation.

Table A-3.2
SAE J366b Truck Noise Levels

Truck Comparisons	Percentile Levels			
	Median (dBA)	Upper 10 (dBA)	Upper 1 (dBA)	Upper 0.1 (dBA)
Existing truck fleet (GM)	87.6	92.3	96.2	98.9
Existing new trucks (EPA)	84.7	87.6	89.7	91.6
Trucks regulated at 83 dBA (GM)	80.5	81.8	82.2	83.6
Trucks regulated at 75 dBA (GM)	72.5	73.8	74.8	75.6

However, the statutory mandate given to EPA in the Noise Control Act is to promulgate regulations which are requisite to protect the public health and welfare. The statutory mandate is not to set regulatory levels at a point beyond which the rate of return in benefits begins to decrease. The result in Figures A-3.3 through A-3.6, particularly those given by EPA, indicate that the public welfare would not be totally protected if the regulations stopped at 83 dBA. Ideally, the regulatory level would be below 75 dBA if all intrusion factors attributed to truck noise are to be completely removed. However, taking into account the degree of noise reduction achievable through the application of the best available technology and the costs of compliance, as required in the Noise Control Act, may preclude setting the regulatory levels below 75 dBA.

As additional support to the claim that the 83-dBA regulation will result in most of the needed benefits, GM predicted that, in 55 mph traffic, the noise from a single truck regulated at 83 dBA is usually less than 10 dBA above the noise from a steady stream of light vehicles at distances greater than 70 feet. In making these predictions, the median level used by GM for trucks regulated at 83 dBA was 82.0 dBA, which is similar to the level of 82.3 dBA used by EPA in assessing the benefits to public welfare. Both EPA and GM assumed that the passby noise levels for 83 dBA trucks had a Gaussian distribution with a standard deviation of 2.0 dBA. Therefore, the predictions by GM appear reasonable. However, additional benefits will be realized in other situations, such as exposure to low speed traffic noise where engine-related noise usually dominates over tire noise. Tire noise is not encompassed by the proposed regulations.

GM presented the estimates of SAE J366b truck noise levels for existing trucks and trucks regulated at 83 dBA. These levels are given in Table A-3.2. GM concluded that the 83-dBA regulation will result in large reductions of low speed traffic noise. However, since the proposed regulations apply only to new trucks, comparison of tested levels of new trucks should be made in assessing the impact of the 83-dBA regulation. The estimated levels for existing new trucks given in Table A-3.2 are derived from data taken from reference levels for existing new trucks given in Table A-3.2 are derived from data taken from reference 6. level for new trucks by 4.2 dBA, instead of 7.1 dBA as implied by GM. The tested levels from the noisiest new trucks will be reduced by 7.3 dBA, instead of 15.3 dBA. In addition, GM failed to consider the tested noise levels from new trucks regulated at 75 dBA shown in Table A-3.2. These levels are derived using the same assumptions used by GM in deriving the levels for 83-dBA regulated trucks. An additional reduction in the tested levels of 8 dBA should occur for trucks regulated at 75 dBA, from which added benefits should result as previously discussed.

In final support of their position, a film was presented by GM in the public hearings in Washington, D. C. In this film, the measured levels given in Table A-3.3 were presented. According to GM, the small differences between noise levels corresponding to the 83-dBA and 80-dBA regulated trucks is expected at 55 mph. Data taken from reference [7], corrected

Table A-3.3
Noise Levels Recorded on GM Truck Noise Film

Regulated Limit	SAE J366b Standard Passby Microphone at 50 feet	Urban Acceleration Microphone at 125 feet	35 mph Cruise Microphone at 125 feet	55 mph Cruise Microphone at 150 feet
86 dBA	85.2 dBA	76.8 dBA	79.3 dBA	77.5 dBA
83 dBA	80.5 dBA	72.5 dBA	75.3 dBA	75.5 dBA
80 dBA	78.2 dBA	72.0 dBA	73.7 dBA	75.2 dBA

for differences in observation distances, show that noise from ribbed tires at 150 feet could be as high as 75 dBA. The levels for the 83 dBA and 80-dBA regulated trucks cruising at 35 mph show a difference comparable to the difference in the tested levels. However, the difference in levels for the 83 dBA and 80-dBA regulated trucks for urban acceleration at 125 feet is only 0.5 dBA. This small difference is probably because of the high background noise level that existed during the measurements. In other typical low-speed acceleration situations where the background noise level would be lower, greater differences would probably occur.

In addition, it should be noted that the 86-dBA regulated truck measured 0.8 dBA below the regulated limit whereas the 83- and 80-dBA regulated trucks measured 2.5 and 1.8 dBA below the limit. Therefore, the differences between the roadside levels for the 86- and 83-dBA regulated trucks are higher than the differences between the roadside levels for the 83- and 80-dBA regulated trucks.

Action in Response to Public Comment: The estimates of the benefits presented by EPA indicate that appreciable benefits will be derived from regulating new medium and heavy trucks at levels lower than 83 dBA and considerations of the benefits to the public health and welfare alone do not justify relaxing the proposed regulations.

A-3.3 IMPACT OF OTHER TRAFFIC NOISE SOURCES

A-3.3.1 Mobile Homes

Identification: The Recreation Vehicle Industry Association (A-2.6.8.1) commented that since motor homes are substantially quieter than medium and heavy trucks, they are not a major source of noise and, therefore, should be exempted from the proposed regulations.

Discussion: The 1975 production of Type A motor homes, most of which fall into the classes over 10,000 lbs gross vehicle weight reading, is approximately 30,000, according to the Recreation Vehicle Industry Association. The estimated production of medium gasoline trucks given by EPA is 202,000 [8]. This indicates that about 15 percent of the new medium gasoline trucks produced in 1975 are mobile homes. However, mobile homes are driven fewer miles on the average than other medium and heavy trucks, so that less exposure to noise from mobile homes may exist.

The Recreation Vehicle Industry Association also commented that mobile home manufacturers normally do not alter the engine, power train, or exhaust systems. Since these are the major sources of noise, it is unlikely that motor homes are substantially quieter than medium gasoline trucks.

Action in Response to Public Comment: It has not been shown that exempting motor homes from the proposed regulations will not significantly reduce benefits. The Agency has not exempted motor homes from the regulations.

A-3.3.2 Truck Tires

Identification: Freightliner (A-2.1.4.1), International Harvester (A-2.1.6.1), Mack Truck (A-2.1.7.4), White Motor (A-2.1.10.2), and Donaldson (A-2.2.2.3) commented that the benefits for regulating trucks to levels below 83 dBA will be small, since at high speeds, uncontrolled tire noise will dominate engine-related noises that will be controlled by the regulations. The benefits will be small, according to Freightliner and White Motor, because heavy linehaul trucks typically are operated at speeds over 35 mph. Freightliner commented that typical tire noise from a loaded tractor and trailer with half-worn tires is about 84 dBA at 55 mph. Donaldson Company claimed that at highway speeds, truck tire noise frequently exceeds 80 dBA at 50 feet. The American Trucking Associations (A-2.3.1.1) commented that tire noise will reduce the benefits to be derived from the proposed regulations. The Ford Motor Company (A-2.1.3.2) and the Department of Transportation

(A-2.5.4.2) suggested that the contributions from truck tires should be identified separately in assessing benefits. DOT presented estimates of reduction in freeway traffic noise with all trucks equipped with crossbar tires on the drive wheels and with all trucks equipped with only ribbed tires. The Donaldson Company (A-2.2.2.3) and Schwitzer (A-2.2.6.1) claimed that since tire noise cannot be reduced below 80 dBA, regulations below 80 dBA will be ineffective. The Department of Transportation (A-2.5.4.1), Minnesota (A-2.5.14.2) and New York State (A-2.5.16.1) suggested that regulations on truck tires be considered. DOT recommended that regulations on tire noise of 83 dBA in 1977, and 80 dBA in 1981, for a 50 mph coast-by be adopted concurrently with the proposed new truck regulations. The National Organization to Insure Sound Control Environment (A-2.5.17.2) suggested that the regulations be enforced at speeds up to 50 mph, since tire noise is not a dominant factor at speeds below 50 mph.

Discussion: The impact of high speed (freeway) traffic noise should be less than the impact of low speed (urban street) traffic noise for the following reasons [2].

1. The number of people exposed to outdoor noise from freeway traffic is less than the number of people exposed to outdoor noise from urban street traffic. EPA estimates that 59.0 million people are exposed to outdoor noise from urban street traffic noise with a day-night equivalent noise level (L_{dn}) greater than 60 dBA, whereas 3.1 million people are exposed to similar noise levels from freeway traffic [3].

2. The reductions in freeway traffic noise levels will be less than the reductions in urban street traffic noise because of the contributions made by truck tire noise in freeway traffic.

In response to comments made by DOT, the truck tire noise level used by EPA for predicting the overall noise levels for new regulated trucks has been revised from 77 dBA to 81 dBA [2]. This level corresponds to the peak level observed at 50 feet for a single unit (2-axle) loaded truck passby at 55 mph with half-worn ribbed tires [7]. Some trucks, such as those with more than two axles, will generate higher tire noise levels; whereas in other trucks (those unloaded and equipped with new tires), the levels will be lower. The 81-dBA tire noise level is in agreement with comments made by the Donaldson Company that tire noise levels above 80 dBA are frequently encountered. The tire noise level of 84 dBA, given by Freightliner is for existing trucks which may often be equipped with crossbar tires. The noise levels for individual existing trucks used in estimating benefits were based on survey data where tire noise was not identified separately.

The effects of noise from truck tires on the reductions in traffic noise can be separately identified by comparing the estimates of the noise reductions for urban street and freeway traffic. The differences can be attributed largely to contributions made by tire noise.

Because most of the benefits from the proposed regulations will result from reductions in low speed traffic noise, the regulations should not be delayed until more information is available on quieting tires. Quieting truck tires will have a significant effect only on the reductions in high speed traffic noise. EPA is engaged in the development and acquisition of information to support future regulatory action on truck tires [9].

The noise from a ribbed tire increases from levels of approximately 66 dBA when unloaded at 35 mph to about 72 dBA at 50 mph [7]. This increase is enough to become a significant factor in complying with a 75-dBA or lower regulation, if the regulations were enforced at speeds up to 50 mph. For crossbar tires, the noise levels would be higher; therefore, the National Organization to Insure Sound Control Environment is incorrect in commenting that tires would not become a factor if the maximum enforcement speed is increased from 35 to 50 mph.

Action in Response to Public Comment: The estimates of benefits from reductions in freeway traffic noise have been revised to include the higher noise level of 81 dBA for truck tires. However, a fact that larger benefits will result from the reduction in urban street traffic noise is emphasized.

A-3.3.3 Buses

Identification: The Department of Transportation (A-2.5.4.2), New York State (A-2.5.16.2), and San Diego County (A-2.5.18.1) commented that buses should be included in the new truck regulations. DOT added that buses are usually operated in densely populated areas and are frequently accelerating so that they generate higher levels than assumed by EPA (73 dBA at 50 feet). Los Angeles County (A-2.5.12.1) suggested that an effort to regulate noise from buses be initiated.

Discussion: Information is currently being gathered by EPA on buses for possible future regulatory action. A typical roadside level of 79 dBA at 50 feet from existing buses was used by EPA in estimating the benefits for the regulations on new trucks [2]. This level is 2 dBA higher than the levels used by EPA for medium trucks and supports the comments made by DOT.

Action in Response to Public Comment: No further action has been taken.

A-3.4 Environmental Impact Statement

Identification: The Federal Highway Administration (A-2.5.8.1) commented that an Environmental Impact Statement is required.

Discussion: Environmental Impact Statements are required on all regulatory actions proposed after 15 October 1974. Since the proposed regulations were submitted to the Administrator for publication before October 15, 1974, an Environmental Impact Statement is not required for the noise emission regulations on new medium and heavy trucks. It should be noted that most of the information contained in Environmental Impact Statements has been gathered and reported by EPA in this document.

Action in Response to Public Comment: A separate Environmental Impact Statement has not been prepared.

Appendix A-4
TECHNOLOGY

A-4.1 ACCURACY OF COMPONENT SOURCE LEVELS

A-4.1.1 Fan Noise

Identification: The Cummins Engine Company (A-2.2.1.3) suggested that the noise of 63 fans tested in 1973 averaged 83.3 dBA and 25 fans tested in 1974 averaged 82.1 dBA. Similarly, the Department of Transportation (A-2.5.4.7) questioned the validity of the statement in the preamble by stating, "In contrast (to the statement in the preamble) we suggest that many cooling systems generate noise levels in excess of 80 dBA..." DOT supported this statement with the DOT Quiet Truck Program baseline data on three fans which ranged from 83 to 86 dBA.

Discussion: The question of whether most fans generate more noise than 80 dBA cannot be confidently resolved on the basis of the above data base. The Cummins and DOT data may not be drawn from a base which is representative of the medium and heavy truck population. Cummins manufactures only engines for diesel trucks constituting about one third of the medium and heavy truck population. Similarly all of the three trucks identified by DOT are class 8 cab-over-engine linehaul tractors.

Data in Figures 5-3, 5-4 of reference 8, show that 13 out of 21 samples were below 80 dBA.

Action in Response to Public Comment: The sentence in question in the preamble has been deleted.

A-4.1.2 HRBDG Levels

Identification: International Harvester (A-2.1.6.9) and the Department of Transportation (A-2.5.4.13) commented that the truck component source levels for 55-65 mph cruising conditions taken from the Highway Research Board Design Guide (HRBDG), and used in the EPA analysis of the benefits to public welfare [8] are higher than the SAE J366b levels. Since the SAE J366b levels for the engine-related noises should be higher than the engine-related noise levels under cruise conditions, the levels used by EPA may be incorrect.

Discussion: The comments are correct, there appears to be a discrepancy in the Highway Research Board Design levels. In revising the estimates of the benefits to be derived from the reduction in freeway traffic, the levels in the HRBDG were not used.

Action in Response to Public Comment: The levels given in Table 2 of Vol. 5 of the Highway Research Board Design Guide are no longer used by EPA.

A-4.1.3 Engine Noise

Identification: The Cummins Engine Company (A-2.2.1.2) commented that engine noise depends on engine power as well as engine type and design.

Discussion: Data on the engine noise levels of 35 diesel engines show little dependence of noise level on engine power [6].

Action in Response to Public Comment: Since this issue has little impact on the technology required to comply with the proposed regulations, no further action has been taken.

A-4.2 EFFECTIVENESS OF NOISE CONTROL TREATMENTS

A-4.2.1 Engine Quiet Kits

Identification: The Freightliner Corporation (A-2.1.4.2) commented that engine quieting kits reduce diesel engine noise by only about 2 dBA, not up to 4 dBA as claimed by EPA.

Discussion: Investigations of diesel engine noise reduction have shown that it is technically feasible to achieve reductions up to 9 dBA without the use of noise barriers mounted to the truck cable structure [10]. Most of the reduction appeared to be due to the use of covers and isolating components. Hardware, such as parts for the isolation of diesel components and shields mounted to the engine, has been developed and put into production for three diesel engine models which achieve noise reductions of up to 6 dBA [11]. Therefore, quieting kits are available which quiet diesel engines by more than the 2 dBA cited by Freightliner Corporation.

Action in Response to Public Comment: No further action has been taken.

A-4.2.2 Radiator Shutters

Identification: The Department of Transportation (A-2.5.4.4) commented that cooling system radiator shutters should not be considered noise reduction equipment as indicated by EPA in the preamble to the proposed regulations [9].

Discussion: Data on the cooling system noise levels for the International Harvester DOT Quiet Truck with shutters–open and closed–indicate that when shutters are closed, the cooling system noise level is on the average more than 3 dBA higher [12]. When the shutters are closed, the fan stalls which increases the noise output. Therefore, radiator shutters are not noise abatement equipment, and DOT is correct in their comment.

Action in Response to Public Comment: Thermostatically controlled shutters are not referred to as noise reduction equipment in the preamble to the regulations.

A-4.2.3 Fan Treatment

Identification: The Department of Transportation (A-2.5.4.6) commented that when radiator fans of different designs were used and the air-flow rate held constant, the fan noise remained essentially the same.

Discussion: DOT based their comment on tests of different fans conducted in the DOT Quiet Truck Program [12]. In the first set of test results, different fans were installed in the original cooling system without making other modifications to the cooling sytem. Of the 11 fans tested, it was possible to develop an adequate amount of airflow with only six fans. Using each of these six fans, the fan speed at maximum engine speed was varied until the required air flow was developed. The shroud coverage was the same for all fans. The measured noise levels had a range of only 3 dBA. However, it is not clear whether some of these fans were partially stalled, which would affect the noise output.

A second set of tests were conducted after modifications were made to improve the fan environment and reduce the cooling system noise. Results from these tests indicate that the range of fan noise for the seven fans tested was 4 dBA and that conventionally-designed fans were among the quietest. Unfortunately, the fan coverage by the shroud was not the same for each fan tested, varying from 125 percent to 85 percent. These differences in fan coverage affect the fan environment which is often as critical as the actual fan design in reducing fan noise [12]. Thus, a different range of noise levels for the seven fan designs could result when a constant fan coverage is used.

In the fan tests on the International Harvester DOT Quiet Truck, all relevant fan design parameters were not considered. In addition, because some of the fans could have been stalled in the first set of tests and fan coverages were not the same in the second set of tests, it should not be concluded from these tests that different fan designs cannot be used to achieve appreciable reductions in fan noise.

Action in Response to Public Comment: No further action has been taken.

A-4.3 REQUIREMENTS FOR TRUCK NOISE CONTROL

A-4.3.1 Cooling System

Identification: The Ford Motor Company (A-2.1.3.11, A-2.1.3.12, and A-2.1.3.13) commented that many of their diesel and gasoline trucks will require a fan clutch and modifications to cooling systems in order to comply with the 83- and 80-dBA regulation. General Motors (A-2.1.5.8) claimed that fan clutches will be required for most heavy diesel trucks to comply with the 80-dBA regulation. For the 75 dBA regulation, GM (A-2.1.5.13) claimed that larger radiators or remote cooling systems will need to be installed in most diesel trucks. GM (A-2.1.5.8) called only for a viscous fan drive for gasoline trucks regulated at 83 or 80 dBA. A larger radiator was called for to meet the 75-dBA regulation. International Harvester (A-2.1.6.8) implied that an extensive redesign of the cooling system will be required for heavy diesel trucks to comply with the 83 dBA regulation. The Department of Transportation (A-2.5.4.12) commented that a cooling system noise level of 65 dBA will be required for trucks to comply with the 75-dBA regulation. This will require radiators larger than those presently available, which may be impractical in trucks with conventional cabs because of visibility requirements.

Discussion: In reply to these comments, we note that a fan noise level of 70 dBA is low enough to allow compliance with either the 83 or 80 dBA regulation [13]. In the International Harvester DOT Quiet Truck, cooling system noise with the radiator shutters open was reduced from 81 dBA to 70 dBA by using a sealed, contoured shroud with a reduced tip clearance, a redesigned radiator and different-fan-to-radiator distance [12]. The changes associated with this approach should not be considered extensive since no changes in radiator or fan size, or location of the fan or cooling system was required.

A fan noise level of 64 dBA would be low enough to allow compliance with the 75 dBA regulation [13]. A larger radiator (2000 sq. in.), a larger slower-turning fan, a fan shroud and partial engine enclosure were used in the Freightliner DOT Quiet Truck to reduce the cooling system noise from a level of 83 dBA to 64 dBA [14]. With this cooling system, the overall truck noise level was measured at 72 dBA with the fan on [15]. Similar techniques can be applied to trucks in order to comply with the 75-dBA regulations.

In trucks with conventional cabs, techniques used on the International Harvester DOT Quiet Truck, such as optimizing fan-to-radiator distances and using radiators with serpentine fins, [12] can be employed to reduce the need for larger fans and radiators so that visibility requirements could be met.

Action in Response to Public Comment: There is general agreement on the treatments required to reduce cooling system noise to levels low enough for trucks to comply with the proposed regulations. No further action has been taken.

A-4.3.2 Exhaust System

Identification: The Ford Motor Company (A-2.1.3.11) claimed that many of their heavy diesel trucks will require larger mufflers to meet an 83-dBA regulation. For the 80-dBA regulation, Ford Motor (A-2.1.3.12) predicted that double-wall exhaust pipes and wrapped mufflers will also be needed. General Motors (A-2.1.5.8) commented that double-wall mufflers and exhaust pipes will be required on many heavy diesel trucks for the 83-dBA regulation. The addition of larger packed mufflers will be needed to meet the 80-dBA regulation. For the 75-dBA regulation, GM claimed that larger wrapped mufflers with premufflers and larger double-wall exhaust piping will need to be added. All diesel engines will require turbocharging to reduce exhaust noise enough to meet the 75-dBA regulation, according to General Motors (A-2.1.5.12). In order to meet the 83-dBA regulation, International Harvester (A-2.1.6.8) claimed that an extensive redesign of the exhaust system will be needed.

The Department of Transportion (A-2.5.4.7) pointed out that on the International Harvester DOT Quiet Truck the exhaust pipe shell noise was initially 83 dBA and the muffler shell noise 74 dBA, where the exhaust discharge noise was 76 dBA. Therefore, exhaust shell noise will need treatment in order to meet the 83-dBA regulation. DOT (A-2.5.4.8) also pointed out that mufflers are available to reduce exhaust outlet noise to 75 dBA for all popular diesel trucks.

Discussion: In reply, consider the requirements for each regulatory level. For the 83-dBA regulation, a design level for the exhaust system of 73 dBA should be adequate [13]. Data acquired in the DOT Quiet Truck Program show that this goal is achievable. Sealing exhaust leaks reduced the exhaust shell noise on the Freightliner DOT Quiet Truck from 75 dBA to 71 dBA. Using available mufflers, the exhaust outlet noise was further reduced to 66 dBA. On the International Harvester DOT Quiet Truck, sealing exhaust leaks and using larger wrapped mufflers reduced the total exhaust noise level to 72.5 dBA [16]. The comments on the required exhaust treatment for the 83-dBA regulation are in general agreement with the experiences in the DOT Quiet Truck Program. However, the required treatments should not be considered extensive, as claimed by International Harvester Company.

An exhaust noise level of 69 dBA should be adequate to enable most trucks to comply with the 80-dBA regulation. Adding wrapping to the exhaust piping on the International Harvester DOT Quiet Truck with sealed exhaust leaks and larger wrapped mufflers reduced the shell noise enough to reduce the total exhaust noise level to about 70 dBA [16]. The addition of a partial engine enclosure reduced the shell noise on the Freightliner DOT Quiet Truck with sealed exhaust leaks [14]. With an exhaust outlet level of 66 dBA using available mufflers, the total exhaust level would be approximately 70 dBA. In general, these results are in agreement with comments made by truck manufacturers.

An exhaust manifold muffler, larger wrapped mufflers, stack silencers, partial engine enclosure and exhaust joint seals were suffient to reduce the exhaust noise on the Freightliner DOT Quiet Truck enough to allow the overall truck noise level to be reduced to 72 dBA [15]. This level is low enough to comply with the 75-dBA regulation and allow for a 3 dBA tolerance. The exhaust system treatments used on the Freightliner DOT Quiet Truck are similar to the treatments suggested by General Motors for trucks to comply with the 75-dBA regulation. General Motors was the only contributor to offer comments on the required exhaust treatment for the 75-dBA regulated truck. All of the diesel trucks considered by GM were assumed to be equipped with two-stroke naturally-aspirated engines, which constitute a minority of the diesel engine population and in general have higher unmuffled exhaust noise levels than four-stroke and/or turbocharged diesel engines [6]. As pointed out by General Motors, double wall larger exhaust piping will be needed to reduce shell noise, particularly for two-stroke diesel engines.

Turbocharging diesel engines will help reduce the exhaust noise by around 5 to 10 dBA [8], since the exhaust gases are passed through the turbocharger. If the engine in the International Harvester DOT Quiet Truck had been turbocharged, the difficulty with reducing exhaust noise level would have been eased. In their comments, General Motors added that turbocharging increases engine efficiency and ease of meeting exhaust emission standards. Therefore, turbocharging will probably become more widely used and may become a part of the most cost effective method of reducing exhaust noise in order to comply with the 75-dBA regulation. Although there is little data to support the claim by GM that turbocharging will be required on all 75-dBA regulated trucks, it may be used on most of them.

In the preamble to the proposed regulations, it was stated that exhaust shell noise is low enough that very few trucks will require exhaust shell noise treatment in order to reach levels low enough to comply with the 83-dBA regulation. In both the International Harvester and Freightliner DOT Quiet Trucks, some treatment of the exhaust shell noise was required to reduce the truck noise level to a level low enough to comply with the 83-dBA regulation. Therefore, the statement in the preamble appears to be incorrect, as pointed out by the Department of Transportation. However, it should be noted that the shell noise levels given by DOT in their comments are for the International Harvester DOT Quiet Truck which had a two-stroke diesel engine. In general, two-stroke diesel engines have higher exhaust noise levels than four-stroke diesel engines. Therefore, the levels quoted by DOT should not be considered as representative of all diesel engines.

Data on exhaust outlet noise levels for existing trucks with four-stroke diesel engines [6] shows that DOT is correct in commenting that mufflers are available which reduce outlet noise to 75 dBA or below. The experience on the International Harvester DOT Quiet Truck with available mufflers on a two-stroke diesel engine [16] also supports the comment made by DOT.

Action in Response to Public Comment: Corrections have been made in response to comments by DOT on exhaust shell noise and available exhaust mufflers.

A-4.3.3 Engine

Identification: The Ford Motor Company (A-2.1.3.20 and A-2.1.3.11) predicted that for the 83-dBA regulation engine-noise shields will be needed and that some of the noisier engines will no longer be usable. For the 80-dBA regulation, full encapsulation for diesel engines and noise shields for gasoline engines will be required, according to Ford (A-2.2.3.12). Ford also claimed that internal engine modifications will be needed for the 80-dBA regulation. General Motors (A-2.1.5.8) commented that engine noise barriers will be required for many diesel trucks to meet the 83-dBA regulation. For the 80-dBA regulation, full underpans and absorptive material will need to be added and engines will need internal modifications. The engine modifications will include barrel-shaped, tight-clearance pistons to control piston slap which is the major source of diesel engine noise, according to General Motors (A-2.1.5.10). To meet the 75-dBA regulation, General Motors (A-2.1.5.8) claimed that diesel engines will need to be modified, turbocharged and fully encapsulated. General Motors added that engine noise side-shields will be required for gasoline trucks to meet the 75-dBA regulation.

International Harvester (A-2.1.6.8) commented that engine noise shields will be required for the 83-dBA regulation. Mack Trucks, Inc. (A-2.1.7.7) claimed that the 80-dBA regulation may require the encapsulation of some engines and removal of the noisier engines. The 75-dBA regulation will require the elimination of a majority of existing diesel engines and the encapsulation of the few which remain, according to Mack Trucks. The Donaldson Company (A-2.2.2.6) asserted that many engines will require partial enclosures to meet the 80-dBA regulation and all will require full enclosures to meet the 75-dBA regulation. The American Trucking Associations, Inc. (A-2.3.1.4) stated that major engine redesigns will probably be required in order to obtain the engine noise reductions necessary to comply with the proposed regulations.

Discussion: EPA has shown that an engine noise level of 77 dBA should be low enough to allow compliance with the 83-dBA regulation [13]. Using the maximum noise levels for gasoline engines and 12 diesel engine models, treatments necessary to reduce engine noise to 77 dBA was derived [13]. The results of this study show that gasoline engines would not require noise treatment [13]. Without internal modifications to the engine, side shields, which provide 2-4 dBA attenuation, may be used on 68 percent of existing diesel engines [13]. Side shields and an underpan may be used in 32 percent of the diesel engines [13]. Side shields and underpans provide 4-10 dBA attenuation [17]. These comments are in general agreement with those received from the public. When the Ford Motor Company claimed that certain engines will no longer be usable in trucks complying with the 83-dBA regulatory level, we believe they were not referring to a matter of technological unfeasibility, but rather to a question of economic effectiveness. Certain noisy engines may be adequately quieted by use of engine kits, side shields or enclosures. However, it is probably more responsive to the market demand to avoid using these engines and offer quieter ones in their place.

For the 80-dBA regulation, the reduction of engine noise to 73 dBA should be sufficient [13]. None of the existing truck engines have noise levels 73 dBA or below [8]. Gasoline engines should require side shields to reach 73 dBA. Side shields should be adequate for 23 percent of the present population of new diesel engines [13]. Underpans and side shields may be required for 62 percent of existing diesel engines and 17 percent of new diesel engines may require partial enclosures [13]. Maximum noise levels for existing engines have been used in predicting the required engine treatment. The engine noise levels used in the background document to the proposed regulations [8] are in error. It was incorrectly assumed that the engine noise levels were for engines outside the truck cab. The presence of the cab provides at least 2 dBA attenuation which resulted in estimates of in-truck engine noise levels that were low by approximately 2 dBA. This error has been corrected and the additional engine noise treatment provided.

Since it is likely that some reductions in diesel engine noise will be achieved, it appears that the comment made by the Donaldson Company, that many engines will require partial enclosures is an overstatement. The full engine encapsulations called for by the Ford Motor Company and the Mack Truck Company to meet the 80-dBA regulation should not be required for any of the existing diesel engines. The use of underpans and side shields, along with modifications to the engine, as suggested by the General Motors Corporation, will probably not be needed on most trucks for the 80-dBA regulation.

General Motors Corporation is correct in commenting that piston slap is a major source of diesel engine noise. However, it should be noted that other sources, such as combustion, fuel injection equipment, valve trains, gearing and accessories, also contribute to engine noise [11]. In addition, investigations on engine noise reduction have resulted in reductions of 9 dBA and that most of the reduction in this investigation appeared to be due to the use of covers and isolating components. When costs are considered, the use of covers, shields and isolating components is the most attractive solution to engine noise reduction [10]. Therefore, the reduction of piston slap should not be considered as the only effective method of reducing engine noise.

For the 75-dBA regulation, an engine noise level of 68 dBA should be low enough [13]. In order to reach this level, most diesel engines will require full or partial enclosures. Some of the noisiest of the present diesel engines may require quiet kits in addition to enclosures [13]. Presently-available gasoline engines may require side shields and underpans to reach engine noise levels of 68 dBA or below [13]. General Motors Corporation predicted that side shields would be sufficient. The treatments presented here for the noisiest of existing diesel engines are in general agreement with those suggested by General Motors Corporation for all diesel engines. It should be noted that all of the diesel engines considered by General Motors were two-stroke. Two-stroke diesel engines have engine noise levels at least 4 dBA lower than the noisiest existing engines [13]. The 75-dBA regulation should not force the elimination of a majority of diesel engines, as indicated by Mack Trucks, since techniques for reducing the noise from existing diesel engines to 68 dBA are available. Redesign of diesel engines and the addition of covers and isolated components will probably eliminate the need for full encapsulations on many trucks. The Donaldson comment that all diesel engines will require full encapsulation is probably pessimistic.

In their comments, General Motors added that turbocharging increases engine efficiency and helps to meet exhaust emission standards. With the increased concern recently over fuel conservation and control of air emissions, the use of turbochargers on diesel engines will become more attractive for reasons not related to noise reduction. Therefore, when fuel savings and the control of air and noise emissions are all considered, the use of turbochargers could be incorporated by most engine manufacturers to meet the 75-dBA regulation.

On the Freightliner DOT Quiet Truck, the use of a partial engine enclosure, isolated-mass engine mounts and an engine quiet kit was sufficient to reduce an initially noisy engine (84 dBA) to a level low enough to allow an overall level of 72 dBA to be reached [15]. Therefore, trucks with initially noisy engines can be quieted enough to comply with the 75-dBA regulation. It is not likely that the 75-dBA regulation will force the elimination of a majority of diesel engines as claimed by Mack Truck Company.

Although engine redesigns will probably not be required to meet the proposed regulations, as suggested by the American Trucking Associations Inc., redesigning diesel engines and adding covers and isolated components will probably be a cost effective method of reducing engine noise. The demand on engine manufacturers for quiet engines by truck manufacturers will encourage the quieting of many of the present diesel engines and the introduction of some new quieter models.

Action in Response to Public Comment: No further action has been taken.

A-4.3.4 Air Intake System

Identification: The Ford Motor Company (A-2.1.3.12) claimed that treatment of air intake systems will probably be required for diesel trucks to meet the 80-dBA regulation. For the 75-dBA regulation, General Motors (A-2.1.5.8) predicted that air-cleaner silencers will be needed on some diesel trucks. International Harvester Company (A-2.1.6.8) asserted that extensive redesigns of air intake systems will be required to meet the 83 dBA regulation.

Discussion: The noise levels for the air intake systems for the unquieted DOT Quiet Trucks were as follows: Freightliner – 62 dBA [15], International Harvester – 72 dBA [16], and White – below 65 dBA [18]. Changing the rain cap on the International Harvester DOT Quiet Truck reduced the air intake noise to 69 dBA [16]. An air intake system noise level of 69 dBA should be adequate for trucks to meet the 83- or 80-dBA regulations [13]. Thus, it appears that no significant changes from current practices for air intake treatment is needed for the 83- and 80-dBA regulations.

For the 75-dBA regulation, the noise from air intake systems will need to be reduced an additional 4 dBA to 65 dBA on most trucks. The air intake silencer used on the International Harvester DOT Quiet Truck reduced the air intake noise by 4 dBA [16]. Therefore, General Motors is correct in commenting that some trucks will require an air intake silencer to meet the 75-dBA regulation.

Action in Response to Public Comment: No further action has been taken.

A-4.3.5 Other Sources

Identification: The White Motor Corporation (A-2.1.10.4) commented that other noise sources in trucks yet to be measured or treated will need treatment in order to comply with lower regulatory levels. General Motors Corporation (A-2.1.5.17) claimed that tire and aerodynamic noise (65-73 dBA), axle noise (up to 78 dBA), truck frame radiation (up to 70 dBA), truck cab radiation (up to 65 dBA) and transmission noise (up to 77 dBA) must be treated in addition to engine, cooling, exhaust and air intake systems in order to comply with the 75-dBA regulation. According to the Cummins Engine Company (A-2.2.1.4), transmission noise, with an average level of 75.5 dBA, and chassis noise, with an average level of 70 dBA at 30 mph, will need treatment for the 75-dBA regulation.

Discussion: Some data on source levels, and treatments of noise from sources other than engine cooling, exhaust and air intake systems are available to deal with these points. The noise level from the rear axle reported for the Freightliner DOT Quiet Truck was 58 dBA [14]. The peak tire and aerodynamic noise was 62 dBA [14]. These levels are lower than those given by GM. No treatment of the rear axle or tires was required on the Freightliner DOT Quiet Truck to quiet it to a level of 72 dBA.

The treatment of noise radiated from the transmission, truck frame and cab is included on the Freightliner DOT Quiet Truck. The partial enclosure covered the transmission. In their response to the proposed regulations, General Motors Corporation also included the transmission inside enclosures. The isolated-mass engine mounts reduced the transmission of structure-borne noise to the truck frame and cab, reducing the noise radiated by the frame and cab. Special vibration mounts for the engine were considered by GM in the treatments for the trucks. It appears that General Motors is correct in stating that in some trucks, treatment of the transmission, truck frame, and cab will be required to comply with the 75-dBA regulation. However, effective treatment of these sources has been demonstrated.

Action in Response to Public Comment: No further action has been taken.

A-4.4 DESIGN TOLERANCE

A-4.4.1 Manufacturing and Test Variables

Identification: The Freightliner Corporation (A-2.1.4.3), General Motors Corporation (A-2.1.5.7), International Harvester Company (A-2.1.6.5), Mack Trucks Inc. (A-2.1.7.5) and the American Trucking Associations Inc. (A-2.3.1.3) all commented that design targets for truck manufacturers will need to be 2 to 3 dBA below the regulatory level. The Ford Motor Company (A-2.1.3.8) claimed that the design target would be at least 3 dBA below the regulatory level. According to Paccar Inc. (A-2.1.9.1), the design target would be at least 2 dBA below the regulatory level. Donaldson Company (A-2.2.2.4) predicted that a design target of 2 to 5 dBA below the regulatory level would be necessary. The Department of Transportation (A-2.5.4.10) claimed that a design tolerance of 4 dBA would be needed; 2 dBA to account for the variation in the measured noise levels for trucks of the same configuration and 2 dBA to account for design uncertainties.

Discussion: In the EPA analyses of the technology, costs of compliance [13], and benefits to the public health and welfare [2] it is assumed that medium and heavy trucks will be designed and built with median measured noise levels approximately 2.5 dBA below the regulatory level. The 2.5 dBA figure agrees with most of the comments received from truck manufacturers and is believed to be accurate.

Action in Response to Public Comment: A design target of 2.5 dBA below the regulatory level has been included in the assessments of the required noise reduction technology, and the benefits and costs associated with various regulatory options for medium and heavy trucks.

A-4.4.2 Degradation of the Effectiveness of Treatment

Identification: Paccar Inc. (A-2.1.9.2) and The White Motor Corporation (A-2.1.10.3) commented that there is a lack of information on the degradation of the performance of noise reduction hardware with time. Paccar Inc. (A-2.1.9.2) and The Cummins Engine Company (A-2.2.1.1) indicated that little information exists on the changes in engine noise levels with age. Mack Trucks (A-2.1.7.6) claimed that it is impossible to determine the design noise levels necessary to compensate for any increases in noise levels over the "useful life" of the truck. According to the Chrysler Corporation (A-2.1.1.3), it is not possible to determine the acceptable design ranges on the parameters for devices which control noise over the useful life of trucks. The Automotive Exhaust Systems Manufacturers Committee (A-2.6.3.1) pointed out that there is little data on the useful life of an exhaust system and that the acquisition of enough data to determine the useful life of an exhaust system would not be technically feasible. The Department of Transportation (A-2.5.4.15) commented that the slight decrease in the noise with age observed on the International Harvester DOT Quiet Truck could be partly attributed to careful maintenance.

Discussion: This issue will have an impact on the design targets set by truck manufacturers if the "useful life" provision in the proposed regulations is included in the final regulation. With this provision, the manufacturers will have to allow for deterioration of noise abatement equipment with age in designing and building trucks so that the trucks comply with the regulatory level during its "useful life."

There are two potential sources of data on the degradation of the performance of noise control equipment with age. The first is the DOT Quiet Truck Program in which three quieted truck models (Freightliner, International Harvester and White) have been placed into line-haul service for approximately 1 year. An increase in the overall noise level of about 2 dBA was reported for the Freightliner truck [19]. However, part of the increase may be attributed to the replacement of the original underpan with one of a different design and overfueling caused by the uncalibrated fuel delivery system. Reports dealing with the other eight DOT Quiet Trucks (four International Harvester and four White trucks) have yet to be published.

The second potential source of data on the degradation of noise abatement treatment is the experience of the owners of trucks that comply with existing State or local new truck regulations. In California, a not-to-exceed 83-dBA regulation on the noise emissions from new trucks with a CVWR of over 6000 pounds became effective on January 1, 1975. This has not allowed sufficient time for useful degradation data to be obtained. The 86-dBA regulation (in effect for some time in California) has not required the application of extensive noise treatment, so that little degradation data is available from 86-dBA regulated trucks. Therefore the comments concerning the lack of information on degradation of noise abatement and the changes in noise levels with age appear to be correct. It is difficult, therefore, for truck manufacturers to set design targets which taken into account the "useful life" provision in the proposed regulations.

Action in Response to Public Comment: The "useful life" requirement has been omitted in the final regulations. However, EPA intends to include a "useful life" requirement in the future and has reserved a section in the regulations for incorporation of a "useful life" in the future.

A-4.5 AVAILABILITY OF THE TECHNOLOGY REQUIRED FOR COMPLIANCE

Comments which deal in general with the availability of the required technology for compliance to the proposed regulations are treated separately from the comments which treat the adequacy of the Freightliner DOT Quiet Truck as a demonstration of the technology required to comply with the 75-dBA regulation.

A-4.5.1 General Availability of Technology

Identification: Several comments were received concerning the availability of the technology required for compliance with the proposed regulations. The following commentors claimed that the required technology is not available or has not been demonstrated for all trucks: Chrysler Corporation (A-2.1.1.1), Ford Motor Company (A-2.1.3.5), General Motors Corporation (A-2.1.5.15), International Harvester Company (A-2.1.6.7), Oshkosh Truck Corporation (A-2.1.8.1), Paccar Inc., (A-2.1.9.3), Schwitzer (A-2.2.6.2), W. S. Hatch Company (A-2.3.4.1), The Department of Transportation (A-2.5.4.11), Chamber of Commerce (A-2.6.4.2) and Motor Vehicle Manufacturers Association (A-2.5.4.11). Comments by the Friends of the Earth and Sierra Club (A-2.4.4.2) and George Wilson (A-2.4.6.1) claimed that the required technology is available.

Oshkosh Truck Corporation, Paccar Inc., Schwitzer, and the U.S. Chamber of Commerce did not provide supporting evidence for their claim that the technology is not available. The Motor Vehicle Manufacturers Association added that EPA has not met the statutory requirement to take into account the best available technology in setting regulations on noise emissions. According to W. S. Hatch Company, the regulations should not be promulgated until equipment has been developed that can be used in meeting the regulations.

Chrysler Corporation claimed that medium diesel trucks are the most difficult to quiet, since medium-duty diesel engines are noisier than heavy-duty engines, and that no medium diesel trucks have been built that comply with the 75-dBA regulation. According to the Ford Motor Company (A-2.1.3.7), vehicle testing indicates that truck noise levels approaching 77 dBA cannot be reached. A level approaching 77 dBA would be required to comply with the 80-dBA regulation. The Department of Transportation and the Donaldson Company (A-2.2.2.5) claimed that the available information is not sufficient to assure that technology for compliance with the 75-dBA regulation is available, since only one of the three attempts in the DOT Quiet Truck Program to reach truck noise levels below 75 dBA was successful. General Motors commented that the technology to mass-produce trucks which comply with the 75-dBA regulation is not available. Ford Motor claimed that "off-the-shelf" hardware does not exist that will produce the noise reductions necessary to comply with the 80- or 75-dBA regulation. The technology to meet the 80-dBA regulation does not exist for a full truck line, according to International Harvester, because a 2 and 3/4-year lead time is required to redesign each truck model and a full set of reliability tests is needed for each truck model.

The Friends of the Earth and Sierra Club (A-2.4.4.1) claimed that sufficient technology is available to comply with the proposed regulations and that the lead time for the 80-dBA regulation could be shortened by one year. They also commented that research in this country, as well as in England and Germany, has clearly shown that the 75-dBA regulation can be attained with available technology. Walker Manufacturing (A-2.2.7.1) added that the technology for exhaust systems would permit shorter lead times. George Wilson, a consultant in acoustics and noise control, commented that the technology is available for the 75-dBA regulation and added (A-2.4.6.2) that General Motors claimed that they would have no problem in meeting the 80-dBA regulation proposed by the State of California. The City of Chicago (A-2.5.2.1) commented that the results from the DOT Quiet Truck Program indicated that a 75-dBA regulation can be met.

Discussion: It is believed that the technology to bring medium and heavy trucks into compliance with regulatory levels as low as 75 dBA has been demonstrated as being available as asserted by Friends of the Earth and Sierra Club, and George Wilson. EPA has shown that the technology to comply with the 75-dBA regulatory level has been demonstrated, and thereby has met the statutory requirement on available technology. Demonstrated technology to quiet each major truck noise source enough to allow trucks to comply with the 75-dBA regulatory level is discussed in Section 5 of this document.

Promulgating the regulations after noise treatment equipment necessary for compliance to the proposed regulations has been made available for all truck models, as suggested by W. S. Hatch Company and the Ford Motor Company, or as implied in comments by General Motors Corporation, after the mass-production of regulated trucks has been demonstrated, is not recommended since without the regulations, the production of noise treatment equipment and quiet trucks may be substantially delayed. The demonstration of the availability of the technology for the development of such hardware is sufficient.

The following factors may be partly responsible for the fact that the noise levels of the final configurations of the International Harvester and White Motors DOT Quiet Trucks were not as low as the 72 dBA level of the final configuration of the Freightliner DOT Quiet Truck. In many cases, these factors involved policy decisions and do not represent limitations on achievable noise reductions.

1. The goal for the lowest overall noise level (the "Reduced Noise Floor Goal") for the White Motors truck was 77 dBA [18].

2. International Harvester and White Motors did not use a manifold muffler in the exhaust system. The technology for the manifold muffler used by Freightliner was developed concurrently to the quieting programs by International Harvester and White Motors and was not available for application on the International Harvester and White Motors trucks. The manifold muffler used on the final configuration of the Freightliner truck had an insertion loss of approximately 7 dBA [14].

3. International Harvester did not increase the size of the cooling fan. Increasing the fan size would have probably permitted the fan speed to be reduced without a loss in cooling capacity. A larger radiator may have been needed to accommodate a larger fan, which may have required modifications to the cab.

4. Although White Motors did explore the use of a larger fan, they did not optimize the fan to radiator distance or increase the cooling efficiency of the radiator. These techniques permitted fan noise reductions of approximately 4 and 2 dBA, respectively, on the International Harvester truck [12].

5. International Harvester [20] and White Motors [18] used close-fitting engine covers and partial engine enclosures separately, whereas Freightliner used both techniques simultaneously on a single truck to quiet engine noise [15].

6. Less absorbing material was used by International Harvester and White Motors inside their partial engine enclosures than was used by Freightliner in their enclosure. International Harvester used a 1-inch thick layer of absorbing material [20], where the layer thickness was 2 inches on the Freightliner truck [14]. White Motors used absorbing material on the underpan only [18]. Absorbing material was used on other parts, as well as the underpan, on the other DOT Quiet Trucks.

These factors indicated that it should be possible to further reduce the noise levels of the International Harvester and White Motors DOT Quiet Trucks. Therefore, the fact that these trucks did not achieve levels below 75 dBA should not constitute evidence that technology is not available for compliance with the 75-dBA regulation.

The results from tests performed in the DOT Quiet Truck Program contradict the assertion made by the Ford Motor Company that results from tests indicate that truck noise levels approaching 77 dBA cannot be reached. As stated above, an SAE J366b test level of 72 dBA was obtained by one of the participants in the DOT Quiet Truck Program.

The Chrysler Corporation is correct in commenting that no prototype medium diesel truck has been built to meet a 75-DBA regulation. The population-weighted average of the engine noise levels provided by truck manufacturers for medium-duty diesel engines [13] is about 82.5 dBA under SAE J366b test conditions for the engines installed in the truck. For heavy-duty diesel engines, the population-weighted average noise level is also about 79.5 dBA, [13]. Therefore, the Chrysler Corporation is correct in commenting that medium-duty diesel engines are on the average noisier than heavy-duty engines. However, the noisiest of available medium-duty diesel engines is only 1 dBA noisier than the heavy-duty diesel engine used in the Freightline DOT Quiet Truck. The engine in the Freightliner truck initially had a noise level of 84 dBA [15]. General Motors has indicated that it should be possible to reduce engine noise levels by 1-3 dBA with engine modifications [21]. With these reductions, the engine noise treatments demonstrated on the Freightliner DOT Quiet Truck should be sufficient to quiet all medium diesel trucks enough to comply with a 75-dBA regulatory level.

The reduction of medium-duty diesel engine noise can also be considered as follows. A 9 dBA reduction in diesel engine noise was achieved without using encapsulation techniques [10]. The partial enclosure used on the Freightliner DOT Quiet Truck demonstrated a noise reduction of 11 dBA. Application of both of these demonstrated engine noise treatments should be more than sufficient to reduce the noise from the noisiest medium-duty diesel engine enough to allow medium trucks to comply with a 75-dBA regulatory level. Therefore, building a prototype medium diesel truck which would comply with a 75-dBA regulatory level is not necessary to show that technology is available to bring medium diesel trucks into compliance with a 75-dBA regulatory level.

All hardware used in the DOT Quiet Truck Program is adaptable to large scale production. The noise treatment hardware for the exhaust and cooling systems used in the DOT Quiet Truck Program are "off-the-shelf" items. The partial engine-transmission enclosures, isolated-mass engine mounts and exhaust manifold muffler were not "off-the-shelf" items. However, there is no evidence to indicate that these noise treatments cannot be incorporated into the mass-production of quiet trucks. Therefore, technology applications upon which production manufacturing can be based for trucks to comply with a 75-dBA regulation have been demonstrated and the comment of General Motors Corp. is not correct that technology is not available to mass produce trucks complying with a 75-dBA regulation.

A major redesign may be required for the inclusion of all of the noise abatement treatments necessary to comply with regulatory levels as low as 75 dBA. A major redesign, including testing prototype vehicles, takes 2-3/4 years according to comments made by the International Harvester Company. The lead time for the 80-dBA regulatory level in the proposed regulation is 6 years, and 8 years for the 75-dBA regulatory level. This allows time to perform major redesigns of two different models, one at a time for the 80-dBA regulation and three models for a 75 dBA regulation. However, since many models will share similar types of noise abatement hardware, such as partial engine enclosures and larger fans and mufflers, the basic design changes will be similar so that several models could be redesigned simultaneously with only differences in detail. The lead times for the 80-dBA and 75-dBA regulatory levels in the proposed regulations should be adequate, if the truck manufacturers utilize as much of the available time as possible.

Action in Response to Public Comment: The technology required for compliance to the proposed regulations has been demonstrated as being available. Therefore, the availability of technology did not require that the regulations be relaxed from those proposed.

A-4.5.2 Freightliner DOT Quiet Truck

Identification: Six truck manufacturers (Chrysler, Ford, Freightliner, General Motors, International Harvester, and Mack) claimed that the results from the Freightliner DOT Quiet Truck do not adequately demonstrate that the technology is available to build trucks which comply with a 75-dBA regulation.

Chrysler Corp. (A-2.1.1.1) claimed that, since the Freightliner DOT Quiet Truck was measured at 75 dBA, it will not comply with a not-to-exceed 75-dBA regulation. Mack Trucks Inc. (A-2.1.7.8) commented that the Freightliner truck was a cab over the engine truck and that such trucks are quieter than similarly equipped trucks with conventional cabs. Freightliner (A-2.1.4.5), General Motors (A-2.1.5.9), and International Harvester (A-2.1.6.6) indicated that the Freightliner truck was easier to quiet because the cab had an engine compartment designed for larger engines. More space was available for an engine enclosure and larger radiators than is available on most production heavy diesel trucks. Therefore, it is necessary to demonstrate that the 75-dBA regulation can be met on trucks with less space in the engine compartment, according to Freightliner, General Motors, and International Harvester. In addition, International Harvester claimed that the fundamental design criteria was compromised because the engine cooling in the final configuration was not adequate. Freightliner (A-2.1.4.4) added that the straight-ribbed tires used on the final configuration of the Freightliner DOT Quiet Truck were not suitable for highway use. Ford Motor Company (A-2.1.3.6) claimed that the Freightliner truck was involved only in line-haul service which is probably not the most severe type of operation. Therefore, evidence has not been provided that trucks quieted enough to meet a 75-dBA regulation can also meet reliability requirements under all typical service conditions.

Discussion: The final configuration of the Freightliner DOT Quiet Truck was measured at 72 dBA by Freightliner personnel with the cooling fan on and at 71 dBA by the California Highway Patrol with the fan off [15]. The test site in both measurements had a hard surface between the truck and measurement point. The truck was prepared for fleet operation, and the measurements were conducted according to SAE J366a test procedures. Therefore, the Freightliner truck would be in full compliance with a not-to-exceed 75-dBA regulation. A 3 dBA design tolerance needed for mass-production is included in the 72-dBA measured level for the Freightliner truck. The measurement results referred to by the Chrysler Corporation were taken from data presented in one of the early reports in the Freightliner DOT Quiet Truck Program [22]. These data were taken after the application of the initial noise reduction treatment. The final configuration included changes in the exhaust manifold muffler, engine mounts, engine enclosure (from a full to a partial enclosure), fan, and exhaust piping and mufflers. These changes were made to increase the noise reduction at minimum increases in costs.

Data taken from test trucks numbers 04, 11 and 12 in Reference 23 do not support the assertion made by Mack Trucks that trucks with the cab over the engine (COE trucks) are significantly quieter than similarly-equipped trucks with a conventional cab. Truck 04 had a conventional short-nose cab with a SAE J366b measured noise level of 88 dBA. Trucks 11 and 12 had a cab over the engine and noise levels of 86.5 and 88 dBA, respectively. These trucks all had similar Cummins diesel engines and single vertical exhaust systems. This limited amount of published data on similarly powered COE and conventional trucks is not sufficient to verify that the COE style will make a truck quieter. However, there is little reason to believe that a larger data base would show significant differences (greater than 2-3 dBA) between similarly equipped COE trucks and conventional trucks, since noise characteristics of the dominant sources of noise (engine, fan and exhaust system) would be essentially the same for both cab styles.

Of more importance to the general issue of the availability of required technology for compliance than differences in cab style is whether the Freightliner DOT Quiet Truck was initially noisier than most trucks. The initial noise level for the Freightliner truck was 88 dBA [15]. This level is higher than about 95 percent of the 384 sampled new diesel trucks given [6].

Freightliner, General Motors and International Harvester are correct in pointing out that the cab in the Freightliner DOT Quiet Truck had an engine compartment designed for larger engines so that more room was available for noise treatment than that available on many new production trucks. In fact, the Freightliner model was selected because of the added space available in the engine compartment, designed to accommodate up to a 650-horsepower diesel engine, and a radiator with a frontal area of 2000 square inches. One of the objectives of the DOT Quiet Truck Program was to apply available noise abatement technology to heavy diesel trucks to reduce the noise levels to the lowest practical level. Selecting a model with a smaller engine compartment may have required modifications to the cab and may have cost the program more without changing the noise abatement technology required to meet the 75-dBA goal.

If the cabs of new trucks are redesigned, the same principles of noise abatement, such as attenuating engine noise with shields or enclosures and absorptive material, muffling the exhaust, attenuating the radiated noise from exhaust piping and mufflers and providing slow speed fans in the cooling system, could be used to obtain noise reductions similar to those obtained for the Freightliner DOT Quiet Truck. In other words, the noise abatement technology demonstrated on the Freightliner truck is representative of the available technology and is applicable to all trucks, if some truck cabs are modified to accommodate larger engine compartments and radiators. Cab redesign is possible with available technology. Therefore, the question becomes one of the necessary lead time to modify truck models in time to comply with the proposed regulations. This question is addressed in Section A-4.5.1.

International Harvester is correct in commenting that the engine cooling capacity on the final configuration of the Freightliner DOT Quiet Truck was below specifications. The air-to-boil temperature of the final configuration was 121°F under full-power at 15 mph [15]. The factory recommended air-to-boil temperature is 125°F. Therefore, the air-to-boil temperature of 121°F for the final configuration of the Freightliner truck was not a serious compromise in the fundamental design criteria. No attempt was made to improve the cooling efficiency of the radiator in the final configuration of the Freightliner truck so that the remaining cooling capacity of 4°F in air-to-boil temperature could probably be obtained by improving the efficiency of the radiator. However, the cooling was believed adequate. In 100,000 miles of line-haul service, the Freightliner truck encountered no engine cooling problems. [19]

Freightliner Corporation is correct in commenting that the tires on the final configuration of the Freightliner DOT Quiet Truck were not suitable for highway use. The tires used on the final configuration were 10.00 X 22 General HCR straight-ribbed tires [15]. However, for the tests conducted by the California Highway Patrol, the Freightliner was equipped with General Power Jet 11.0 X 24.5 tires on the front and General DCL 11.0 X 24.5 tires on the rear [15] which are conventional-ribbed tires suitable for highway use. If conventional-ribbed tires had been used during testing of the Freightliner truck, the overall noise levels would not have been significantly affected since the noise levels from new ribbed tires are usually less than 65 dBA at the vehicle test speed of approximately 25 mph used during the tests on the Freightliner truck [7].

The comment made by Ford Motor Company that the Freightliner DOT Quiet Truck was involved only in line-haul service is correct. Ford Motor is also correct in pointing out that the Freightliner truck has not demonstrated the reliability of trucks regulated at 75 dBA in all types of services. Adequate lead times are provided in the proposed regulations for manufacturers to conduct the necessary reliability tests. There is no reason to believe that the technology demonstrated to be reliable on the Freightliner DOT Quiet Truck could not be adapted to trucks involved in other types of services without serious losses in reliability.

Action in Response to Public Comment: The Freightliner DOT Quiet Truck is accepted by EPA as a demonstration of available technology for quieting medium and heavy trucks to noise levels low enough to comply with a 75-dBA regulation.

A-4.5.3 Performance Compromises

Identification: Ford Motor Company (A-2.1.3.5) commented that "off-the-shelf" hardware does not exist which will produce the noise reductions necessary to comply with the 80- or 75-dBA regulation, meet reliability requirements and not reduce truck performance. Ford Motor Company (A-2.1.3.9) added that high backpressure in exhaust systems is associated with high noise reduction and reduced engine performance.

General Motors Corporation made the following comments on the performance compromises associated with the noise treatments needed to comply with the proposed regulations.

1. The technology is not available to manufacture engine noise barriers which satisfy durability requirements and are easy to install and remove (A-2.1.5.11).

2. The durability of packed mufflers, tight-clearance pistons, new engine mounting systems and absorptive materials in engine compartments is not known (A-2.1.5.14 and A-2.1.5.18).

3. The encapsulation of engines will cause increases in engine compartment temperatures from approximately 100° F to 200° F, which may affect the durability of some engine mounted components and create a fire hazard (A-2.1.5.19).

Discussion: The development and production of "off-the-shelf" noise treatment hardware will probably not occur until after the regulations are promulgated. The technology to design and manufacture the noise treatment hardware necessary to comply with the proposed regulations and satisfy reliability requirements is believed to exist. There may be some reductions in truck performance caused by increases in weight produced by the addition of noise treatment hardware. However, increases in performance will be associated with some noise treatments, such as fan clutches and turbocharging diesel engines.

Although some increase in backpressure was experienced in reducing exhaust noise on the Freightliner and International Harvester DOT Quiet Trucks, the backpressure for the exhaust systems on the final configurations was within specified limits. The exhaust outlet noise was reduced by 16 dBA on the Freightliner truck with an increase in backpressure from 4.5 to 7.0 inches of water [14]. The average backpressure for the baseline Freightliner truck model is 12.0 inches of water [15].

On the International Harvester DOT Quiet Truck, the exhaust outlet noise was reduced by 11.5 with an increase in backpressure from 23 to 45 inches of water [16]. The higher backpressure was within the limits specified by the engine manufacturer [16]. Therefore, some increases in back pressure may occur with reductions in exhaust noise, however it should be possible to maintain the back pressures for treated exhausts within the limits specified by engine manufacturers.

The Freightliner DOT Quiet Truck has been operated in line-haul service. In the first 100,000 miles of service, the serviceability has been good, the noise treatment hardware has, in general, performed well and no unusual maintenance problems were encountered [24]. The Freightliner truck is equipped with special engine mounts, packed mufflers, and a partial engine enclosure comprised of engine noise shields with absorptive material. Therefore, the experience with the Freightliner truck indicates that special engine mounts, packed mufflers, engine noise barriers, and absorptive materials, which will satisfy maintenance and durability requirements, can be built.

No reliable data on the durability of engines with tight-clearance pistons used to reduce engine noise is known. Therefore, the comment on the subject made by General Motors appears to be correct. However, the need to use tight-clearance pistons may not be required in order to comply with the proposed regulations (see Section A-4.3.3).

Engine encapsulation should increase the engine compartment temperatures, even when adequate liquid cooling is provided for the engine, since the cooling provided by the air flow over the engine may be reduced by encapsulation. However, the increase in temperature should be less than the 100°F as indicated by General Motors since engine compartment temperatures in current production trucks may often reach more than 100°F. It should be possible to provide adequate cooling inside engine encapsulations by means of lined ducts and ventilating fans to minimize unusual heat damage to engine components and maintain adequate reductions in engine noise levels. It may also be possible to mount heat sensitive engine components outside the enclosure.

In the International Harvester DOT Quiet Truck program, some concern was expressed about the fire hazards produced by oil saturated absorptive material located close to the engine [20]. These materials could be placed away from the engine on the engine compartment walls or noise barriers and covered with a thin film to prevent the material from becoming saturated with oil. The avoidance of the use of absorptive material in underpans should also decrease fire hazards. These techniques were used in the partial engine enclosure on the Freightliner DOT Quiet Truck. So far, no fires have been reported on this truck in current field tests. [19]

Action in Response to Public Comment: No further action has been taken.

A-4.5.4 Tire Noise Reduction

Identification: General Motors (A-2.1.5.16) and Donaldson Co. (A-2.2.2.3) commented that the technology to reduce tire noise much below the present levels is not available. The State of Delaware (A-2.5.3.1) claimed that the technology for reducing tire noise was not adequately addressed. Schwitzer Engineering Components (A-2.2.6.1) claimed that tire noise at freeway speeds cannot be reduced below about 80 dBA. The tire noise level of 77 dBA at 55 mph, used by EPA in estimating benefits, is not attainable by any tires known today, according to the Department of Transportation (A-2.5.4.14).

B. F. Goodrich (A-2.2.3.1) suggested that the regulatory levels below 83 dBA be postponed until more information is available on quieting truck tires. The American Trucking Associations Inc. (A-2.3.1.2) claimed that a comprehensive study of the technology of quieting tires and the effect of quieting tires on safety and costs of operation must be completed before the regulations should be adopted.

Citizens Against Noise (A-2.4.3.2) claimed that technology is available to produce quieter tires.

Discussion: The technology for quieting truck tires is not necessary for compliance to the proposed regulations. Available ribbed tires, suitable for highway use, have noise levels of approximately 66 dBA at 35 mph when mounted on an unloaded truck [7]. The speeds during tests will be less than 35 mph so that the noise from ribbed truck tires will be less than 66 dBA during testing. Tire noise levels less than 66 dBA are generally low enough to allow trucks to comply with a 75-dBA regulation

Most of the benefits from the proposed regulations will come from the reduction of low speed traffic noise, where truck tires are not a dominant source of noise (Section A-3.3.2). Therefore, the reduction of truck tire noise is not necessary to achieve significant benefits.

Truck tires may be the subject of future regulatory action by EPA [9], at which time the issue of the availability of the technology for the reduction of truck tire noise will be addressed.

Action in Response to Public Comment: No further action has been taken.

A-4.6 OTHER ISSUES

A-4.6.1 Second Stage Manufacturers

Identification: Rexnord (A-2.2.5.1) and the National Solid Wastes Management Association (A-2.6.7.1) commented that mounting a mixer on a truck chassis does not materially affect the truck's noise emissions.

Discussion: If, when mounting a mixer on a truck chassis, the exhaust system or engine noise barriers are not modified, the noise emissions of the truck will probably not be significantly changed. However, relocating exhaust piping or mufflers, or cutting holes in engine noise barriers can affect the noise emissions of a truck. In order to prevent increases in the noise emissions, it will be necessary to provide careful instructions to the second stage manufacturers on the modifications which affect noise emissions.

Action in Response to Public Comment: The responsibilities of the first and second stage manufacturers for the prevention of modifications which may increase the noise emissions have been specified in the regulations.

A-4.6.2 Buses

Identification: The Department of Transportation (A-2.5.4.9) commented that there is no fundamental difference in the noise control technology for trucks and buses. This comment was made in support of including buses in the proposed regulations.

Discussion: Although the fundamental technologies of quieting buses and trucks are similar, a separate consideration of the environmental and economic impacts would be required before buses could be included in the new truck regulations. EPA is gathering information for separate regulatory action on buses.

Action in Response to Public Comment: No further action has been taken.

Appendix A-5
COSTS OF COMPLIANCE

A-5.1 INCREASES ON TRUCK PRICES

A-5.1.1 Estimates of Truck Price Increases

Identification: Several truck manufacturers presented estimates of truck price increases for compliance to the proposed regulations. Table A-5.1 presents the estimates given by truck manufacturers.

Ford Motor Company (A-2.1.3.14) included design and development costs and costs associated with EPA's requirements to document noise-control hardware. According to Ford, these costs were not included in the EPA estimates. Ford (A-2.1.3.15) also stated that if 10 percent of the tested trucks were allowed to exceed the regulatory level by 2 dBA, the price increases would be reduced by more than one-half. General Motors (A-2.1.5.21) and International Harvester (A-2.1.6.10) claimed that the EPA estimates are low because the EPA estimates were based on regulatory levels and not the design levels which would be 2-3 dBA below the regulatory levels. The increased costs for development and testing, manufacturing, tooling, compliance testing, dealer and customer services associated with noise abatement equipment were included in the General Motors' estimates (A-2.1.5.25). General Motors (A-2.1.5.23) added that the EPA estimates are outdated. The White Motors Corporation (A-2.1.10.6) estimates do not include costs for testing, research and development, engineering, inflation or excise taxes. According to International Harvester (A-2.1.6.11) and White Motors (A-2.1.10.7), the increases in truck prices should increase at a much faster rate as the regulatory levels are reduced. The American Trucking Associations, Inc. (A-2.3.1.7) claimed that the increases in truck prices will rise exponentially as noise levels are reduced.

The Donaldson Company (A-2.2.2.8) claimed that EPA estimates are low by at least 25 percent. The U. S. Chamber of Commerce (A-2.6.4.3) and the American Trucking Associations Inc. (A-2.3.1.8) commented that EPA estimates were too low, but did not specify by how much. The costs of turbocharging diesel engines (A-2.3.1.5) and modifying truck cabs (A-2.3.1.6) were not included in the EPA estimates, according to the American Trucking Association. The Associated General Contractors of Colorado (A-2.6.2.1) claimed that the EPA estimates are totally unrealistic.

Table A-5.1. Estimates of Truck Price Increases Presented by Truck Manufacturers

Truck Manufacturer	Regulatory Levels					
	83 dBA		80 dBA		75 dBA	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Chrysler Corp. (2.1.1.4)	-	$500	-	$1200	-	-
Ford Motor Co. (2.1.3.14)	$163-194	$514-973	$700-900	$1800-2500	-	
Freightliner Corp. (2.1.4.7)	-	$456	-	$ 500-700	-	$1000-1200
General Motors Corp. (2.1.5.25)	$25	$365	$130	$1090	$350	$4450
International Harvester Co. (2.1.6.10)	-	$583	-	$2150	-	-
Paccar Inc. (2.1.9.4)	-	$210-400	-	$ 700	-	$1400
White Motors Corp. (2.1.10.6)	-	$261	-	$1307	-	-

The Chamber of Commerce (A-2.6.4.5) asserted that the regulations will cause trucks to be priced beyond reach. By the time the regulations become effective, inflation will have increased the truck price according to the American Road Builders Association (A-2.6.1.2).

The Department of Transportation (A-2.5.4.16) pointed out that the EPA estimates were higher than the price increases quoted in the DOT Quiet Truck Program. Freightliner achieved 72-74 dBA at costs of $1400, International Harvester 78 dBA for $1290 and 80 dBA for $516, and White Motors 77-79 dBA for $1307 and 79-81 dBA for $260.

The City of San Francisco (A-2.5.19.1) commented that the trucks are now capable of obtaining 80-dBA noise levels at reasonable costs. The noise level from a bus was reduced from 90 to 81 dBA by retrofitting noise treatment hardware at a cost of $600.

Discussions: The population-weighted average of the EPA estimates of truck price increases are presented in Table A-5.2 [13]. In deriving these estimates, it was assumed that compliance testing would be conducted with the fan on for trucks equipped with fan clutches. If the fan is permitted to be turned off during testing, lower price increases are expected [13]. The estimates on Table A-5.2 represent revisions of the estimates given in the Background Document to the proposed regulations [8]. The revised estimates are higher than the original estimates.

Table A-5.2. EPA Estimates of Average Truck Price Increases for Proposed Regulations

Type of Truck	Regulatory Levels 83 dBA	80 dBA	75 dBA
Medium gasoline ...	$ 35	$180	$ 665
Heavy gasoline	$135	$280	$ 815
Medium diesel	$426	$865	$1624
Heavy diesel	$387	$715	$1454

For comparison, EPA and truck manufacturers estimates are presented in Figure A-5.1 for diesel trucks. For the 83-dBA regulatory level, the estimates from Chrysler, Ford, Freightliner, and International Harvester, are higher than the EPA estimates. For the 80-dBA regulatory level, the estimates from Chrysler, White Motors, Ford, and International Harvester are higher than the EPA estimates. The estimates from Freightliner and Paccar were lower than the EPA estimates. The spread of estimates for the 80-dBA regulatory level is larger than the spread of estimates for the 83-dBA regulatory level.

Three truck manufacturers (General Motors, Paccar, and Freightliner) made estimates of truck price increases for the 75-dBA regulatory level. Only the estimates made by General Motors exceed EPA estimates for the 75-dBA regulatory level.

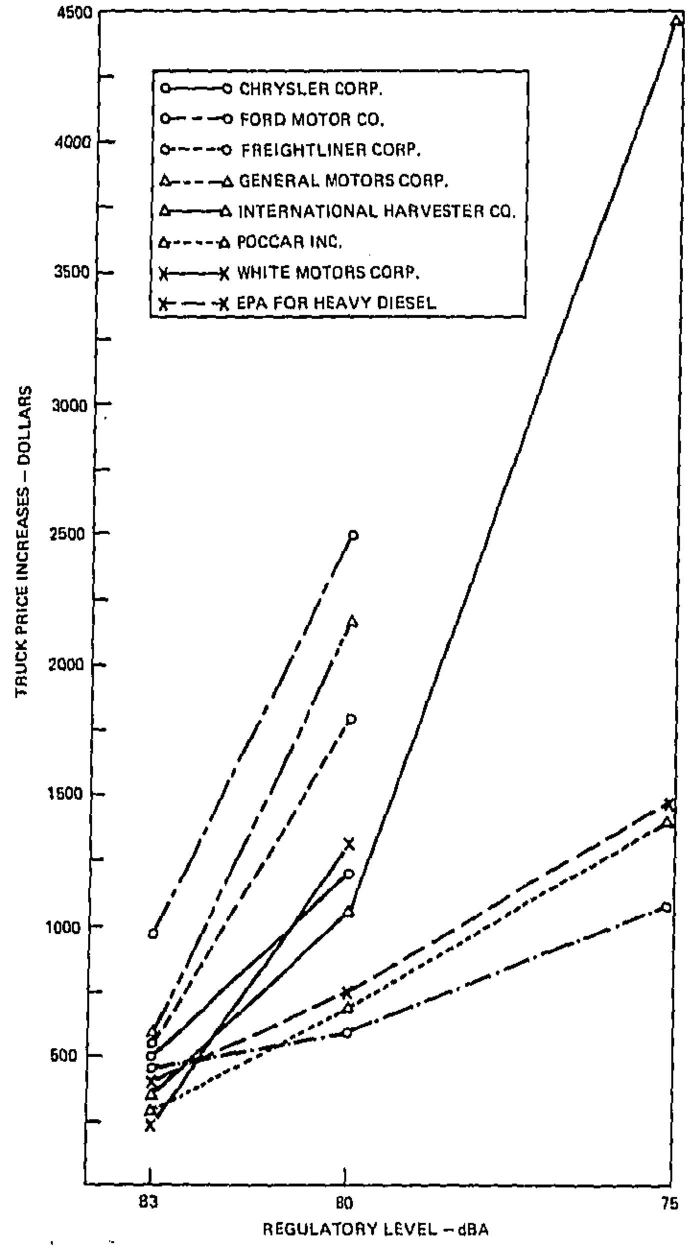

Figure A-5.1. Estimates of Truck Price Increases

Ford and General Motors presented estimates of price increases for gasoline trucks. The Ford estimates are higher than EPA estimates for the 83- and 80-dBA regulatory levels. For the 83-, 80- and 75-dBA regulatory levels, General Motors' estimates for gasoline trucks are lower than the EPA estimates. For the 75-dBA regulatory level, the General Motors' estimate is nearly one-half the EPA estimate.

The differences between the EPA and truck manufacturers' estimates may be attributed to differences in the following:

- The noise treatment hardware claimed as necessary to comply with the regulatory levels,
- The estimates of the costs of each unit of noise treatment hardware.

The differences in noise treatments are discussed in Section A-4.3. There is general agreement on the treatments needed to reduce cooling, exhaust, and air intake system noise. However, the engine noise treatments claimed by truck manufacturers as necessary for diesel trucks to comply with the proposed regulations are greater than should be needed on most diesel trucks (Section A-4.3.3). This contributes to the higher estimates given by truck manufacturers.

It is not possible to determine the extent that estimates of costs for individual noise treatment hardware contributes to the differences in estimated truck price increases, since estimated costs for individual noise treatment hardware were not presented by truck manufacturers in their public comments. EPA presented costs estimates for noise control hardware for cooling, exhaust, engine and air intake noise treatment for trucks equipped with gasoline engines and for trucks equipped with one of twelve diesel engine models [13]. The engine models were selected to cover most of the presently available truck engines. Because the costs of quieting trucks are largely dependent on the initial engine and exhaust noise levels, the estimates of price increases were organized according to engine type and model, instead of truck model. The EPA estimates of price increases are based on cost estimates presented in the DOT Quiet Truck Program, truck manufacturer's estimates of price increases for individual noise treatment hardware, and list prices for hardware currently in production.

All of the design levels for each truck component noise level are low enough to allow trucks to comply with not-to-exceed regulatory levels. The overall design level is 2-3 dBA below the regulatory level [13]. Thus, EPA estimates of truck price increases take into account the necessity to design below regulatory levels.

A markup on manufacturing costs of 50 percent, given for the Freightliner DOT Quiet Truck [25], was used by EPA in estimating the price increases. It is believed that this factor is sufficient to cover the increased costs for development, testing, and dealer/customer services associated with noise treatment. The costs associated with compliance testing is treated separately and not included in the price increases presented in Table A-5.

The EPA estimates are given in terms of 1973 dollars. Recently, a high rate of inflation has increased the dollar cost. In order to update EPA estimates for use in assessing the economic impact, the estimates were multiplied by rates of wholesale price indices for 1973 and 1975 for the truck manufacturing industry. (See Appendix D)

Replacing a naturally aspirated diesel engine with a turbocharged engine was not found necessary in order to comply with the proposed regulations (Section A-4.3.2). Therefore, including the costs of turbocharging diesel engines in estimates of truck price increases (as suggested by the American Trucking Association) is not necessary. However, differences in truck prices with a turbocharged or naturally aspirated diesel engine can be determined from engine prices and estimates of increases in truck prices given by EPA. (See Section 6)

Redesigning some truck cabs may be necessary to accommodate an engine enclosure and/or a larger radiator. When an engine enclosure and larger radiator are required in trucks, the cost of redesigning the cab is included with the cost of the engine enclosure. On heavy trucks where only a larger radiator is needed, the increased cost of enlarging the cab to accommodate the larger radiator is included with the cost of the cooling system treatment. On medium trucks, a larger radiator should not require redesigning the truck cab. Thus, the American Trucking Associations, Inc. is incorrect in commenting that EPA estimates of truck price increases do not include the costs of redesigning the truck cab.

If 10 percent of new trucks are allowed to exceed the regulatory level by 2 dBA, as suggested by the Ford Motor Company, the design levels necessary to comply with the proposed regulations could be increased by about 1 dBA (Section A-3.2.4). Linear interpretations of EPA estimates for the 83- and 80-dBA regulatory levels indicate that a 1-dBA increase in design levels should result in decreases in truck price increases of approximately $50 for gasoline trucks, and $100 for diesel trucks at the 80-dBA regulatory level. These estimates are approximately half the estimated reductions in truck price increases for 90 percent compliance given by Ford (with the exception of the estimates given for "Premium Diesel Trucks" where Ford estimated a decrease of $588).

General Motors, Paccar, Freightliner, and EPA have presented estimates of truck price increases for more than two regulatory levels, such that some indication on the rate at which truck prices may increase with lower regulatory levels can be derived. In each set of estimates, the rate of increases in truck prices with lower regulatory levels rises. Only the estimates by General Motors, however, confirm the comments made by International Harvester, White Motors, and the American Trucking Association that there is a much faster rate of increased prices at lower regulatory levels. The comments by White Motors and International Harvester are based on costs estimates derived from participation in the DOT Quiet Truck Program. These costs estimates are discussed later.

A significant rise in truck prices at lower regulatory levels may not occur for the following reasons:

- The costs of some noise treatments, such as cooling system and engine treatments, do not rapidly rise at lower regulatory levels, and

- The costs of treating sources other than the engine, cooling system and exhaust system, do not increase rapidly for regulatory levels approaching 75 dBA.

The estimated costs of treatment of cooling system noise for heavy trucks is $110 for the 83-dBA regulatory level, $125 for the 80-dBA regulatory level and $200 for the 75-dBA regulatory level [13]. The largest increase in incremental costs occur for the 83-dBA regulatory level because of the need for a fan clutch so that the radiator shutters can be removed. Without this treatment, little fan noise reduction can be achieved. Also, the estimated costs for engine noise treatments do not rapidly rise with larger noise reductions [13].

The noise sources needing treatment at the 83-dBA regulatory level are the cooling system, the exhaust system, and the engine. At the below 80-dBA regulatory level, treatment of the air intake is added, at an estimated maximum price increase of $30. Treatment of transmission noise (included in the treatment of engine noise with no price increase) is added for the below 80 dBA regulatory level. Therefore, reducing the regulatory level to below 80 dBA should not result in a large cost increase in treating additional noise sources which would add to the rate of increased truck prices at lower regulatory levels.

In the DOT Quiet Truck Program, both International Harvester [12] and White Motors [18] selected the "worst case" trucks for quieting, whereas Freightliner selected one with more available space for the installation of noise treatment. All three participants in the DOT Quiet Truck Program applied noise treatments to the selected trucks, without making significant modifications to the truck cab. This may have placed some constraints on the International Harvester and White Motors trucks for the space available for engine enclosures absorptive materials, manifold mufflers and larger slower-turning fans which may have decreased the cost-effectiveness of the noise treatment. The Freightliner truck was less limited for space.

In the proposed regulations, the lead times for compliance to the 80- and 75-dBA regulatory levels should be sufficient to allow cab redesigns when necessary to accommodate noise treatment in a more cost-effective manner. Since the Freightliner truck was not space-limited (as should be the case for well-designed new trucks), the estimates of price increases given for the Freightliner truck are believed to be a better reflection of the price increases that should occur on new trucks built in compliance with the proposed 80- and below regulatory levels.

The comment by the City of San Francisco applies to retrofitting buses and is difficult to relate directly to the costs of manufacturing new quiet trucks.

Action in Response to Public Comment: The EPA estimates of truck price increases have been revised in response to public comments and to include new information made available since the publication of the Background Document to the proposed regulations [8]. The revised estimates are based, in large part, on documented data and are derived from specified costs for individual noise treatments. These estimates are believed by EPA to be as accurate as the available data on costs will permit. Further revision has been taken.

A-5.1.2 Future Price Increases

Identification: General Motors Corporation (A-2.1.5.22) commented that the decrease in costs of noise treatment due to future improvements in noise control technology should not be included in estimates of truck price increases. The costs of noise treatment hardware will be reduced under full production, according to Professional Drivers (A-2.3.6.3).

Discussion: In the final estimates of truck price increases used in assessing the costs versus benefits of the regulations, no assumptions were made on reductions in costs for improvements in noise control technology or increases in the production of noise treatment hardware. However, brief consideration is given to the possible reductions in costs which may result in the future. One of the possible improvements in noise control technology is the reduction in engine noise by redesigning engines. Estimates of truck price increases are given with the assumption that diesel engine noise can be reduced to 77-dBA and gasoline engine noise to 75-dBA in order to demonstrate the potential savings which may be realized with the reduction of engine noise. (See Section 6)

Little data exists on the reduction in costs to be realized under full production of noise treatment hardware. However, some reductions should occur. In attempting to project the potential reductions in truck price increases, EPA assumed that the costs of noise control hardware, currently in production but not in demand (such as fan clutches and the best available exhaust mufflers) will decline by 10 percent as a result of increased production.

The costs of hardware not currently in production (such as manifold mufflers and engine enclosures) will decline by 50 percent under full production. If the assumptions on the reduction of engine noise and costs under full production prove to be accurate in the future, the price increases for medium gasoline and heavy diesel trucks may decrease by more than one-half, for heavy gasoline trucks, by more than two-thirds, and for medium diesel trucks by approximately one-fourth.

Action in Response to Public Comment: Sensitivity of estimates of truck price increases to assumptions on improvements in noise control technology and costs reductions under full production have been briefly considered. However, the assumptions are to be verified and estimates of price increases derived without these assumptions are used in supporting the selection of the final regulatory levels.

A-5.2 CHANGES IN OPERATING COSTS

A-5.2.1 Losses in Revenue

Identification: Freightliner Corporation (A-2.1.4.6) commented that noise treatment for the 75-dBA regulatory level will add 700 pounds to trucks resulting in losses of approximately $1000 per year per truck in revenues for the bulk hauler. Donaldson (A-2.2.2.7) pointed out that engine enclosures will reduce payload capacities. The truck owner, whose truck is weight-limited, may lose $600 annually because of weight increases caused by the 83-dBA regulation, and $1600 annually for the 80-dBA regulation, according to White Motor Corporation (A-2.1.10.5). The American Trucking Associations, Inc. (A-2.3.1.11) commented that the weight of noise treatment will affect the bulk haulers the most and that EPA has not considered this point. Overdrive Magazine (A-2.3.5.1) claimed that increases in weight for noise treatment will cause the following losses in revenues: for the general freight hauler, $8 to 69 per year for the 83-dBA regulatory level, and $170 per year for the 75-dBA regulatory level; and for the bulk hauler, $51 to 445 per year for the 83-dBA level, and $1000 per year for the 75-dBA level. W. S. Hatch Co. (A-2.3.4.2) claimed that the weight increases due to noise treatment have a serious impact on the bulk hauler. General Motors (A-2.1.5.27) pointed out that a 6½ percent reduction in cargo volume would result in bringing one of their truck models into compliance with the 75-dBA regulatory level.

Discussion: The average increased weight estimate for heavy diesel trucks complying with the 83-dBA regulatory of 141 pounds can be determined by using the weight increases given in Table 6-8 and Table 6-1 and computing the population-weighted average. For the 80-dBA regulatory level, an average increase in weight for heavy diesel trucks of 339 pounds can be computed; and for the 75-dBA regulatory level, 705 pounds. The value of 705 pounds of increased wieght agrees with the value given by the Freightliner Corporation.

For the bulk hauler, the loss in revenue per mile due to an increase in tare weight of 1 pound is estimated at \$12.5 x 10^{-6} [25]. Using this factor, and an average mileage of 54,000 miles for heavy diesel trucks [6], the average loss in revenue for the bulk hauler should be approximately \$95 per year for the 83-dBA regulatory level, \$229 per year for the 80-dBA regulatory level, and \$476 per year for the 75-dBA regulatory level. The estimates are lower than the estimates given by Freightliner, White Motors, and Overdrive Magazine. However, for trucks which accumulate over 100,000 miles or more annually in the bulk hauling service, the losses in revenues may approach \$1,000 as estimated by Freightliner and Overdrive Magazine.

For the general cargo hauler, the loss in revenue per mile due to an increase in tare weight of 1 pound is estimated at \$1.94 x 10^{-6}. Using this factor, the average loss in revenue for the general cargo hauler should be approximately \$15 for the 83-dBA regulatory level, and \$74 for the 75-dBA regulatory level. These estimates are lower than the estimates given by Overdrive Magazine.

It should be noted that the discussed losses in revenues would be eliminated with an increase in the legal limits on the Gross Combination Weight (GVW) of 700 pounds or more.

The 6½ percent loss in cargo volume predicted by General Motors is a result of the assumption that a remote cooling system will be required in back of the truck cab. The remote cooling system, according to General Motors, is required to provide the necessary cooling for a fully enclosed diesel engine. However, projected reductions in engine noise without enclosure techniques (Section A-4.3.3) indicate that full enclosures will probably not be used in complying with the 75-dBA regulatory level in 1983. Therefore, the loss in cargo volume caused by the remote cooling system will probably not occur on most trucks.

Action in Response to Public Comment. The presented estimates for average losses in revenues caused by increases in tare weight are, in general, lower than the estimates presented in public comments. However, since the above estimates are based on data presented in the DOT Quiet Truck Program and documented average annual mileage figures, these estimates should be more representative of the actual losses in revenues which will occur as a result of the regulations. No further action has been taken.

A-5.2.2 Changes in Rates of Fuel Consumption

Identification: Donaldson (A-2.2.2.7) commented that engine enclosures will result in losses in fuel economy. The estimates of fuel savings presented by the Department of

Transportation are too high, according to the American Trucking Associations, Inc. (A-2.31.9). The DOT estimates of fuel savings were derived in support of an assessment of costs and benefits of different regulatory options. The Federal Highway Administration, Ohio (A-2.5.8.4) suggested that the changes in rates of fuel consumption be determined.

Discussion: The combined effect on the rates of fuel consumption of increases in tare weight, increases in exhaust backpressure, and changes in accessory horsepower requirements produced by noise treatments have been estimated by EPA. (See Section 6) The increases in fuel consumption produced by increases in truck weight and exhaust backpressure are small compared to the decreases in fuel consumption produced by the reduction in accessory power requirements for more efficient and quiet cooling system designs or for cooling systems equipped with a fan clutch [13].

The estimates of fuel savings in Section 6 indicate that the American Trucking Associations, Inc. is correct in that the DOT estimates of fuel savings are too high.

Action in Response to Public Comment: Estimates of changes in rates of fuel consumption and associated costs for trucks complying with the proposed regulations have been presented. No further action has been taken.

A-5.2.3 Fuel Savings for Fan Clutches

Identification: Freightliner Corporation (A-2.1.4.8) and Paccar, Inc. (A-2.1.9.6) commented that fuel savings from the use of fan clutches should not be credited to the noise regulations, since fan clutches will be widely used without the regulations. Freightliner claimed that the need to conserve fuel will also encourage the use of fan clutches. In addition, the proposed test (which does not permit testing with the fan off) removes the advantage of using fan clutches in complying with the proposed regulations, according to Freightliner. General Motors (A-2.1.5.24) included the costs of fan clutches in estimates of increases in truck prices, but did not include the savings in operating costs from fan clutches. According to General Motors, there is not enough data on fuel savings.

Discussion: Fan clutches will be used on most heavy trucks, in order to remove radiator shutters. When closed, radiator shutters prevent significant reductions in fan noise by means of improvements in fan and fan-shroud design. Since most new medium trucks are not presently being equipped with radiator shutters, fan clutches are not needed. Fan treatments, less costly than fan clutches, will probably be used on most medium trucks, even if fan-off testing is permitted. Savings in accessory horsepower requirements will result from improved cooling system designs on medium trucks [13].

On heavy trucks, savings should occur because the fan clutch will disengage when the fan is no longer required for cooling. Based on field tests, such as the tests on the Freightliner DOT Quiet Truck, the fan will be off more than 99 percent of the time during normal operation [19]. Comments presented by Rockford Clutch in the public hearings in Arlington, Va. also indicated that the fan will be off most of the time.

Changes in rates of fuel consumption have been estimated by EPA with and without claiming credit for the savings from more efficient fans and fan clutches [13]. Using these figures, changes in operating costs have been estimated with and without claiming credit for the fuel savings from more efficient fans and fan clutches. The actual changes in operating costs associated with regulations will be in between these two cost estimates, since, in the absence of noise regulations on truck noise emissions, other concerns, such as the need to conserve fuel, will encourage the use of more efficient fans and fan clutches. In order to be consistent, the costs of more efficient fans and fan clutches were not included by EPA in estimating the costs of compliance, when credit for savings was not taken. (See Section 6).

Action in Response to Public Comment: EPA has estimated the costs of compliance with and without claiming credit for fuel savings from the use of more efficient fans and fan clutches. No further action has been taken.

A-5.2.4 Changes in Maintenance Costs

Identification: The Federal Highway Administration, Ohio (A-2.5.8.2) suggested that the estimates of changes in operating costs should take into account increased costs for maintenance. Donaldson (A-2.2.2.7) commented that engine enclosures will increase maintenance costs. Chrysler Corporation (A-2.1.1.5) claimed that noise treatment for the 80-dBA regulatory level will cause an increase in annual maintenance costs of $800 per truck. For diesel trucks, the average increases in annual maintenance costs per year will be $179 for the 83-dBA regulatory level, $304 for the 80-dBA level and $305 for the 75-dBA level, according to General Motors (A-2.1.5.26). These estimates include increased labor costs for ordinary maintenance and replacement parts.

The Regular Common Carrier Conference (A-2.3.7.1) commented that truck manufacturers' estimates of increases in annual operating costs may be higher than EPA estimates because the manufacturers considered the increase in needed maintenance as the truck ages. The Regular Common Carrier Conference added that the costs of repairs for fan clutch failures should be included in estimates of changes in operating costs. The American Trucking Associations, Inc. (A-2.3.1.10) suggested that the costs per increased failure for engines with close-fitting pistons need to be included in the estimates of costs of compliance.

Discussion: Changes in maintenance costs, including increases associated with engine enclosures, have been included in the estimates of changes in operating costs [13]. For heavy diesel trucks, EPA estimates of changes in annual maintenance costs are $-20 for the 83-dBA regulatory level, $32 for the 80-dBA level, and $180 for the 75-dBA level (See Section 6). These estimates include changes in required maintenance labor and replacement parts. The savings in maintenance costs associated with exhaust gas sealers [25] are included in the EPA estimates. These savings may have been omitted in the estimates made by Chrysler and General Motors, accounting for the differences between EPA, General Motors, and/or Chrysler estimates. However, since increases in maintenance costs for each noise treatment were not given by General Motors or Chrysler, it is not possible to identify the causes of differences between the EPA, General Motors, or Chrysler estimates.

The EPA estimates for changes in annual maintenance costs are for the average change in costs over the life of the truck. Thus, the EPA estimates do include increase in maintenance costs as the truck ages.

The comment by the Regular Common Carrier Conference that fan clutch failures will increase costs is probably based on earlier experiences with fan clutches with high failure rates. In the public hearings in Arlington, Va., Rockford Clutch commented that current fan clutches are reliable. Therefore, significant increases in maintenance costs are not expected to result from fan clutch failures. The part which causes the fan clutch to fail on the Freightliner DOT Quiet Truck has been redesigned for future manufacture [19].

In estimates of costs, EPA did not include the costs for internal modifications to quiet diesel engines. Existing engines were assumed to be used in estimating truck price increases. Therefore, the changes in maintenance costs due to potential increases in failure rate of modified engines with close-fitting pistons are not included in the EPA estimates of changes in maintenance costs.

Action in Response to Public Comment: Estimates of changes in maintenance costs for the proposed regulations have been revised. The revised estimates are based on documented data from the DOT Quiet Truck Program. No further action has been taken.

A-5.3 COSTS OF COMPLIANCE TESTING

Identification: General Motors, (A-2.1.5.20), Paccar, Inc. (A-2.1.95) and the Federal Highway Administration, Ohio (A-2.5.8.3) commented on the costs of compliance. The following estimates of the cost for a site suitable for compliance testing were present in public comments; General Motors -- $286,000, Paccar -- $147,000 to 346,000, Cummins Engine Co. (A-2.2.1.5) -- $150,000, and Koehring Company (A-2.2.4.2) -- $500,000 to $1,000,000. Independent testing would cost $1800 per truck according to Paccar. General Motors claimed that a $500,000 facility would be required for development testing. For special purpose construction vehicles, the Koehring Company (A-2.2.4.3) estimated testing costs at $2,935 to 11,380 per vehicle.

Discussion: The total annual costs of compliance testing has been estimated by EPA for the truck manufacturing industry as $155,000 to $230,000 (Appendix H). With an annual truck production of 412,346 [8], the costs of testing would be $0.38 to 0.57 per truck. Compared to other costs of compliance, such as truck price increases and changes in operating costs, the cost for compliance testing should be negligible.

The EPA estimates of the costs of compliance testing includes testing costs for production verification and selective enforcement auditing, transportation to and from test sites, and preparation of all reports required in the proposed regulations. Estimates were made for individual truck manufacturers covering all but 4 percent of the industry.

The costs of facilities required for development testing are included in the markup of the manufacturing costs of 50 percent to obtain price increases. (See Section 6).

The estimates of costs of testing presented by Koehring are for off-the-road construction vehicles and include costs of disassembling the vehicles for transportation to a suitable test site. Such vehicles have been omitted from the regulations.

Action In Response to Public Comment: Estimates of the costs of compliance testing show that these costs are negligible in comparison to other costs of compliance. No further action has been taken.

Appendix A-6
COSTS VERSUS BENEFITS

A-6.1 JUSTIFICATION OF COSTS AND BENEFITS

Identification: International Harvester (A-2.1.6.13) commented that the initial price increases far outweigh any benefits to the public welfare. According to the American Trucking Associations, Inc. (A-2.3.1.12), costs rise exponentially as truck noise levels are reduced, yet the benefits decrease to the point of little or no return. Ford Motor (A-2.1.3.10) claimed that the total cost of over 3 billion dollars for the proposed regulations is not worth the 3 dBA reduction in community noise in 1990. Ford Motor Company (A-2.1.3.19) added that the nonsensitive observer requires 8 dBA to just detect an intensity difference of a pure tone, and that the 75-dBA regulation will reduce individual truck noise by only 3.5 dBA at highway speeds. Therefore, the noise reductions from the 75-dBA regulation will not be noticeable. General Motors (A-2.1.5.27) commented that the total cumulative costs for the proposed regulations will be $16.2 billion in 1990, and the noise reduction will be 10.1 dBA; whereas, the costs for an 83-dBA regulation will be $5.2 billion (or 32 percent of $16.2 billion) and the noise reduction will be 8 dBA (or 80 percent of 10.1 dBA). Therefore, the additional costs of $11 billion for the small increase in benefits is not cost effective.

The Department of Transportation (A-2.5.4.17) presented estimates of the reduction in the noise from urban street and freeway traffic for different regulatory alternatives. Using the monetary value on urban property associated with changes in urban traffic noise of $20/ person/dB, monetary values for the estimated traffic noise reductions were computed by DOT. For the proposed regulations, the costs estimated by DOT are greater than the monetary value of the benefits, so that the proposed regulations are not cost-effective, according to DOT. According to the analysis of the increasing marginal costs and decreasing marginal benefits presented by the Council on Wage and Price Stability (A-2.5.6.1), the 80-dBA and 75-dBA regulatory levels are not justified. The estimated benefits included changes in property value and fuel consumption. The costs and benefits were cumulated by the Council on Wage and Price Stability to the year 2000 and discounted at a rate of 10 percent to a 1975 present value.

In their response to the above comments, General Motors Corp. (A-2.1.5.29) claimed that the estimates of savings given by the Department of Transporation and the Council on Wage and Price Stability are too high which led to overstatements of the benefits for different regulatory alternatives.

Discussion: The price increase given by International Harvester for a heavy truck regulated at 80 dBA is $2150, one of the highest estimates given in the public comments for a heavy diesel truck regulated at 80 dBA (see Figure A-11) and $1696 higher than the estimated price increase given by EPA [4].

The population-weighted averages of EPA estimates of truck price increases and EPA estimates of benefits in terms of traffic noise reduction given in Table A-6.1 indicated that the price increases become larger and the differences in benefits become smaller as the regulatory level is reduced. However, these estimates do not support the comment made by the American Trucking Association, Inc. that the costs rise exponentially and the benefits decrease to the point of little or not return.

Table A-6.1
EPA Estimates of Costs and Benefits

Regulatory Option	Average of EPA Estimates of Truck Price Increases for Lowest Regulatory Level*	Urban Street Traffic Noise Reduction in 1990*
83 dBA in 1977	156	4.0 dBA
83 dBA in 1977 80 dBA in 1981	333	5.2 dBA
83 dBA in 1977 80 dBA in 1981 75 dBA in 1973	915	6.3 dBA

*With fan-off testing.

**With a 4 dBA reduction in non-truck vehicle noise levels.

The 3-dBA figure quoted by Ford Motor Company as the reduction in the traffic noise was taken from the EPA estimates of the traffic noise reduction associated with new truck regulations and related to present traffic noise levels. However, a more realistic measure of benefits is the difference in the projected change in noise levels with and without the proposed regulations. In the revised estimates given by EPA, the urban street traffic noise reduction is 6.3 dBA in 1990, more than twice the number quoted by the Ford Motor Company. EPA has also revised the estimates of costs. The present value of the cumulative costs for the proposed regulations is estimated to be approximately $3.2 billion in 1990 (See Appendix E). Fuel savings from more efficient fans and fan clutches are not included in the EPA estimates of $3.2 billion. Including fuel savings for more efficient fans and fan clutches, results in a savings in the cumulative costs of approximately $2.2 billion instead of a cost of $3.2 billion. The actual cumulation costs attributed to the regulations will fall in between these two estimates.

Since the Ford estimate of costs falls close to the highest of the EPA costs estimates, the Ford estimates of benefits appear to be low, they probably underestimated the cost-effectiveness of the proposed regulations in their comments.

The comment made by Ford Motor Company on the detectability of an intensity difference in a pure tone signal is not relevant to the exposure to truck noise. The human response to the noise from a truck is not similar to the human response to a pure tone. In many siutations, a single truck passby may raise the noise level above the background noise by less than 8 dBA. However, since the noise is associated with a single identifiable source, it usually produces greater distraction.

Even if an individual does not detect the XdB difference between two single-event passbys, the statistical distribution of the entire population will be shifted XdB, and, hence, benefits to the population will shift accordingly. It is inappropriate to compare single-event judgements with statistically determined benefits to a large population.

General Motors based their comments on estimates of average traffic noise reductions and total cumulative costs. Therefore, for the purpose of discussing the GM comments, estimates of average traffic noise reductions and total cumulative costs have been computed from the EPA analyses of benefits and costs for noise regulations on truck noise emission, using the same cumulative procedure as GM even though this is not a significant number. As noted in Section A.3.3.2, a more representative measure of benefits than the reduction in average traffic noise levels is the equivalent number of people impacted (P_{eq}). Also, the cumulative costs are properly represented in terms of present value or uniform annualized costs (See Section A.7.7.3). For example, the present value for the proposed regulations cumulated to 1990 is $3.2 billion which is the number corresponding to the $8.0 billion in the table (See Table A-7.1). The appropriate measures, based on standard financial procedures, were used by EPA in selecting the final regulation.

A comparison of the EPA and GM estimates of reductions in urban street traffic noise levels and cumulative costs are given in Table A-6.2. The GM estimates of benefits and costs are both higher than the EPA estimates. For the EPA estimates, the ratio of the increase in costs to the increase in noise reduction for the proposed regulations compared to the 83 dBA in 1977 regulation is $2.6 billion/dBA. The corresponding figure computed from the GM estimates is $5.2 billion/dBA, which is twice the value computed from the EPA estimates. EPA does not consider that the ratio dollars per dBA is a useful or significant number. It is presented here only for the purpose of comparing GM's computations and EPA's. As discussed in Sections A.3.2.2, A.5.1.1 and A.7.7.3, the estimates of benefits and costs given by EPA have been revised. The revised estimates are based on documented data and modeling techniques which are more representative of the total populations of the people impacted by truck noise and the trucks subjected to the regulations than the modeling techniques used by GM. Therefore, the EPA estimates are probably more accurate than the GM estimates.

Table A-6.2
Comparison of EPA and General Motors Estimates of
Costs and Benefits

Regulatory Option	Cumulative Costs to 1990 (Billion of Dollars)		Urban Street Traffic Noise Reduction in 1990 (dBA)	
	EPA*	GM	EPA	GM
83 dBA in 1977	1.9	5.2	4.0	8
EPA Proposed Regulations	8.0	16.2	6.3	10.1

*Without credit for costs and savings from more efficient fans, fan clutches and exhaust gas seals. These estimates of cumulative costs represent less than 0.6% of the estimated total trucking revenues cumulated over the same period of 1977-1990.

The Council on Wage and Price Stability assumed that the regulatory level will be achieved on all trucks in the year in which the level becomes effective. This leads to an overstatement of the benefits. Assigning a monetary value to the traffic noise reduction in order to measure benefits can be misleading. Improvements in the quality of the environment, such as the reduction of noise, may not always be reflected in changes in property values, as summed by DOT and the Council on Wage and Price Stability.

The total cost or saving estimates made by DOT for different regulatory alternatives were based on the costs of quieting and operating the Freightliner DOT Quiet Truck. These costs were applied to all medium and heavy trucks by DOT. The costs for medium gasoline trucks, which make up over one half of the medium and heavy truck population, are significantly different from the costs associated with heavy diesel trucks such as the Freightliner DOT Quiet Truck [13]. The Council on Wage and Price Stability corrected this apparent oversight by using the General Motors estimates of costs for medium trucks and DOT estimates of costs for heavy trucks.

The DOT assumptions which have the most influence on the outcome of their analysis are given below.

1. All trucks are operated 70,000 miles per year.

2. The power savings with the cooling fan off is 19.5 hp for all trucks.

3. The price increase for trucks will be as given in Table A-6.3.

4. All new regulated trucks will be equipped with fan clutches and the resulting savings can be credited to the regulations on new truck noise emissions.

In the cost-benefit analysis conducted by the Council on Wage and Price Stability, medium trucks were assumed to average 35,000 miles per year and heavy trucks 70,000 miles per year. The price increases of trucks assumed by the Council are given in Table A-6.4. Otherwise, the DOT assumptions given above were used.

Table A-6.3
Estimates of Truck Price Increases Used in the DOT Analysis of Costs vs. Benefits

Type of Truck	Regulated Level: 83 dBA	80 dBA	75 dBA
Medium Gasoline....	$329	$1076	$1075
Medium Diesel	$329	$1076	$1075
Heavy Gasoline	$329	$1076	$1075
Heavy Diesel	$329	$1076	$1075

Table A-6.4
Estimates of Truck Price Increases Used in the Costs-Benefit Analysis by the Council on Wage and Price Stability

Type of Truck	Regulatory Level: 83 dBA	90 dBA	75 dBA
Medium Gasoline....	$ 25	$ 130	$ 350
Medium Diesel......	$ 25	$ 130	$ 350
Heavy Gasoline	$329	$1076	$1075
Heavy Diesel	$329	$1076	$1075

In estimating the cumulative costs, EPA used the following assumptions. These assumptions are more detailed and appear to be more realistic than those used by DOT or the Council on Wage and Price Stability.

1. The average annual mileage for medium gasoline trucks is 10,000 miles, medium diesel trucks 21,000 miles, heavy gasoline trucks 18,000 miles and heavy diesel trucks 54,000 miles. The annual mileage for each truck is a function of truck age, decreasing with increasing age [8].

2. The power savings for a fan clutch is 15 hp for heavy trucks. It is assumed that fan clutches will not be used on medium trucks for noise reduction. The power savings for more efficient fans on medium gasoline used to comply with the proposed regulations are as follows: for the 83-dBA regulatory level–2.5 hp, for the 80-dBA level–4.5 hp, and for the 75-dBA level–6 hp. For medium diesel trucks, twice the savings for medium gasoline trucks are used.

3. The price increases for trucks will be as given in Table A-6.5. These estimates are based on the assumptions that trucks equipped with fan clutches will be permitted to be tested with the fan off and that credit for the costs of fan clutches are credited to the noise regulations.

4. The costs and fuel savings for fan clutches cannot be credited entirely to the noise regulations. Other factors, such as fuel conservation, will encourage their use.

Table A-6.5
Estimates of Truck Price Increases Used in the Cost-Benefit Analysis by EPA

	Regulatory Level		
Type of Truck	83 dBA	80 dBA	75 dBA
Medium Gasoline....	$ 35	$180	$ 665
Medium Diesel......	$426	$850	$1624
Heavy Gasoline	$125	$255	$ 715
Heavy Diesel	$356	$589	$1363

In their response to the comments by DOT and the Council on Wage and Price Stability, General Motors suggested changes in the above assumptions that were in general agreement with all of the EPA sssumptions; except, General Motors claimed that the price increases for diesel trucks were understated by EPA, DOT, and the Council on Wage and Price Stability.

The cumulative costs to 1990 for the proposed regulations are estimated by EPA as -\$3.3 billion (a savings), when credit for the costs and savings from more efficient fans, fan clutches and exhaust gas seals is included, and \$8.0 billion without taking credit for more efficient fans, fan clutches and exhaust gas seals. The actual costs that should be credited to the proposed regulations will be in between these two estimates. The EPA estimates differ significantly from the corresponding estimates given by the DOT (\$9.1 billion) and the Council on Wage and Price Stability (\$13.8 billion) with credit for fuel savings. This indicates that the result of the cost-benefit analysis is sensitive to the above assumptions, Because the assumptions made by EPA are believed to be more realistic, EPA cost estimates should be more accurate.

Action in Response to Public Comment: Based on the EPA analyses of costs and benefits, regulations similar to those recommended by DOD have been adopted, with the intent of promulgating lower regulatory levels in the future. The recommendations made by the Council on Wage and Price Stability based on their cost-benefit analyses have not been adopted, since some of the key assumptions made in each analysis are subject to question. The recommendation made by General Motors on the regulatory levels are based on estimates of costs which appear to be high. Therefore, the GM recommendation has not been adopted.

A-6.2 OTHER REGULATORY APPROACHES

A-6.2.1 Stricter Enforcement of Existing Regulations

Identification: Donaldson Company (A-2.2.2.2) and Associated General Contractors of Colorado (2.6.2.1) commented that significant noise reductions will result from strict enforcement of the Interstate Motor Carrier Regulations. Lawrence Auerbach (A-2.4.2.1) suggested that strict enforcement of existing regulations should accompany the regulations on new trucks.

Discussion: EPA has made estimates of the benefits associated with the Interstate Motor Carrier Regulations. The reduction in equivalent number of people impacted P_{eq} is estimated by EPA to be 3.3 million for the Interstate Motor Carrier Regulations out of a total of 37.3 million for existing conditions. Adding the proposed regulations is estimated to produce an additional reduction in P_{eq} of 8.5 million in 1990, with the assumption that there will be no reduction in the noise levels from non-truck vehicles. In making these estimates, strict enforcement of all regulations is assumed. These estimates indicate that the reductions in P_{eq}, resulting from the Interstate Motor Carrier Regulations will not be adequate in the long term, and that additional reductions provided by the proposed regulations on new trucks will be needed.

Lawrence Auerback is correct. None of these regulations will be effective without strict enforcement.

Action in Response to Public Comment: No further action has been taken.

A-6.2.2 Regulations on The Noise Source

Identification: The States of Delaware (A-2.5.3.2), Mississippi (A-2.5.13.3), Minnesota (A-2.5.14.2), New Mexico (A-2.5.15.2) and Virginia (A-2.5.21.1), and the District of Columbia (A-2.5.7.1) commented that the height of truck exhaust stacks has an impact on the effectiveness of roadside noise barriers and therefore should be addressed in the regulations. Indiana (A-2.5.10.1) suggested that the exhaust system should be required to be located beneath the truck body. The Department of Transportation (A-2.5.4.18) recommended that EPA consider the benefits of using vertical vs. horizontal exhaust systems. Several suggested advantages for each were offered by DOT.

Discussion: The height of the exhaust stacks will determine the location of the source of exhaust outlet noise. For trucks regulated at 75 dBA, exhaust outlet noise is expected to be approximately 65 dBA or below [13]. At freeway speeds, truck tires, which typically have levels of 81 dBA or greater [7], will dominate the exhaust outlet noise by about 15 dBA for 75 dBA regulated trucks. Therefore, near freeways where most roadside barriers are used, the effectiveness of roadside barriers in attenuating the noise from regulated trucks will not be significantly improved by lowering exhaust stack heights.

The suggestions offered by DOT should be useful to the manufacturer in meeting the new truck regulations and providing other desirable characteristics, such as the reduction of splash and spray visibility problems. However, since the regulations are based on noise emission performance, the type or location of the exhaust system should be left to the manufacturer.

Action in Response to Public Comment: The height of exhaust stacks or locations of exhaust systems is not treated in the noise emissions regulations on new medium and heavy trucks.

A-6.2.3 Treatment of Noise Path

Identification: The Ford Motor Company (A-2.1.3.17) recommended that a trade-off analysis be performed on quieting truck versus using noise abatement along highways and in buildings.

Discussion: The insulation of all buildings and homes would probably be prohibitively expensive, offer no protection outdoors, and be very difficult for local jurisdictions to regulate and impossible under the Noise Control Act for EPA to regulate. Using noise abatement treatments, such as barriers, along urban streets, where the greatest noise impact in terms of P_{eq} occurs, is not feasible. However, the use of noise abatement treatment along freeways is available for use near noise-sensitive areas. For these reasons, little attention was devoted to the trade-off analysis suggested by Ford Motor Company.

Action in Response to Public Comment: No further action has been taken.

A-6.2.4 Control of Truck Use

Identification: Ford Motor Company (A-2.1.3.17) suggested that a trade-off analysis be conducted on the benefits and costs of quieting trucks versus controlling the use of trucks. The State of Delaware (A-2.5.3.3) recommended that some provisions be adopted for noise reduction of old trucks. According to Citizens Against Noise (A-2.4.3.3), regulations should be adopted to force operators to retrofit all trucks: PROD (A-2.3.6.3) commented that after promulgation of the proposed regulations, in-use regulations on interstate motor carriers should be modified to bring the noise levels from old trucks closer to those of new regulated trucks. California Highway Patrol (A-2.5.1.1) suggested that regulations on operational noise levels be adopted to prevent truck noise levels from increasing with the age of the truck. A night curfew on all trucks was recommended by Citizens Against Noise (A-2.4.3.4).

Discussion: Restrictions on truck usage is left to local jurisdictions by the Noise Control Act. Local regulations on the use of trucks should be used in conjunction with national new truck and Interstate Motor Carrier Regulations to provide greater protection against noise in noise sensitive areas. The areas which are sensitive to noise can be better defined by local governments more familiar with the communities involved. A trade-off analysis of new truck regulations versus regulations on the use of trucks, other than the estimates of costs and benefits given by EPA for the Interstate Motor Carrier Regulations, is not required, since both local in-use and national regulatory actions are needed and may be used to complement each other.

EPA is considering modifying the Interstate Motor Carrier Regulations in the future to bring the levels closer to the new truck regulatory levels. This could be used to prevent significant degradation of the noise levels required under the new truck regulations. Retrofitting old trucks will probably be considered, although it should be noted that retrofitting trucks is less cost-effective in reducing noise levels than including noise treatment in designing and building new trucks. Therefore, the regulatory levels which require retrofitting noise treatment should not be expected to be as low as regulatory levels for new trucks.

EPA has no legal basis in the Noise Control Act for setting a curfew on the operation of trucks at night.

Action in Response to Public Comment: Modifying the Interstate Motor Carrier Regulations to bring the regulatory levels closer to those in the new truck regulations are under consideration by EPA. Other regulatory actions on truck use are left to local jurisdiction.

A-6.3 REGULATORY STRATEGY

Identification: Ford Motor Company (A-2.1.3.18) recommended that the regulations on new trucks be delayed until the effects of the Interstate Motor Carrier Regulations can be assessed. Mack Trucks, (A-2.1.7.2), Donaldson Company (A-2.2.2.9), the American Trucking Associations (A-2.3.1.11), and the U.S. Chamber of Commerce (A-2.6.4.4) suggested that the effect of the 83 dBA new truck regulation be assessed before adopting the 80 dBA new truck regulation. International Harvester (A-2.1.6.13) recommended that the 80-dBA regulation be delayed until 1983 and the effect of the new truck regulations be re-evaluated in 1979.

According to Paccar, Inc. (A-2.1.9.7) regulating medium and heavy trucks separately should be used to increase the ratio of the benefits and costs, since medium trucks impact an estimated 34.6 million, whereas heavy trucks impact an estimated 2.7 million.

Discussion: Setting and assessing the effects of each regulatory level on trucks, one at a time, would delay the achievement of the ultimate goal of removing the noise impact produced by medium and heavy trucks. Time would be needed to perform an assessment of the effects of each regulatory level, solicit and evaluate public comment, and provide sufficient lead time for truck manufacturers to respond to the next regulatory level. The strategy taken by EPA in the proposed regulations is to obtain the greatest protection of the public health and welfare in the shortest time without imposing any unreasonable burdens on truck manufacturers and users, or the national economy.

EPA estimated that the equivalent number of people impacted (P_{eq}) by urban street traffic is 34.6 million and by freeway traffic 2.7 million. In making these estimates, it was assumed that medium and heavy trucks are part of both urban street and freeway traffic. In their comments, Paccar, Inc. appears to have incorrectly interpreted the estimated P_{eq} for urban street traffic as the number of people impacted by medium trucks only and the estimated P_{eq} for freeway traffic as the number of people impacted by heavy trucks only. Therefore, the information presented by Paccar, Inc. cannot be used to justify regulating medium and heavy trucks separately.

Action in Response to Public Comment: No change in the regulatory strategy taken by EPA for new medium and heavy trucks has been taken in response to public comment.

A-6.4 NEED FOR STRICTER REGULATIONS

The issue of more lenient regulations is addressed in Section A-6.1, "Justification of Costs and Benefits", where several of the public comments claimed that the benefits for the proposed regulations do not justify the costs so that the regulations should be relaxed.

Identification: Alan Parker (A-2.4.5.1), the City of Chicago (A-2.5.2.2), the City of Des Plaines (A-2.5.5.1), Los Angeles County (A.2.5.12.2) and San Diego County (A-2.5.18.2) all recommended that regulatory levels similar to those of Chicago and California be adopted by EPA. San Francisco (A-2.5.19.1) commented that the proposed regulations are too lenient. Texas (A-2.5.20.1) suggested that lower regulatory levels and shorter lead times be considered. According to New Mexico (A-2.5.15.1), the regulations should be more in keeping with the 70 dBA L_{10} FHWA standards for residential, hospital and school areas. Citizens Against Noise (A-2.4.3.2) claimed that the regulatory levels should be lowered to bring truck noise levels down to the levels of automobiles.

Discussion: The Noise Control Act requires that EPA set standards which are requisite to protect the public health and welfare and that EPA take into account the noise reduction achievable through the application of the best available technology. EPA has identified outdoor noise levels with an L_{dn} equal to or less than 55 dBA as requisite to protect public health and welfare with an adequate margin of safety [1]. Using this level as a criterion, estimates of the equivalent number of people impacted by urban traffic noise will be at least 11.5 million with the proposed regulations on new medium and heavy trucks in effect and with noise levels from vehicles other than medium and heavy trucks reduced by 4 dBA [13]. Using the same procedure, the existing P_{eq} of 37.3 million would be reduced by an estimated 40 percent, if all noise from medium and heavy trucks was removed and other traffic noise remained unchanged. If, in addition to removing all medium and heavy truck noise, a reduction in noise levels from other traffic noise sources of 10 dBA is assumed, the P_{eq} would be reduced by an estimated 95 percent. These estimates indicate that the regulatory levels lower than those given in the proposed regulations are necessary to protect health and welfare, as suggested in the above public comments. However, in the above argument, the noise reduction achievable through the application of the best available technology was not taken into account, as required by the Noise Control Act.

The proposed regulations can be met with the application of the best available technology (See Section).

At this time, technology availability cannot be validated for regulatory levels lower than 75 dBA or for a shorter lead time on the proposed regulations. Therefore, taking into account the noise reductions achievable through the application of the best available technology will make it difficult for EPA to defend regulations which are more stringent than those proposed. Further, the cost and economic impact resulting from various technology applications must be considered by the Administrator.

It is difficult to relate the FHWA standards and the EPA regulations on new medium and heavy trucks since the FHWA standards are given in terms of L_{10} for all traffic and the EPA regulations are given in terms of not-to-exceed levels for trucks under test conditions designed to measure the maximum noise level. Since the median roadside level for 75-dBA regulated trucks is expected to be around 71 dBA [13] and medium and heavy trucks will make up about 7 percent of the traffic population on most streets in residential, hospital or school areas, the EPA regulations should not violate the 70 dBA L_{10} FHWA standards

For existing automobiles, roadside levels are about 65 dBA [13]. Therefore, in order to reduce truck noise levels to the levels for automobiles would require lower regulatory levels which may not be achievable using the best available technology.

Action in Response to Public Comment. The stringency of the regulations from those proposed by EPA has not been increased because the technology may not be available for compliance with more stringent regulations.

Appendix A-7
ECONOMIC IMPACT

A-7.1 CURRENT ECONOMIC SLUMP

Identification: Ford Motor Company (A-2.1.3.20) and Schwitzer Company (A-2.2.6.4) indicated that the noise control costs will be an added inflationary burden upon the trucking industry, which would make recovery from the recession more difficult.

The State of Louisiana (A-2.5.11.2) and the Associated General Contractors of Colorado (A-2.6.2.4) expressed concern over the current state of the economy and asked that the economic impact analysis be reassessed to take into account the current state of the industry. The U.S. Chamber of Commerce (A-2.6.4.8) claimed that the EPA economic impact analysis on the proposed regulations is outdated.

Discussion: Industry sales of medium and heavy trucks reached a peak of 446,793 in 1973. In 1974 sales were only 420,534; down about 6%. Estimated truck production for 1975 was down approximately 19% from 1974 levels. Truck registration figures* for the 10 months through October 1975 show a substantial variation between manufacturers. Substantial decreases occurred for all manufacturers. Compared to the same period in 1974, the smallest decrease occurred for Dodge (5%). Chevrolet, FWD, International and Western Star experienced decreases in the 20–27% range. Autocar and GMC experienced a 32% decline. Brockway, Freightliner, Kenworth, Mack, Peterbilt and White all experienced decreases of over 40%.

The elasticity calculations for the change in demand for trucks given in Appendix C indicate that although fewer trucks will be sold the net revenue to truck manufacturers and employment in the industry are not likely to fall and will even increase under all regulations (Tables 7-13 and 7-14). The extent of the adverse impact of the regulations should therefore be limited to the increased inventory requirements for the more expensive equipment.

*Registrations lag production so that increases in registrations will occur later than production.

The state of the economy as a whole does have a direct effect on trucking and thus on truck sales [8]. Price increases due to noise control equipment, however, are not likely to exacerbate the cyclical downturn from the manufacturers point of view. In other words, it is the demand for transportation services rather than the price of trucks which primarily determines truck sales.

Action in Response to Public Comments: The EPA economic impact analysis has been updated to reflect recent economic conditions.

The inflationary effect on the economy as a whole, if manufacturers pass on 100 percent of cost is discussed in Section 7. Due to the inelastic nature of the demand for trucks, the manufacturing industry will not experience decreased revenue due to the regulation, assuming that all costs are passed on.

A-7.2 SUPPLY OF QUIET ENGINES

Identification: Ford Motor Company (A-2.1.3.21) and International Harvester (A-2.1.6.16) indicated that manufacturers experienced a shortage of quiet diesel engines when the 83-dBA regulatory level took effect in California and some other States. It was further asserted that this condition would be amplified when the proposed EPA regulations increase the demand for quiet engines. Oshkosh Truck Corporation (A-2.1.8.2) commented that heavy truck manufacturers will be dependent on the ability of engine manufacturers to produce quiet engines.

Discussion: Brand loyalty amongst purchasers of trucks to particular engine manufacturers is strong according to one truck manufacturer. In addition there is no company which produces only noisy engines. Therefore, it is not likely that individual engine manufacturers will experience significant losses in sales due to the 83-dBA regulation.

However, for the 80- and 75-dBA regulatory levels, the demand for quiet engines should increase. The 80-dBA regulatory level is proposed to take effect in 1982, thus allowing a 6-year lead time for development of quieter diesel engines. It has been estimated that engine noise can be reduced by as much as 9 dBA without using enclosure techniques [10].

The Department of Transportation is sponsoring research to quiet diesel engines. The results of this research are scheduled for availability to the public within the next 3 years. Assuming that a 2-year lead time is required for implementation, the DOT-sponsored engine quieting technology could be applied to increase the supply of quiet engines by 1982.

Action in Response to Public Comment: Lead times appear to be adequate for diesel engine manufacturers to meet the expected increase in demand for quiet engines for the 80- and 75-dBA regulatory levels.

A-7.3 SHIFTS IN BUYING HABITS

Identification: Ford Motor Company (A-2.1.3.22), Freightliner Corp. (A-2.1.4.9), International Harvester (A-2.1.6.15), and Mack Trucks Inc. (A-2.1.7.9) stated that the adoption of the proposed regulatory level will seriously limit their product line offering because truck–engine configurations could no longer be marketed. According to these comments, this impact is expected to be particularly severe when the 75-dBA regulatory level takes effect. General Motors (A-2.1.5.30) asserted that the noise standards will cause major shifts in buying habits. Federal Highway Administration, Ohio (A-2.5.8.7) pointed out that the impact of relative cost increments for gasoline and diesel trucks upon buyer patterns should be determined.

Discussion: Some trucks which comply with the 83-dBA regulatory level will probably cost more than others [13]. However, the 83-dBA regulatory level applied nationally should not force the elimination of any truck models, as suggested by International Harvester and Mack Trucks. The lead times for the proposed 80- and 75-dBA regulatory levels provide sufficient time for major truck redesigns where necessary, to accommodate noise treatments (Section A-4.5.1) and avoid eliminating truck configurations.

At all regulatory levels medium diesel trucks experience the greatest price increase [13]. Heavy diesel trucks experience the second largest percent price increase at 83 dBA but the lowest at 75 dBA. Medium gasoline trucks experience large increases only for a 75-dBA regulatory level. When no credit for the savings from more efficient fans, fan clutches, and exhaust gas seals is taken, the changes in annual operating costs are less than $38 for all types of trucks for the 83- and 80-dBA regulatory level [13]. These small changes in operating costs should not have a significant impact on buying habits. However, for a 75-dBA regulatory level, the changes in annual operating costs are estimated to be $277 for medium diesel and $180 for heavy diesel [13]. When credit for savings from more efficient fans, fan clutches and exhaust gas seals are taken, a savings in operating costs occurs for all types of trucks, except the medium diesel. These changes in price and operating costs are likely to have some effect on the type of engine and truck chosen.

Medium diesel trucks have a relatively unimportant role in most sectors of the economy. About half of the increased costs of medium diesel trucks will be borne by two sectors: construction and for-hire (See Table 7.30). It may not be possible for the construction sector to substitute gasoline for diesel trucks in many applications. Some substitution is likely, however, in the for-hire sector.

The largest potential impact of increased costs for medium gasoline trucks is in agriculture. The price differentials between medium gasoline and medium diesel trucks make any shifts away from gasoline trucks unlikely.

The construction and retail sectors each own 21 percent of all the heavy gasoline trucks in use (See Table 7-30). Heavy gasoline trucks, however, represent almost half of the trucks used by construction industry. No other sector depends on heavy gasoline trucks for more than a quarter of its truck usage. The projected changes in both capital and operating costs will tend to favor the use of heavy gasoline over heavy diesel trucks. However, the sector purchasing the majority of heavy diesel trucks is the for-hire sector. This section is also the most dependent on heavy diesel trucks. Costs for this industry are shown in Appendix G. Due to the high mileage travelled by users of heavy diesel trucks, it is unlikely that a major shift will occur.

A shift has been predicted from light-heavy to heavy-heavy trucks in order to reduce per ton-mile operating costs [26]. The same argument would indicate a willingness to buy heavy diesel trucks as long as their fuel costs per ton-mile is lower than for heavy gasoline trucks.

The EPA analysis of the economic impact of the proposed regulations does not include the different demand elasticities for each type truck or the substitution of one type of truck with another. Therefore, information on shifts in truck buying is not available. In order to include the necessary level of detail, an analysis of the market by truck model would be required.

Action in Response to Public Comment: Estimates of the reduction in demand have been made for medium and heavy trucks, assuming equal demand elasticities. Estimates of shifts in truck buying have not been made.

A-7.4 IMPACT UPON TRUCKING COMPANIES

Economic impact of the noise regulation upon the trucking companies is examined in this document. Issues relating to profits and competition were of particular importance to trucking companies and trucking associations.

A-7.4.1 Profits

Identification: The Overdrive Magazine (A-2.3.5.4) made the assertion that increases in truck costs will reduce profits for truckers and make it difficult to obtain necessary loans. The non-availability of loans will force many truckers out of the trucking business, according to Overdrive Magazine.

Discussion: The impact on total trucking revenues and operating margins has been considered by EPA (Tables 7-25 and 7-26). The for-hire sector was considered separately (Appendix G). The financial problems and the economic outlook for the industry are discussed.

The ability to obtain loans is directly related to the financial strength of a particular company as well as access to money markets. Certain segments of the industry are in financial distress. The price increases which will occur in 1977 (only 1-1/2 years after the economic trough for trucking) are relatively small. However, economic conditions at the time when the other regulations come into effect are likely to be far more important determinants of the ability of truckers to obtain loans, than the price increases due to noise control. A tight money market could make financing hard to obtain.

Action in Response to Public Comment: Ensuring that rate increases coincide with cost increases will avoid a heavy drain on truckers' cash resources. Means to assist truckers to obtain loans in a competitive money market should be considered. Because of the relatively low rates of return in trucking, the industry is particularly sensitive to high interest rates. Rate increases should be allowed which provide for these interest payments as well as the capital costs.

A-7.4.2 Small & Independent Truckers Position

Identification: The Overdrive Magazine (A-2.3.5.6) asserted that the EPA had not determined the economic impact upon independent truckers, who in the magazine's opinion will suffer the most. The proposed regulations could reduce profitability, which could force some small truckers out of business, according to Overdrive Magazine (A-2.3.5.4) and the U.S. Chamber of Commerce (A-2.6.4.7). According to the Regular Common Carrier Conference (A-2.3.7.3), operators cannot afford current increases in truck prices and the noise regulation will make conditions worse for truck operators.

Discussion: This document covers all types of trucking. The problems of the smaller companies are discussed (See Section 7).

It is generally accepted that a small company may not be able to absorb costs as readily as a large one. Small trucking companies (including owner-operators) tend to have poorer credit ratings, less sophisticated accounting practices, and pay higher prices for fuels and parts. Their operating margins are smaller (Table 7-27) than those of the large companies. Given these disadvantages, an increase in the price of trucking services may have a greater impact on small companies than on large ones. Many trucking companies were operating very close to break-even in 1974 and 1975. Obviously, even a small delay in passing on costs, can have an impact on companies in this position.

If rate increases are granted rapidly and loans can be obtained, the small trucking companies should not feel too great a burden. They may, however, have to pay a premium for funds which larger, more-profitable companies do not. Smaller bank loans, in general, carry higher interest rates [27]. The rate increase should take this into account.

Action in Response to Public Comment: If timely rate increases are granted to cover costs due to noise treatment, little impact on small trucking companies should result. Therefore, the Interstate Commerce Commission should be aware of the increased costs which are likely to occur.

A-7.5 IMPACT ON TRUCK MANUFACTURERS

Identification: The Koehring Company (A-2.2.4.5) claimed that the proposed regulations could put some truck manufacturers out of business. Crane Carrier Company (A-2.1.2.1) commented that the small truck manufacturer would experience a greater economic impact, since the small manufacturer cannot compete with larger manufacturers for the required technical talent. The small manufacturer depends more on the specialty truck market that is more sensitive to price increases, according to the Crane Carrier Company.

Discussion: The elasticity of the truck market is such that truck price increases, when passed on to the truck purchasers, result in increases of revenue to the truck manufacturers. (See Table 7-13). Some increase in the amount of financing required for inventories is likely, however. This will affect cash flow to some extent. The proposed regulations are not likely to put any truck manufacturers out of business, as long as all costs are passed on.

The demand for specialty trucks is estimated to be less sensitive to price increases than the demand for general-purpose trucks. The sales of specialty trucks are more sensitive than the sales of general-purpose trucks to the conditions of the sector of the economy in which they are used. For example, sales of trucks for use in the construction industry are controlled to a large extent by the economic conditions of that industry.

Some of the technology required for compliance has been or will be made available to the public through research sponsored by the Federal government. Examples of such research include the DOT Quiet Truck Program and an ongoing program to reduce diesel engine noise. Research sponsored by the Federal government should reduce the costs to small truck manufacturers for obtaining technical assistance.

Action in Response to Public Comment: A serious economic impact on truck manufacturers is not expected.

A-7.6 IMPACT ON STATE HIGHWAY NOISE TREATMENT PROGRAMS

Identification: The savings to States for highway noise treatments, such as noise barriers, and in the values of private property, should be included in the analysis of the economic impact of the proposed regulations, according to the States of Delaware (A-2.5.3.4), Mississippi, (A-2.5.13.4) and New Mexico (A-2.5.15.3). New Mexico added that highway noise barriers cost about $100/foot. The State of Texas (A-2.5.20.2) suggested that the impact on State governments providing highway noise treatments during the period before EPA regulations become effective, should be addressed.

Discussion: The States of Delaware, Mississippi, and New Mexico are correct in suggesting that some savings in highway noise treatments should result from the EPA proposed regulations. However, because such treatments are used primarily in local areas where the noise impact is high, the total costs nationwide for such treatment are impossible to predict accurately. Some treatment will still be required in addition to the EPA regulations in order to provide sufficient protection in certain situations, particularly along freeways where tire noise dominates.

The Department of Transportation considered the effect of the regulations on property values. However, as discussed in Section A-6.1, assigning monetary values (in terms of changes in property values) to the benefits to the public welfare can be misleading.

The lead times in the proposed regulations have been selected to provide adequate time for truck manufacturers to comply with the regulations. Decreasing the lead times to decrease the burden on States for providing highway treatment, could have a serious impact on truck manufacturers in attempting to comply with the regulations.

Action in Response to Public Comment: Estimates of costs to States for providing highway treatments in situations of high noise impact are not included in the economic impact analysis.

A-7.7 IMPACT ON NATIONAL ECONOMY

This part of the analysis of public comments is concerned with the national economy. The commentors expressed concern ranging from the inflationary aspects of the regulation to cumulative costs of all Federal regulations that impact the trucking industry. The major issues are discussed below.

A-7.7.1 Inflation

Identification: Freightliner (A-2.1.4.10), General Motors (A-2.1.5.32), B. L. Atkins (A-2.4.1.1), Paccar (A-2.1.9.8), White Motor (A-2.1.10.4) and the U.S. Chamber of Commerce (A-2.6.4.6) expressed concern about the inflationary effect of the proposed regulations. The Federal Highway Administration, Ohio (A-2.5.8.6) commented that the impact of the proposed regulations on consumer prices should be determined.

Discussion: The greatest inflationary impact is felt if all costs are passed on by each sector. The inflationary effect thus shows up as an increase in truck transportation cost per dollar of final demand The average percentage increase should be about 0.3 percent in the year 2000 (Table 7-29). The largest increase will be experienced by the miscellaneous mining sector. This will be 0.19 cents per dollar of final demand. Other increases are around 0.01 to 0.03 cents per dollar (Table 7-29).

Action in Response to Public Comment: The inflationary impact has been estimated by EPA. No further action has been taken.

A-7.7.2 Inflation Impact Statement

Identification: General Motors (A-2.1.5.33), International Harvester (A-2.1.6.14), White Motor Corp. (A-2.1.10.8), Gifford Mill Company (A-2.3.3.1), Overdrive Magazine (A-2.3.5.5) and the Motor Vehicle Manufacturers Association (A-2.6.6.4) requested an inflationary impact statement. Overdrive Magazine added that the inflation impact statement should go into greater depth than in the background document for the proposed regulations.

Discussion: An inflation impact statement has been prepared by EPA, which goes into greater depth than provided in the background document for the proposed regulations.

Action in Response to Public Comment: No further action has been taken.

A-7.7.3 Total Costs of EPA Proposed Regulations

Identification: Table A-7.1 presents the yearly and cumulative cost estimates of the proposed regulation by General Motors (A-2.1.5.31) and EPA. GM contended that the costs are unprecedented in their magnitude and will contribute to inflation. The Department of Transportation (A-2.5.4.19) claimed that the total cost estimated by EPA cannot be used to assess the economic impact, since the EPA estimates do not include production tolerances. The estimates of total costs should include agency costs for enforcement, manufacturers' costs and costs to small businesses and consumers, according to the Associated General Contractors of Colorado (A-2.6.2.3). The Motor Vehicle Manufacturers' Association (A-2.6.6.3) claimed that the EPA estimates of cumulative costs are low since all of the costs incurred in the intervening years were not taken into account.

Discussion: One of the sources of the differences between the GM and EPA estimates of total costs is the differences in the computational procedures used in making the estimates. EPA depreciated the costs of the truck over a 10-year period. GM accounted for the cost of the truck at the time of purchase. For the purpose of this discussion, the EPA estimates of

Table A-7.1
GM Forecasts Compared With EPA Forecasts of Total Costs
(Millions of Dollars)

Year of Purchase	GM Forecasts Figure VII-4, to 76			Recommend EPA Estimate†		
	Option G*	Option E	Option A	Option G	Option E	Option A
1977	100.6	100.6	100.6	19.7	19.7	19.7
1978	141.2	141.2	141.2	39.4	39.4	39.4
1979	183.6	183.6	183.6	59.1	59.1	59.1
1980	227.3	227.3	227.3	78.7	78.7	78.7
1981	272.5	459.1	459.1	98.0	131.2	131.2
1982	319.5	536.7	536.7	116.8	183.1	183.1
1983	368.4	617.4	1377.6	134.7	233.9	358.7
1984	418.9	701.2	1509.5	151.8	283.3	532.2
1985	463.0	779.9	1637.9	168.1	331.5	703.5
1986	508.7	861.8	1771.0	183.6	377.7	871.1
1987	527.6	919.0	1881.1	196.1	419.4	1,031.7
1988	548.6	978.5	1995.2	208.6	459.5	1,186.2
1989	569.8	1040.8	2113.9	221.2	498.3	1,333.5
1990	591.9	1105.5	2236.7	233.9	535.8	1,472.9
TOTAL	5,241.6	8,652.6	16,171.4	1,909.5	3,650.6	8,000.8

*Refer to EPA Option in Table 4-1.
†Without credit for costs and savings from more efficient fans, fan clutches and exhaust gas seals.

total costs were recomputed using the GM accounting procedure for the cost of the truck. With the GM accounting procedure, the EPA estimates of cumulative costs for the proposed regulations increased by more than $1 billion.

Small differences result from slightly different projections of the truck sales for each type through 1990. Although the same growth rates were used, different initial mixes were used by EPA and GM. In the EPA estimates, the projected sales for each type of truck were multiplied by the capital cost and projected interest cost to obtain the amount to be expended in each year of the life of the truck. Changes in maintenance and fuel costs were computed for each truck type based on mileage. Changes in fuel costs were not included in the GM estimates of total costs. Total capital and operating costs were then summed to give the total annual costs (See Appendix E).

For the proposed regulations, the cumulative costs for 1977-1990 given by GM is 16.2 billion dollars. The EPA estimates of cumulative cost is 8.0 billion dollars. The difference in these estimates is due primarily to differences in truck price increases and changes in maintenance costs used by EPA and GM (See Sections A-5.1.1 and A-5.2.4). When credit for the costs and savings for more efficient fans, fan clutches and exhaust gas seals is taken, the EPA estimates of the cumulative costs is –$3.3 billion (a savings). The cumulative costs which should be credited to the proposed regulations is between the two estimates of $8.0 and –$3.3 billion.

These cumulative costs should be compared with the cumulative revenues for trucking as a whole for the same period (1977-1990). These are estimated to be $1,315 billion approximately (extrapolated using Table 7-22). The GM estimate of costs for Option A represents 1.23 percent fo the cumulative truck revenues. This, however, ignores the time value of money. If we take the GM cost estimates for the proposed regulations (Option A) discounted at 10 percent versus the revenues similarly discounted, costs are .97 percent of revenues. The change is due to the fact that many of the substantial costs for noise treatment are incurred in later years, particularly in terms of increased operating costs.

The GM estimates for the proposed regulations in 1990 are 1.92 percent of 1990 revenues. This ignores fuel savings which is likely to reduce this number to under 1 percent. The EPA estimate of total costs for 1990 is 1.27 percent without allowing for fuel savings. With fuel savings it is 0.10 percent.

The revised EPA estimates of total costs take into account production tolerances needed to build trucks which comply with not-to-exceed regulatory levels. A tolerance of 2-3 dBA below the regulatory level was used by EPA. This tolerance is in agreement with the tolerance suggested by several truck manufacturers (Section A-4.4.1).

The EPA estimates are for the total costs experienced by truck users. The costs may be passed on, in which case, the costs will be incurred by small businesses and other users of transportation services. The costs for EPA to enforce the regulations are estimated to be small (Appendix H) compared to the costs to the truck users and therefore have not been included in the estimates of total costs.

The original EPA estimate of the total annual costs in 1990 were $1.1 billion for the proposed regulations [8]. The revised estimate is $1.5 billion if no credit for any savings in operating costs are taken. Therefore, the revised estimates of total costs with no credit for savings are higher than the original estimates. In addition, estimates of the cumulative total costs are given (See Appendix E), as suggested by the Motor Vehicle Manufacturers' Association.

Action in Response to Public Comment: The estimated costs used by EPA differ from those used by General Motors. The principal source of the differences between the estimates were discussed. However, using the General Motors estimates indicates a limited inflationary impact. Since fuel savings are not included in the GM estimates, the actual impact should be lower.

A-7.7.4 Cumulative Costs of all Federal Regulations

Identification: Mack Trucks (A-2.1.7.10), Overdrive Magazine (A-2.3.5.3), Regular Common Carrier Conference (A-2.3.7.4) and the U.S. Chamber of Commerce (A-2.6.4.9) state that the cumulative costs of the recent Federal regulations on trucks have contributed significantly to increases in truck costs, and therefore, have contributed to the present recession. The American Trucking Association (A-2.3.1.14) and Paccar, Inc., (A-2.1.9.9) stated that trucking costs have already increased by 14 percent and $2,550 respectively, due to Federal regulations.

Discussion: The cumulative costs of all government regulations on trucks has not been considered by EPA. Many different agencies are involved in promulgating these regulations. There is a need to evaluate the proposed regulations on truck noise emissions in the light of the impact on the economy of all government regulations on trucks. In addition to the cumulative effect of Federal regulations on truck prices, the coordination of the effective dates in Federal regulations could reduce the impact on manufacturers by decreasing the number of needed model changes.

Action in Response to Public Comment: An interagency effort is needed to evaluate the cumulative impact of government regulations on the trucking industry. These concerns will be addressed as a part of the interagency/OMB review which will occur prior to promulgation.

A-7.7.5 Research and Development Costs

Identification: The costs of the research and development should be borne by the entire public, according to Overdrive Magazine (A-2.3.5.2).

Discussion: Research and development costs that might be incurred by truck manufacturers will be reflected in higher truck prices. It is expected that most of the increased capital and operating costs of trucks can be passed along to the consumer and thus result in higher transportation costs of commodities transported by trucks. Therefore, the entire public will bear the noise costs. In addition, the Department of Transportation is sponsoring research and development in quieting heavy diesel trucks and diesel engines. The DOT Quiet Truck Program has produced 12 reports on noise treatments applied to three different heavy diesel truck models.

Action in Response to Public Comments: The noise control costs will be borne to a substantial degree by the entire public in the form of higher prices for transported goods and federal taxation to support research and development.

A-7.8 SECOND-STAGE MANUFACTURERS

A-7.8.1 Motor Homes

Identification: According to Recreation Vehicle Industry Association (A-2.6.8.2) an estimated 28 – 34,000 1975 model-year motor homes would fall into the 10,000 lb GVWR category. This amounts to 12 to 15 percent of the trucks in the medium gasoline category and about 35 to 40 percent of the total motor home market.

The industry association points out that there are a large number of motor home manufacturers who are small in size and not likely to have sufficient funds for noise control research, development, compliance testing, and certification. It was claimed that unequal hardships would affect competition in the motor home industry.

Discussion: The major sources of truck noise are the engine, exhaust, and fan. These sources will be treated by the chassis manufacturer. The Recreational Vehicle Industry Association commented that mobile home manufacturers normally do not alter the engine, cooling system, or exhaust system. In addition, chassis manufacturers should provide the second-stage manufacturers with instructions on modifications that can be made without affecting the noise emission characteristics of the vehicle. Therefore, the mobile home manufacturers will not be required to make large investments for noise research and development.

Before the chassis is delivered to the mobile home manufacturer, it is usually not drivable. Therefore, it is difficult for the chassis manufacturer to test before delivery to the mobile home manufacturer. Therefore, the mobile home manufacturer may have to perform the required testing.

Action in Response to Public Comment: The requirements on the chasssis and mobile home manufacturers in complying with the EPA regulations on noise emissions have been carefully specified.

A-7.8.2 Specialty Trucks

Identification: According to the Donaldson Company (A-2.2.2.10), the small manufacturer of special truck equipment will be subjected to unreasonable economic burden. The Construction Machinery Company (A-2.3.2.1) claimed that, if mixer mounters are included in the regulations, the entire sales distribution pattern would be disrupted. The National Solid Waste Management Association (A-2.6.7.2) suggested that the economic impact of the regulations on small companies engaged in solid waste collection be carefully considered. Second-stage manufacturers of solid waste disposal trucks cannot afford the costs of testing, according to the National Solid Waste Management Association (A-2.6.7.3).

Discussion: Compliance with the proposed regulations are largely the responsibility of the chassis manufacturer. The second-stage manufacturers will be required to comply with anti-tampering instructions provided by the chassis manufacturer.

Truck-mounted waste compactors have been identified separately by EPA as major sources of noise. EPA is investigating waste compactors for possible regulatory action. The economic impact on these companies will be included in the EPA investigations.

Action in Response to Public Comment: Since most of the responsibility for compliance rests with the chassis manufacturers, the impact on the second-stage manufacturers is expected to be small.

A-7.9 OTHER ISSUES

A-7.9.1 Impact on Local Areas

Identification: The Koehring Company (A-2.2.4.4) commented that the impact on local areas of closings of truck manufacturing plants, that could be caused by the proposed regulations, should be considered.

Discussion: Total truck sales and employment by truck manufacturers should increase as a result of the regulations (Section 7-2). Therefore, plant closings due to decreases in plant utilization should not occur.

The Koehring Company mentioned that one truck manufacturing plant was closed because of the need to consolidate testing facilities required for the Federal brake regulation. If the required testing for the EPA proposed regulations is performed at an EPA facility, the total annual cost is estimated to range from $7450 for small manufacturers to $59,100 for large manufacturers (Appendix H). These estimates include the production verification and selective enforcement auditing testing costs and transportation costs to the EPA facility. The cost of closing a plant is probably much higher. Therefore, the required testing should not force plant closings.

Action in Response to Public Comment: No further action has been taken.

A-7.9.2 Impact on Postponing Regulatory Levels

Identification: Schwitzer Engineering Components (A-2.2.6.3) claimed that the costs will be enormous if the 75-dBA regulatory level is established and then postponed.

Discussion: Schwitzer Engineering Components is correct in suggesting that there will be added costs involved if a regulatory level below 80 dBA is established and then postponed. Postponing or removing the below 80 dBA regulatory level could impact the ability of truck manufacturers to effectively recover investments in research and development. Disruption of model changes, which must be planned at least 2 years in advance, could be effected by postponing or removing the below 80 dBA regulatory level.

The recent experience of the air-brake standard indicates the problems which can occur due to uncertainty about the timing of a proposed regulation. One company had over 28 production days of finished buses that met the new brake standard in inventory, before the postponement came. There are difficulties in recovering the incremental costs incurred on such inventory until the regulation comes into effect. If companies begin ordering parts and modifying production schedules to meet a regulation, a postponement may be costly. Inventories of parts and finished goods may become large. The lead time for a postponement should be similar to that for any other model change.

Action in Response to Public Comment: The economic impact of any modification to the regulations will be carefully considered by EPA prior to preparing a lower than 80 dBA standard.

Appendix A-8
TEST PROCEDURE

INTRODUCTION

The National Bureau of Standards (NBS), in cooperation with EPA, has examined the submission to the EPA docket and has contributed much to the response material in this section (Appendix A-8).

In this chapter of the docket analysis, only those points having a significant impact on the procedure are shown. Some of the changes offered by NBS are not included in the final regulation due to inadequate supporting data or information. The overall testing procedure does, however, concur with the views of NBS.

A-8.1 Critique of Basic Test Procedure

Identification: International Harvester (A-2.1.6.17) and White Motors (A-2.1.10.10) commented that the test procedure should be improved.

Discussion: The Environmental Protection Agency (EPA) consulted with the National Bureau of Standards regarding the test procedure which was suggested in the proposed regulation. The Bureau of Standards made a series of suggestions for changes which were adopted in the final version of the regulation. These changes are listed below:

Section 205.54-1(b)(1) in the proposed regulation has been replaced by: The test site shall be such that the truck radiates sound into a free field over a reflecting plane. This condition may be considered fulfilled if the test site consists of an open space free of large reflecting surfaces, such as parked vehicles, signboards, buildings or hillsides, located within 30 meters of either the vehicle path or the microphone (Figure 10).

Section 205.54-1(b)(2) in the proposed regulation has been replaced by: The microphone shall be located 15.2 ± 0.3 meters from the centerline of truck travel and 1.2 ± 0.1 meters above the ground plane. The microphone shall be oriented with respect to the source so that the sound strikes the diaphragm at the angle for which the microphone was calibrated to have the flattest frequency response characteristic over the frequency range 100 Hz to 10 kHz.

Section 205.54-1(b)(7) in the proposed regulation has been replaced by: The reference point on the vehicle, to indicate when the vehicle is at any of the points on the vehicle path, shall be the front of the vehicle except as follows. If the engine is located rearward of the center of the chassis, the rear of the vehicle shall be used as the reference point. If the horizontal distance from the reference point of the vehicle to the exhaust outlet is more than 5.1 meters, tests shall be run using both the front and rear of the vehicle as reference points.

Section 205.54-1(b)(8) in the proposed regulation has been replaced by: The plane containing the vehicle path and the microphone location shall be flat within ±0.05 meters.

Section 205.54-1(b)(8) in the proposed regulation has been replaced by: Measurements shall not be made when the road surface is wet, covered with snow, or during precipitation.

Section 205.54-1(b)(9) in the proposed regulation has been replaced by: Bystanders have an appreciable influence on sound level meter readings when they are in the vicinity of the vehicle or microphone; therefore, not more than one person, other than the observer reading the meter, shall be within 15.2 meters of the vehicle path or instrument and the person shall be directly behind the observer reading the meter, on a line through the microphone and observer. To minimize the effect of the observer and the container of the sound level meter electronics on the measurements, a cable sound may be used between the microphone and the sound level meter.

Section 205.54-1(b)(10) in the proposed regulation has been replaced by: The maximum A-weighted fast response sound level observed at the test site immediately before and after the test shall be at least 10 dB below the regulatory level.

Section 205.54-1(b)(11) in the proposed regulation has been replaced by: The road surface within the test site upon which the vehicle travels, and, at a minimum, the measurement area (BCD in Figure 10) shall be smooth concrete or smooth sealed asphalt, free of extraneous material such as gravel.

A-8.2 Need for Stationary or Other Simpler Test

Identification: Mack Trucks (A-2.1.7.11) and White Motors (A-2.1.10.11) suggested that a stationary test be included as a part of the enforcement of the regulations.

Discussion: There is limited correlation between stationary tests and drive-by tests. However, there is insufficient data to enable EPA to promulgate a regulation in which the enforcement method utilizes a stationary test. The noise levels of new trucks tested under these conditions are not nearly as well known as under the low speed, high acceleration test.

A-8.3 Test Site Specifications and Certification

Identification: General Motors (A-2.1.5.35), Mack Trucks (A-2.1.7.12) and White Motors (A-2.1.10.11) commented that the test procedure in the proposed regulations may produce excessive variability in the test data and should therefore include test site correction factors.

Discussion: Test site variability is known to exist to some degree. However, research is needed before correction factors and calibration procedures can be reliably established. Until that time, the test procedure presently in use provides the most reasonable and accurate measurement possible for all sites.

Action in Response to Public Comment: No change to the test methodology was made. EPA clearly understands the problem and intends to work toward development of site correction factors and calibration procedures where possible.

A-8.4 Corrections to Standard Conditions

Identification: General Motors (A-2.1.5.36) and White Motors (A-2.1.10.13) pointed out that the proposed regulations contains no provisions for correcting measured noise levels to standard conditions of temperature, barometric pressure and humidity.

Discussion: This question is discussed briefly by NBS and they concluded that, "at the present time, the data base is such that correction factors for temperature and barometric pressure cannot be defined. Such corrections are needed and research to provide definition of such factors should be given a high priority."

In principle at least, the temperature, barometric pressure, and humidity can influence the measured sound pressure levels in several ways:

- By modifying engine operation (e.g., combustion),
- By affecting sound propagation between the source and the measuring location,
- By affecting the measurement instrumentation.

Action in Response to Public Comments: Standard conditions should be established (e.g., 20° C and 760mm Hg). EPA intends to investigate the problem and work toward development of ways to correct data to these standard conditions.

NBS supplied the following comment on this subject: If calibration devices are utilized which are not independent of ambient pressure (e.g., a pistonphone) corrections must be made for barometric or altimetric changes according to the recommendation of the instrument manufacturer.

A-8.5 Engine Operating Temperature

Identification: White Motors (A-2.1.10.14) suggested that testing take place with the engine coolant at operating temperature.

Discussion: Trucks spend a very small percentage of operating time with engines below or above their "normal" temperature. Thus, the cost and inconvenience of testing at a variety of engine temperatures, in order to find the one at which maximum noise is produced, does not seem worthwhile at this time. However, since measurable differences could occur, the variance in the test procedure may be better controlled if engines are at normal operating temperature during testing.

It may be assumed that truck manufacturers do not conduct tests in such a manner as to result in engine overheating and possible damage. However, tests may be conducted by personnel not under the manufacturer's supervision. In most cases, a 1-minute cooling-off period would not be needed, and if stipulated, would only increase testing time and cost.

Action in Response to Public Comment: NBS suggested that the text below be incorporated into the test procedure and this has been done.

> "The truck shall be brought to its normal operating temperature prior to commencement of testing. During testing, appropriate caution shall be taken to maintain the engine at temperatures within normal operating range."

A-8.6 Operation of Thermostatic Fans and Radiator Shutters

Identification: Freightliner (A-2.1.4.11), General Motors (A-2.1.5.37), International Harvester (A-2.1.6.18), White Motors (A-2.1.10.15), Schwitzer (A-2.2.6.5), Horton (A-2.2.8.1) and Bendix (A-2.2.9.1) suggested that vehicles equipped with thermostatically controlled fan clutches should be tested with fan off.

Discussion: Considerable data exists demonstrating the small amount of time that a thermostatically controlled radiator fan operates at or near maximum rpm (see Appendix I). Their use also causes significant fuel savings to occur.

Statements have been made for allowing noise tests to be made with fans declutched thus enabling manufacturers to use demand-actuated fans in conjunction with marginal cooling systems that would require the fan to operate most of the time. However, at highway speeds additional cooling capacity of the fan is very small compared to the cooling provided by "ram air." Thus, the truck manufacturer must size his cooling system so that the fan is really needed only under conditions of very low road speeds and high engine heat output (e.g., long, slow hill climbs).

Action in Response to Public Comment: The regulation now allows vehicles with fan clutches to be tested with the fan not operating. Thereby, an incentive is provided to use fan clutches, resulting in lower noise output for the majority of the time and a fuel savings.

A-8.7 Deceleration Test

Identification: Chrysler (A-2.1.1.6) and International Harvester (A-2.1.6.19) commented that a deceleration test should be required only on trucks equipped with an engine brake.

Discussion: The comments that deceleration noise levels are below acceleration noise levels for trucks not equipped with engine brakes are supported by discussions held between NBS and others. NBS points out that the deceleration test procedure now specified in J366b was added to the original procedure to address the problem of engine brakes.

Action in Response to Public Comment: The deceleration test is now required only on trucks equipped with engine brakes.

A-8.8 Instrumentation

Identification: International Harvester (A-2.1.6.20) and White Motors (A-2.1.10.16) commented that the instrumentation required for compliance testing should be more precisely specified.

Discussion: The commentors are correct in that the instrumentation required for compliance testing needs to be more precisely specified.

Action in Response to Public Comment: The instrumentation required for compliance testing has been more precisely defined. Sound level meters are required to meet ANSI S1.4-1971 specifications.

A-8.9 Repeat Measurements, Tolerances, and Round-Off

Identification: Chrysler (A-2.1.1.7), Freightliner (A-2.1.3.23), Mack Trucks (A-2.1.7.13) and Schwitzer (A-2.2.6.6) claimed that the round-off procedure and number of tests to be used are not adequately described in the proposed regulations.

Discussion: The regulation now allows an unexplained, and unusually high noise measurement to be deleted, and two other points to be those used for computing the average noise level of one side of the vehicle. The points used must still be within 2 dB of each other, as before. The new provision also limits the maximum number of measurements to 4 on each side of the vehicle, to avoid unnecessary repetition.

With respect to variations in measured levels, much of the data upon which EPA bases the analysis of economic and technical feasibility were subject to product variance and measurement variance of roughly the same magnitude as that which will be in existence after the regulation is in effect. The costs of complying with the regulation are closely tied to these variances and hence to the position taken with regard to tolerances.

Action in Response to Public Comment: The entire question of measurement uncertainty requires further investigation such that adequately precise measurements are made. These are areas where the present information is too limited to make a major change to the proposed regulation at this time.

A-8.10 Meter Response

Identification: B.F. Goodrich (A-2.2.3.2) commented that the "slow" meter response on the sound level meter should be used.

Discussion: The comment refers to the measurement of tire noise and does not apply to low speed, engine-related noise measured in the compliance tests in the proposed regulations.

Action in Response to Public Comment: The "fast" meter response is required on testing. No further action has been taken.

Appendix A-9
CLASSIFICATION

A-9.1 Different Regulatory Levels for Different GVWR Categories

Identification: The State of Delaware (A-2.5.3.5) and the Associated General Contractors of Colorado (A-2.6.2.5) suggested that trucks in different GVWR categories be regulated to different noise levels.

Discussion: Data used in determining the classification system to be used in this regulation shows that there are no reliable differences in noise levels between trucks of different GVWR's.

Action in Response to Public: No change in the classification of trucks was made in the regulations.

A-9.2 Vehicle under 10,000 lbs GVWR

Identification: San Diego County (A-25.18.1) commented all trucks over 6,000 lbs GVWR should be regulated.

Discussion: The lower limit for vehicles covered by this regulation was set at 10,000 lbs because of the natural break occurring between light trucks/automobiles and medium/heavy trucks. Also, this break occurs in industry, in many Department of Transportation safety regulations, and in the Interstate Motor Carrier noise standards, recently promulgated by EPA. The single, over 10,000 lbs classification allows a consistent and more simplified enforcement system, after the new trucks become "in use" trucks.

The proposed regulation allows other governments to set new product standards on trucks *under* 10,000 lbs as well as allows the Federal Government to regulate the noise emissions of new light trucks (less than 6,000 lbs.).

Action in Response to Public Comment: The Preamble to the proposed regulation and the Preamble to the final regulation adequately addresses this issue. No changes to the proposed regulation were made.

A-9.3 Motor Homes

Identification: Chrysler Corporation (A-2.1.1.8) and the Recreation Vehicle Industry Association (A-2.6.8.3) commented that motor homes should be excluded from the regulation.

Discussion: Motor homes are considered to be designed primarily for the purpose of transporting one's property (his living area), not necessarily just persons. They are, therefore, defined under the definition of trucks and are covered by this regulation.

Action in Response to Public Comment: No change was made to the proposed regulation regarding exclusion of motor homes from the regulation.

A-9.4 Special Purpose Equipment

Identification: The Department of Transportation (A-25.4-20) and the State of New York (A-2.5.16.3) commented that special purpose equipment should be covered under the regulation.

Discussion: The document which identified "New Medium and Heavy Duty Trucks" as a major source of noise did not identify the various ancillary equipment carried on the different trucks. Due to the facts that the various ancillary equipment is often not continuously operated along roadways (as are the engine and drive train) and produces substantially different acoustic emissions that may require development of new test techniques, the problems of special equipment noise will be addressed in future regulations.

Action in Response to Public Comment: No change to the proposed regulation was made.

A-9.5 Buses

Identification: The Department of Transportation (A-2.5.4.21) and San Diego County (A-2.5.18.1) commented that buses should be included in the regulations.

Discussion: The Preamble to the proposed regulation adequately answered this comment. It is also discussed in the Preamble to the final regulation. EPA plans to regulate buses separately.

Action in Response to Public Comment: No change to the proposed regulation is necessary.

Appendix A-10
ENFORCEMENT

A-10.1

Several of the commenters questioned EPA authority to make broad inspections and right to inspect and photograph records and information pertaining to a manufacturer's activities under the regulations. The commenters felt that such provisions allowed entry into all areas regardless of whether the facility had anything to do with a manufacturer's noise control program.

The Agency authority for the inspection and monitoring section of the regulation stems from the provisions in section 6 of the Act, which provides that any regulations may contain testing procedures necessary to assure compliance with the noise emission standard; and from the authority of section 13, which provides the Administrator the authority to have access to information maintained by a manufacturer to enable the Administrator to make a determination as to whether a manufacturer is acting or has acted in compliance with the Act. EPA interprets the words "testing procedures" to include actions taken to determine either directly, e.g., by emission tests or by inference, by examining the conformity of the product to the information provided the Agency in the Production Verification reports, whether the product is in conformity with the prescribed emission standards. The regulations have been modified so as to limit the inspections and acquisition of data to that information necessary for the Administrator to make a determination that the manufacturer has been or is distributing conforming products into commerce. The authority of EPA personnel is limited to examining records of tests conducted on production verification products or products tested pursuant to SEA; inspecting areas where testing is conducted, where vehicles are stored prior to testing, and inspecting those portions of the assembly line where the products are being assembled. EPA has no interest in entry into developmental laboratory areas or areas not concerned with a manufacturer's activities under the Noise Control Act of 1972.

A-10.2

Several commenters were concerned with the Administrator's discretion to refuse to grant a hearing in situations in which orders were issued under section 11(d) of the Noise Control Act.

The regulations have been modified so that in situations in which 11(d) orders are issued, notification and opportunity for a hearing are afforded.

A-10.3

Several commenters criticized the attempt by the regulations to limit the right of counsel and recommended that such limitation be stricken from the regulations.

As a result of those comments, portions of the regulations that, in fact, limit the right of counsel have been deleted.

A-10.4

Two commenters objected to the provisions in the proposed regulations requiring an employee of a manufacturer to appear personally before an EPA Enforcement Officer on the grounds that the provisions violated the basic principles of fairness and due process.

This portion of the regulation has been eliminated, since section 16(d) of the Act, which provides that the Administrator may issue subpoenas for the attendance and testimony of witnesses for the purpose of obtaining information to carry out the Noise Control Act, provides the necessary authority to accomplish the Administrator's purpose intended by the proposed regulation.

A-10.5

Several commenters felt that cease-to-distribute orders and recall orders went beyond the statute and should be eliminated.

The Agency has interpreted section 11(d) of the Act, which provides for the issuance of Administrative orders, as inclusive of the power to issue cease-to-distribute orders and recall orders. Any such orders would be preceded by notice and opportunity for a hearing.

A-10.6

Two commenters suggested that the provision requiring a manufacturer to furnish free reasonable assistance to EPA Enforcement Officers is invalid.

The scope and definition of reasonable assistance have been modified from that contained in the proposed regulation. It is not anticipated that a manufacturer will incur any cost in complying with the reasonable assistance requirements of these regulations.

A-10.7

Two commenters suggested that because of the penalties provided for by the Act and the cost associated with establishing and maintaining a test site it was their belief that EPA must make a control site available to all persons affected by the regulations.

EPA is currently planning a noise enforcement test facility to be located in Sandusky, Ohio. The facility will be used to conduct EPA required enforcement tests in addition to conducting manufacturer requested tests. Such tests performed at the request of the manufacturer will be accomplished at a reasonable cost to the manufacturer.

A-10.8

One commenter suggested that the regulations purport to permit the Administrator to superintend the manufacture of vehicles rather than control the distribution of such vehicles into commerce.

EPA does not intend to interfere in the manufacturing process. EPA is interested only in obtaining information as to the conformity of production products with the regulations. The criteria that the vehicles selected for testing be built using normal production processing does not "control" the production process and is included for the purpose of providing assurance to the Administrator that tests are being performed on typical vehicles.

A-10.9

Many commenters requested that the definition of manufacturer be clarified in view of the fact that there are many companies that install ancillary equipment, and it was unclear as to whether these nonchassis/cab manufacturers were also responsible for complying with the individual requirements of the regulation.

The regulations require that the first person who creates the entity that conforms to the definition of vehicle is responsible for production verification and for complying with the labelling requirements. Any person who performs subsequent manufacturing operations on the new products after it has become a vehicle as described within these regulations need not duplicate production verification or labelling operations. However, it is incumbent upon this subsequent manufacturer to assure that his manufacturing operations do not cause the product to exceed the prescribed standards or obscure or remove the required labels. In order that the Administrator may determine the effect on the noise performance of the vehicle, the subsequent manufacturer is subject to the selective enforcement audit of these regulations.

A-10.10

Several commenters described the information recording and reporting requirements as burdensome and costly.

The regulations have been revised so that most of the information required to be submitted is sales literature that describes the product, and the amount of information to be submitted with test reports has been substantially reduced. The regulations have also been revised so that all data may be mailed to EPA as opposed to the proposed telephone reporting requirements. The regulations have also been revised so as to permit execution of reports required to be filed by a manufacturer's authorized company representative in lieu of a corporate vice-president as specified in the proposal. The final regulations also provide that when information has been previously submitted and has remained the same, subsequent reports need only refer to previous submissions.

A-10.11

Several commenters felt the cost of the administrative enforcement provisions would be significant because of the large number of products that would be required to be tested as a result of the production verification and audit test provisions and the need to construct added test facilities to accomplish all the required testing.

EPA has reexamined the cost impact of the administrative enforcement provisions of production verification and selective enforcement auditing and have again found them to be reasonable. As a result of information gathered during the rulemaking process, which included a public hearing and many written submissions to the docket, several modifications were made to the regulations in the area of administrative enforcement provisions. These modifications have made the PV and SEA process more flexible and tailored to an industry with varied production loads and a varied product line. These changes have resulted in reductions in cost to the manufacturer over those that would have been incurred based on the proposed regulations. Significant capital expenditures may be eliminated by those manufacturers who avail themselves of the EPA enforcement test facility at Sandusky, Ohio, in lieu of constructing additional facilities.

A-10.12

Several of the commenters recommended self-certification, as is now used under the Motor Vehicle Safety Act, as a method of assuring compliance with the standards. Several also suggested that if EPA believes that production verification testing is cost-effective, the alternative proposal of testing a preproduction prototype could be adopted.

One manufacturer suggested that self-certification followed by selective enforcement audit would provide the Administrator with an objective and cost-effective means of assuring compliance.

The production verification concept embodied in these regulations is essentially a self-certification approach. However, the compliance testing is required to be performed on production units. The argued advantage of pre-production prototype testing is that it would preclude a delay on the part of the manufacturer at the beginning of sales of a particular configuration due to his inability to test because of inclement weather. These regulations provide for a 45-day period in which conditional verification is granted by the Administrator for a configuration pending completion of the required test.

This change is intended to resolve the concern about delays caused by weather and to preserve the EPA desire that production units be tested to determine compliance.

A-10.13

One commenter suggested that the regulations compelled him to schedule the noisiest configuration in a category for the first production.

Another commenter found that the configuration identified as having the highest sound pressure level within a category most probably would not be the first configuration built and, in fact, might not be built until some time late in the model year or perhaps not built at all in that model year. The commenter suggested that the viable alternative was to allow the manufacturer to production-verify the first configuration built in a category, in addition to the requirement that he production-verify all configurations in a category that were known or estimated to have higher sound pressure levels at the time of their actual production.

This would enable manufacturers to release some vehicles built-in categories that did not have their loudest configuration production-verified, but however did have some configurations verified.

The final regulations permit manufacturers to verify portions of categories based on tests of configurations that are not the highest noise emitters of a particular category.

The regulations provide that a manufacturer may production-verify selected configurations in any order he desires. That is, the manufacturer may, if he desires, select and schedule for production the noisiest configuration, in which case all other configurations within a category would be represented by that configuration, or he could wait until that particular configuration was in fact produced and then test it. Intermediate configurations would be production-verified as they are produced.

A-10.14

One commenter wanted to make clear that mass production does not necessarily mean assembly line production in the heavy trucking industry. Off-line or end of assembly line modification are common.

EPA does not intend to interfere with the industry's normal mode of assembling or manufacturing trucks. It is the intent of EPA simply to test products when they have completed the manufacturer's assembly process regardless of what end of assembly line modifications are required, as long as such procedures are part of the manufacturer's normal mode of operation. It is the intent of EPA to require testing of vehicles that are complete.

A-10.15

Some manufacturers commented that production verification would delay and unnecessarily burden the manufacturer's distribution process since distribution in commerce could not take place until production verification has been completed.

The regulations have been modified so as to permit manufacturers to distribute vehicles into commerce as soon as production begins. However, the requirement still remains that the manufacturer must test certain of his early production models, for the most part the loudest configuration of a category. However, this testing must now take place as soon as weather conditions permit within a 45-day grace period during which conditional production verification is automatically granted.

This 45-day period is designed to accommodate a manufacturer's transportation needs and to provide for poor weather conditions. In addition, the requirement that the manufacturer provide 10-day advance notice of his intention to test has been removed.

A-10.16

Some manufacturers commented that the number of configurations available for sale by them were extremely large and that an effort should be made to minimize the number requiring testing.

One manufacturer suggested that the parameters designating a noise configuration be limited to those that are significant factors in affecting noise levels. The EPA proposed definition of configuration included a great number of unnecessary parameters.

Both the definition of category and configuration have been changed, with the defining parameters significantly reduced. The agency has calculated, based on available information, the total number of categories that would require testing if production verification is carried out in accordance with these regulations and has found that it does in fact require only that a nominal number of products be tested.

A-10.17

Several manufacturers suggested the adoption of Military Standard 414 or some variable tyne sampling plan in lieu of the proposed attributes plan.

An attributes-type sampling plan was proposed because it is independent of the underlying distribution of the data. Variables plans however are dependent on the underlying distribution, and unless the distribution of noise data is normal, the use of a variables plan in any strategy that determines the conformity or nonconformity of a manufacturer's product may not be correct. Several manufacturers provided data to the Agency tending to demonstrate that the distribution of noise data was in fact normal. The Agency has further analyzed such data and has determined that the evidence is not sufficient to warrant the conclusion that noise data is distributed normally. In addition to this analysis, the Agency is proceeding with the development of a variables-type sampling plan that may be proposed for comment in the near future. The sampling plan promulgated in the regulations is independent of the type of distribution that characterizes the data.

One of the chief advantages of a variables plan is that less testing is required to achieve the same information about a sample population. The sampling plan promulgated in the regulations is a modification of the attributes plan proposed several months ago. This plan provides for situations in which production volume is small in addition to significantly reducing the number of products requiring testing. Because of the small number of tests required under the plan promulgated in the regulations, a shift to a variables plan could not be justified on the basis of reducing test burden.

A-10.18

Several commenters interpreted the warranty required by §205.58-1 to be a defects warranty over the life of the vehicle.

The warranty required of the manufacturer is a performance warranty that the vehicle meets the noise emission standards on the date of sale to the ultimate purchaser. Because performance is warranted for the date of sale only, warranty claims must relate back to a nonconformity on that day. To make the best case in relating back to the date of sale, the claimant should be able to point to a defect in design, materials, or workmanship that existed on the sale date and that caused noise emissions to exceed the standard. Thus, although the claim may be made against the manufacturer at any time during the life of the vehicle, such claim must relate back to noncompliance on the date of sale.

One commenter stated that to warrant compliance with noise emission standards, all replacement parts must be supplied by the original manufacturer.

This comment reflects a misunderstanding of the warranty required. Because the warranty covers the noise emission level on the date of sale only, replacement parts needed after a period of use of the vehicle would not normally be at issue under the warranty.

A-10.19

Some commenters asked for a definition of what constitutes tampering and whether the use of aftermarket parts (parts not manufactured or authorized by the original equipment manufacturer) would constitute tampering.

A list of acts that could adversely affect the noise control system of a vehicle and that would constitute tampering, as determined by EPA, will be published in the owner's manual. This will give specific indications of those acts that will be considered tampering by the Agency, unless it can be shown that noise emissions are not adversely affected by the act.

In general, in terms of noise-related aftermarket parts, any nonoriginal equipment aftermarket part (including a rebuilt part) may be installed in or on a vehicle subject to these regulations if the installer has a reasonable basis for knowing that it will not adversely affect noise emissions. For noise-related replacement aftermarket parts, a reasonable basis exists if (a) the installer reasonably believes that the replacement part or rebuilt part is designed to perform the same function with respect to noise control as the replaced part, or (b) the replacement part or rebuilt part is represented in writing by the part manufacturer or rebuilder to perform the same function with respect to noise control as the replaced part.

For noise-related, add-on, auxiliary, augmenting, or secondary parts or systems, a reasonable basis exists if (a) the installer knows of noise emissions tests that show that the part does not cause noise emissions to exceed the time-of-sale standards or to increase, if the noise emissions already exceed the time-of-sale standards; or (b) the part or system manufacturer represents in writing that tests have been performed with similar results (to (a) above); or (c) a Federal, State or local environmental control agency with appropriate jurisdiction expressly represents that a reasonable basis exists.

A-10.20

Some commenters indicated that, in the tampering requirement, submission of information 90 days before introduction of the vehicle into commerce represents an excessively long time period for the manufacturer.

The 90-day requirement in the proposed regulations was established to allow EPA sufficient time to evaluate the tampering data, to prepare a list of the acts that tampering enforcement would focus on, and then to forward this list to the manufacturer for incorporation into the owner's manual. However, to account for the varying production schedules of manufacturers, the final regulation has been changed to allow for a time period based on the need of the manufacturer. The regulation now requires that the manufacturer submit the requested information within an adequate amount of time to provide EPA with 30 days to review the data and to return a tampering list to the manufacturer for printing in the owner's manual. If the Administrator fails to provide the list to the manufacturer within 30 days of the date the information was submitted, the manufacturer is not precluded from distributing the vehicles into commerce. In this case, the list of tampering acts required in the owner's manual shall be omitted until the list is provided and the owner's manual is otherwise reprinted.

A-10.21

Several commenters considered unreasonable and burdensome the requirements for the submission of listings of noise control devices and elements of design (including performance specifications) and acts that might constitute tampering.

The purpose of these requirements in the proposal was to enable the Administrator to determine what acts will constitute tampering. Information submitted by the manufacturer is not to be considered as a final judgment of what constitutes tampering, but will only provide the basic information for determination by the Administrator. The final regulations have been modified so that no separate submission of the list of noise control devices and elements of design is required: this is part of the information required to be provided in the product verification report. The requirement for submission of noise-related performance specifications has been deleted. The generation of the required information by the manufacturer can be performed concurrently with the development of appropriate noise control systems. The testing that will normally be performed in the development of the noise control systems and the manufacturer's engineering experience should provide a substantial basis from which the required information can be generated.

A-10.22

Some commenters stated that the requirement of issuing maintenance instructions imposes a tremendous administrative burden upon the manufacturers.

The purpose of these instructions is to provide the purchaser with clear and simple procedures for the proper maintenance necessary to assure that degradation of noise emission levels is eliminated or minimized during the life of the trucks. In the opinion of the Agency, this requirements is not burdensome, because manufacturers presently provide purchasers with instructions and recommended maintenance schedules necessary to keep the vehicles in good operating condition. These required instructions would merely inform the purchasers of the additional procedures and maintenance necessary to ensure that the noise control system will operate as intended. Generally, the information contained in these instructions will be that information developed in the manufacturer's program to design quieter vehicles and that has been obtained from experience with in-use vehicles. Thus, there is generally no need to obtain significant information not otherwise available.

Appendix A-11
MISCELLANEOUS

A-11.1 Effective Dates

Identification: Ford Motor Company (A-2.1.3.24) commented that for the regulations to have consistent impact on manufacturers, they should be effective on calendar years instead of model years.

Discussion: Ford Motor Company justified their statement by the fact that exhaust emission standards go into effect on a calendar year basis and accurate noise tests can only be run after exhaust emission calibrations have been finalized. Having the two effective dates similar would reduce testing requirements considerably. Also, diesel engine manufacturers work on a calendar-year basis for changes they find necessary regarding exhaust emissions. Finally, since the date of manufacture appears on a vehicle's patent plate, enforcement on a calendar year basis should not be difficult.

The manufacturer still holds the option of when to begin and end his model years. He may begin his model years on January 1 and, by his own choice, be consistent with all other manufacturers.

Action in Response to Public Comment: The regulation still requires model years as the designator of the effective time of the regulation. However, due to delays in this final promulgation, the first standard (83 dBA) becomes effective on July 1, 1977, instead of model year 1977, thereby allowing more time for compliance.

A-11.2 Highway Noise Treatment by States

Identification: The States of Minnesota (A-2.5.14.3) and Virginia (A-2.5.1.2) pointed out that states must rely on highway noise treatments until the regulations on trucks become effective.

Discussion: The proposed regulations were drafted considering the requirements to protect health and welfare by reduction of the source limited by the ability of technology to comply and the costs of compliance within a specific time period. The proposed lead times and sound levels were derived using the above logic. The Noise Act further limits the Agency' regulations to that covering specific products. No authority is granted for other areas such as noise barriers and buffer zones. Granted, the levels will not satisfy all highway noise requirements, but they are the best that can be achieved under the authority of the Noise Act, within the constraints of technology and cost.

Action in Response to Public Comment: No further change to the regulation was made, as the logic used in developing the regulation is stated in detail in the Preamble. Extensive back-up data is presented in the Background Document sections on Technology, Economic Impacts, and Health and Welfare.

A-11.3 Representation of Trucking Industry

Identification: The American Trucking Associations (A-2.3.1.15) asserted that the trucking industry was not adequately represented during the development of the proposed regulations.

Discussion: The public has been invited to comment during the development of this regulation by means of an Advanced Notice of Proposed Rulemaking, Notice of Proposed Rulemaking, and public hearings held in Washington, D.C. and San Francisco. EPA has examined all comments received as a result of these formal actions and those received as other industry and citizen inputs were obtained through less formal meetings. It is believed that adequate opportunity for comment has been given to all parties.

Action in Response to Public Comment: No change was made to the proposed regulation as a result of this issue.

A-11.4 Availability of Equipment and Acoustical Engineers

Identification: Buckeye Equipment Company (A-2.2.11.1) questioned the availability of sufficient amounts of equipment and acoustical engineers, for use in quieting work.

Discussion: There are numerous large acoustical consulting firms presently in existence. Should the market demand require expansion in order to assist truck manufacturers, there will be no severe problem, given the presently proposed lead time.

Action in Response to Public Comment: No change was made to the regulation as a result of this issue.

A-11.5 Labeling

Identification: The State of Illinois (A-2.5.9.3) suggested that a label be attached to regulated trucks which states the noise produced at the time of manufacture, GVWR, and model year.

Discussion: The noise level produced at the time of manufacture is defined only when the measurement methodology is also fully described. For this reason, it is deemed unadvisable to place it on a label which could be misunderstood by local enforcement officers who are unfamiliary with the correct testing procedure.

The GVWR and date of manufacture are obtainable from the vehicle registration documents.

Action in Response to Public Comment: No change was made to the proposed regulation as a result of this issue.

A-11.6 High Speed Standard

Identification: The State of New York (A-2.5.16.4) suggested that the regulations include a high speed noise level standard.

Discussion: The Preamble to the Proposed Regulation, section IIIe, suitably discusses the reasons for not proposing a high speed standard at this time. Those reasons are: (1) tires may be regulated at a later date, thereby aiding high speed noise abatement, and (2) the Agency has already limited, to a degree, high speed noise by use of the Interstate Motor Carrier Regulation; more quieting can be required only after additional cost and economic impact analysis work is performed.

Action in Response to Public Comment: No change to the proposed regulation was made as a result of this issue.

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Appendix B
PREDICTIONS OF TRAFFIC POPULATION MIXES

B-1 Traffic Population Predictions for Trucks

The percentages for different model year trucks in the traffic mix are weighted according to total mileage driven by the trucks of the model year or years of interest. Predictions of the total mileage driven are made using the following equation [4].

$$T_c^k = \sum_{j=n_1}^{n_2} P_{c-j}^k \cdot S_j^k \cdot M_j^k \qquad \text{(B.1)}$$

where

T_c^k = total mileage driven by trucks of type k and model years $(c-n_1)$ to $(c-n_2)$ in calendar year c,

P_m^k = number of trucks of type k produced during model year m;

S_j^k = fraction of trucks of type k surviving j years after production,

M_j^k = annual mileage drivenby truck of type k, j years after production;

n_1 = difference in calendar year c and latest model year of interest; and

n_2 = difference in calendar year c and earliest model year of interest.

Annual production rates by types of trucks (P_m^k) necessary in computing T_c^k are given in Table B-1. The production figures for model years prior to 1973 are reported by the Motor Vehicle Manufacturers Association [1]. The figures for model years 1973 and later were computed by assuming a 1.4 percent production growth rate for medium gasoline trucks -0.3 percent for heavy gasoline trucks, 1.5 percent for medium diesel trucks and 5.0 percent for heavy trucks [2]. Percentages of trucks surviving as a function of age (S_j^k) for all truck types are presented in Table B-2. The data contained in Table B-2 are based on heavy diesel truck data both from MVMA [1] and 1972 Bureau of the Census data [3]. Because there were inconsistencies in the data reported by MVMA and the Bureau of Census for heavy gasoline

Table B-1
Annual Production by Type of Truck (Thousands)

Model Year (m)	P^1_m (Medium Gas)	P^2_m (Medium Diesel)	P^3_m (Heavy Gas)	P^4_m (Heavy Diesel)
1960	1473	1	427	124
1961	177	1	34	24
1962	211	3	30	35
1963	222	4	39	43
1964	205	9	36	47
1965	228	9	41	63
1966	228	6	45	77
1967	189	5	39	64
1968	199	5	42	78
1969	219	3	41	96
1970	178	3	40	88
1971	193	3	38	98
1972	245	3	39	126
1973	198	3	40	133
1974	200	3	40	144
1975	202	3	40	155
1976	204	3	40	165
1977	207	3	39	174
1978	210	3	38	185
1979	213	3	38	195
1980	216	3	39	205
1981	219	3	39	214
1982	222	3	39	225
1983	225	3	39	236
1984	229	3	39	248
1985	232	4	39	260
1986	234	4	38	274
1987	237	4	38	288
1988	241	4	38	302
1989	244	4	37	317
1990	248	4	37	333
1991	251	4	36	350
1992	255	4	35	367
1993	258	4	34	385
1994	262	4	33	404
1995	266	4	32	425
1996	270	4	33	443
1997	274	4	34	462
1998	277	4	36	481
1999	281	4	37	502

and medium trucks, the figures in Table B-2 for heavy diesel trucks have been assumed to apply to all trucks. Data regarding annual mileage driven by trucks (M_j^k), required for computation of T_c^k are given in Table B-3. These data were obtained from 1972 Bureau of the Census data tapes [3].

Table B-2
Percentage of Trucks Surviving as a Function of Age

Age of Truck (j)	S_j^k Precent Surviving (k = 1, 2, 3, and 4)
1	99
2	98
3	96
4	93
5	88
6	81
7	73
8	66
9	58
10	52
11	46
12	41
13	36
14	32
15	29
16	25
17	22
18	19
19	16
20	13
21	10
22	8
23	6
24	4
25	2

Table B-3
Annual Mileage per Truck (Thousands)

Age of Truck (j)	M^1_k (Medium Gas)	M^2_k (Medium Diesel)	M^3_k (Heavy Gas)	M^4_k (Heavy Diesel)
1	23	30	33	73
2	20	27	29	67
3	16	24	25	61
4	13	22	21	55
5	11	19	17	50
6	10	17	16	45
7	9	15	15	40
8	8	13	13	37
9	7	12	12	34
10	7	11	10	31
11	6	10	9	28
12	6	9	8	25
13	5	8	7	22
14	5	7	6	20
15	5	7	6	18
16	4	6	5	16
17	4	5	5	15
18	4	5	4	14
19	4	5	4	13
20	3	5	3	12
21	3	5	3	12
22	3	5	3	11
23	3	5	3	10
24	3	5	3	10
25	3	5	3	10

Using the values of P^k_m in Table B-1, S^k_j in Table B-2, and M^k_j in Table B-3, values of T^k_c were computed for calendar years c = 1977, 1981, 1983, 1985, 1990, and 2000, for medium gasoline trucks (k = 1), medium diesel trucks (k = 2), heavy gasoline trucks (k = 3), and heavy diesel trucks (k = 4) and for values of n_1 and n_2 which apply to the regulatory options given in Table 4-1.

In order to compute the fraction of the total truck population for truck type k in calendar year c which were regulated at level i, the total mileage of the model years of truck type k which were subjected to regulatory level i and surviving to calendar year c is divided by the total mileage for all model years of truck type k which are still operating in calendar year c. This ratio is then multiplied by the percentage of the total traffic mix for truck type k to determine the percentage of truck type k regulated at level i which is present in traffic in calendar year c. The results from these computations are contained in Section B-5, where different traffic mixes for trucks and automobiles are assumed for urban street and freeway traffic.

B-2 Traffic Population Predictions for Automobiles

Automobiles are treated as a single class and assumed to include all light vehicles except motorcycles. The percentage of new automobiles introduced each year is assumed to be 9 percent. New automobile sales are assumed to increase at a rate of 4 percent per year. Thus, the cumulative percentage of new automobiles is assumed to increase by a factor of 0.09 $(1 + 0.04)^n$ each year, where n represents the number of years over which the percentage of new automobiles is accumulated. Using the above assumptions, the percentage of new and old automobiles shown in Table B-4 is generated. For purposes of predicting traffic noise levels, new automobiles are defined as automobiles subject to local noise emission regulations, which are assumed to be effective in 1973 and to remain unchanged. To compute the population of new (regulated) automobiles in a given calendar year, the fraction of new automobiles is multiplied by the percentage of the total traffic mix for automobiles. The results are contained in Section B-5, where different traffic mixes for automobiles are assumed for urban street and freeway traffic.

Table B-4
Percentage of New and Old Automobiles and Motorcycles

Year (n)	Percentage of New Vehicles	Percentage of Old Vehicles
1	9.4	90.6
2	19.1	80.9
3	29.2	70.8
4	39.7	60.3
5	50.6	49.4
6	62.0	38.0
7	73.8	26.2
8	86.1	13.9
9	97.8	2.2
10	100.0	0.0

B-3 Traffic Population Predictions for Motorcycles

Motorcycles are not included in the freeway traffic scenarios. For urban street traffic, new (regulated) motorcycles are assumed to accumulate at the same rate as automobiles. Therefore the percentage of new (regulated) motorcycles in urban street traffic is computed for a given calendar year by multiplying the total traffic mix for motorcycles by the fraction of new motorcycles (Table B-4) for the number of years after the assumed regulations on motorcycles become effective (1975).

B-4 Traffic Population Predictions for Buses

Buses are not included in the freeway traffic scenarios, but are contained in the projections of urban street traffic noise levels. The percentage of the total number of buses of the model years which are subject to local regulations beginning in 1975 is based on the cumulative mileage figures generated for medium trucks (Section B-1). That is, the retirement and production rates, and annual mileages for buses are assumed equal to those for medium trucks. Table B-5 shows the cumulative percentages of noise-treated and untreated buses as a function of the number of years after 1975, the year in which regulations on buses are assumed to have become effective. Data in Table B-5 is multiplied by the traffic mix percentage for buses to obtain population figures for regulated and unregulated buses.

B-5 Predictions of Traffic Mixes

Urban street traffic is assumed to be comprised of 1.0 percent heavy trucks, 6.0 percent medium trucks, 91.5 percent automobiles, 1.0 percent motorcycles, and 0.5 percent buses [5]. For regulatory options in which regulatory levels are set according to engine type, a traffic mix of 6.25 percent gasoline trucks and 0.75 percent diesel trucks is derived by assuming that 100 percent of the medium trucks and 25 percent of the heavy trucks are powered by gasoline engines. Using the mileage ratios for trucks as a function of model year presented in Section B-1 and the percentages of regulated and unregulated automobiles, motorcycles and buses presented in Sections B-2, B-3, and B-4, respectively, mixes for urban street traffic as a function of calendar year are computed both with and without assumed noise emission regulations on automobiles, motorcycles and buses and for the different time periods involved in regulatory options for new trucks given in Table 4-1.

The traffic mixes, which are used in predicting urban street traffic noise levels, are given in Table B-6 for medium trucks, Table B-7 for heavy trucks, Table B-8 for gasoline trucks, Table B-9 for diesel trucks, Table B-10 for automobiles, Table B-11 for motorcycles, and Table B-12 for buses.

Freeway traffic is assumed to contain 10 percent trucks and 90 percent automobiles. Applying the same procedure used for urban street traffic, the traffic mixes, which are used in predicting freeway traffic noise levels, are computed. These mixes are given in Table B-13 for trucks and Table B-14 for automobiles.

Table B-5
Percentage of Noise-Treated and Unteated Buses

Years From First Noise-Treated Model	Percentage of Treated Buses	Percentage of Untreated Buses
1	19.7	80.3
2	36.4	63.6
3	49.4	50.6
4	59.5	40.5
5	67.5	32.5
6	74.1	25.9
7	79.3	20.7
8	83.5	16.5
9	86.7	13.3
10	89.5	10.5
11	91.6	8.4
12	93.4	6.6
13	94.7	5.3
14	95.8	4.2
15	96.8	3.2
16	97.5	2.5
17	98.1	1.9
18	98.6	1.4
19	99.0	1.0
20	99.3	0.7
25	100.0	0.0

The numbers shown in Tables B-6 through B-12 are the predictions of the percentages of the total traffic population comprised of vehicles of the indicated type and model years which exist in the indicated calendar year. For example, in Table B-6, it is predicted that in 1983, 2.2 percent of the total urban street traffic will be medium trucks of 1977-1981 model years.

Table B-6
Urban Street Traffic Mix for Medium Trucks

Model Years	Percentages of Total Traffic in Given Calendar Year Comprised of Trucks of Given Model Years					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
Prior to 1978	6.0	2.6	1.7	1.0	0.3	0.0
1978–1982	–	3.4	2.2	1.4	0.5	0.0
1978–1984	–	3.4	4.3	2.8	0.9	0.0
1978–1986	–	3.4	4.3	5.0	1.6	0.2
1978–2001	–	3.4	4.3	5.0	5.7	6.0
1982–1984	–	–	2.1	1.4	0.4	0.0
1982–1986	–	–	2.1	3.6	1.1	0.1
1982–2001	–	–	2.1	3.6	5.2	6.0
1984–1988	–	–	–	2.2	2.0	0.2
1984–2001	–	–	–	2.2	4.8	6.0
1986–2001	–	–	–	–	4.1	5.9
1988–2001	–	–	–	–	2.4	5.8

Table B-7
Urban Street Traffic Mix for Heavy Trucks

Model Years	Percentages of Total Traffic in Given Calendar Year Comprised of Trucks of Given Model Years					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
Prior to 1978	1.0	0.4	0.2	0.13	0.03	0.0
1978–1982	–	0.6	0.4	0.27	0.07	0.0
1978–1984	–	0.6	0.8	0.52	0.15	0.0
1978–1986	–	0.6	0.8	0.87	0.30	0.02
1978–2001	–	0.6	0.8	0.87	0.97	1.0
1982–1984	–	–	0.4	0.25	0.08	0.0
1982–1986	–	–	0.4	0.60	0.21	0.01
1982–2001	–	–	0.4	0.60	0.90	1.0
1984–1988	–	–	–	0.35	0.33	0.03
1984–2001	–	–	–	0.35	0.82	1.0
1986–2001	–	–	–	–	0.69	0.99
1988–2001	–	–	–	–	0.67	0.97

Table B-8
Urban Street Traffic Mix for Gasoline Trucks

Percentages of Total Traffic in Given Calender Year Comprised of Trucks of Given Model Years

Model Years	Calender Year					
	1978	1982	1984	1986	1991	2001
Prior to 1978	6.25	2.71	1.77	1.09	0.34	0.0
1978 - 1982	–	3.54	2.29	1.51	0.55	0.0
1982 - 1984	–	–	2.19	1.43	0.52	0.0
1984 - 2001	–	–	–	2.22	4.84	6.25

Table B-9
Urban Street Traffic Mix for Diesel Trucks

Percentages of Total Traffic in Given Calendar Year Comprised of Trucks of Given Model Years

Model Years	Calender Year					
	1978	1982	1984	1986	1991	2001
Prior to 1978	0.75	0.30	0.15	0.10	0.02	0.0
1978 - 1982	–	0.45	0.30	0.20	0.06	0.0
1982 - 1984	–	–	0.30	0.19	0.06	0.0
1984 - 2001	–	–	–	0.26	0.61	0.75

Table B-10
Urban Street Traffic Mix for Automobiles

Automobile Category	Percentage of Total Traffic in Given Calendar Year Comprised of Given Category of Automobiles — Calendar Year 1978	1982	1984	1986	1991	2001
Untreated	75	35	13	0	0	0
Treated	18	58	80	93	93	93

Table B-11
Urban Traffic Mix for Motorcycles

Motorcycle Category	Percentage of Total Traffic in Given Calendar Year Comprised of Given Category of Motorcycles — Calendar Year 1978	1982	1984	1986	1991	2001
Untreated	0.81	0.38	0.14	0.0	0.0	0.0
Treated	0.19	0.62	0.86	1.0	1.0	1.0

Table B-12
Urban Street Traffic Mix for Buses

Bus Category	Percentage of Total Traffic in Given Calendar Year Comprised of Given Category of Buses — Calendar Year 1978	1982	1984	1986	1991	2001
Untreated	0.32	0.13	0.08	0.05	0.02	0.0
Treated	0.18	0.37	0.42	0.45	0.48	0.50

Table B-13
Freeway Traffic Mix for Trucks

Model Years	Percentages of Total Traffic in Given Calendar Year Comprised of Trucks of Given Model Years					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
Prior to 1978	10	4.3	2.7	1.6	0.5	0.0
1978–1982	–	5.7	3.7	2.4	0.8	0.0
1978–1984	–	5.7	7.3	4.8	1.5	0.0
1978–1986	–	5.7	7.3	4.8	2.8	0.2
1978–2001	–	5.7	7.3	8.4	9.5	10.0
1982–1984	–	–	3.6	2.4	0.7	0.0
1982–1986	–	–	3.6	6.0	1.9	0.2
1982–2001	–	–	3.6	6.0	8.7	10.0
1984–1988	–	–	–	3.6	3.3	0.3
1984–2001	–	–	–	3.6	8.0	10.0
1986–2001	–	–	–	–	6.8	9.8
1988–2001	–	–	–	–	4.9	9.7

Table B-14
Freeway Traffic Mix for Automobiles

Model Years	Percentage of Total Traffic in Given Calendar Year Comprised of Given Category of Automobiles					
	Calendar Year					
	1978	1982	1984	1986	1991	2001
Untreated	73	56	12	0	0	0
Treated	17	34	78	90	90	90

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[2] KEARNEY, A. T. A study to determine the economic impact of noise emission standards in the medium and heavy duty truck industry (Draft). A. T. Kearney Report (April 1974).

[3] BUREAU OF THE CENSUS. 1972 truck inventory and use summary (Magnetic Tape). U.S. Department of Commerce, Bureau of the Census (1972).

[4] MILLER, D. C. Equations used for truck population models, BBN Memo to Charles T. Molloy, EPA/ONAC (May 23, 1974).

[5] OFFICE OF NOISE ABATEMENT AND CONTROL. Comparison of Alternative Strategies for Identification and Regulation of Major Sources of Noise. Environmental Protection Agency, Washington, D.C. 20460 (February 1975).

Appendix C
THE ELASTICITY OF DEMAND FOR MEDIUM AND HEAVY TRUCKS

In this study, we have assumed the demand elasticity for trucks to be -0.7. This is the same elasticity which A. T. Kearney [1] used in the original economic impact analysis of noise regulations for medium and heavy trucks.

Other studies which have explicitly considered the demand elasticity for heavy trucks have concluded that the demand is inelastic (i.e., elasticity is greater than a minus one). For example, Ueno and Tsurumi [2] estimated the demand elasticity for trucks and buses to be -0.32. This estimate contains (in addition to medium and heavy trucks) buses and light trucks.

The results which were reported by Ueno *et al.* indicate a greater degree of price inelasticity than that used. This implies that the estimate of economic impact is somewhat conservative. Yet another way of approaching the demand elasticity of trucks is via the production function* of the trucking sector and the elasticity of demand for trucking services.

The elasticity of demand ϵ for a factor input is given by the following equation

$$\epsilon = (\alpha - 1)\ \delta + \alpha\ N$$

where

α is the share of total factor payments going to the input whose elasticity is being determined (i.e., the share of capital costs in total cost),

δ is the elasticity of substitution in the production function, and

N is the absolute value of the elasticity of demand for the product (i.e., trucking services).

*Production function is a statement of the relationship between different levels and combinations of productive inputs (called factor inputs, e.g., capital, labor, fuel, raw material, etc.) and the corresponding outputs per time period.

In a recent study by Landenson and Staga [3], a production function with a constant elasticity of substitution equal to one (i.e., $\delta = 1$) was estimated for the U.S. trucking industry. Using two different definitions of capital, α was estimated to be between 0.1 and 0.5.

As pointed out earlier, the elasticity of demand for trucking services N is low. Assuming a value for N of −0.2, then the demand elasticity for trucks will range from a −0.12 to −0.6 depending on the value of α.

The evidence strongly indicates that the elasticity of demand is less than one (i.e., the absolute value), and that, in fact, the estimate of −0.7 is conservative.

SUPPLY ELASTICITY

Assumptions have been made that the industry operates under conditions of constant cost; that is, that the industry supply curve is horizontal. There are, of course, a variety of cost conditions for individual firms that will lead to a constant industry supply price. A constant cost industry does not require that each firm operate under conditions of constant cost. In the Ueno and Tsurumi study [2] the production functions for the auto industry were estimated using production functions which were homogeneous of degree one. This implies a constant cost industry. In another study by Tsurumi [4], the production functions for each auto producer were estimated using a production function which was homogeneous of degree one (i.e., linear). Again, this implies a constant cost industry.

It should be noted that a production function which is homogeneous to degree one gives a constant long run cost only if the firm purchases factor inputs at constant cost. However, in our analysis, we are dealing with a reduction in overall numbers of trucks and a slight increase in dollar sales. Thus, over this rather small range one can comfortably assume that factor costs are constant.

REFERENCES FOR APPENDIX C

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[3] LANDENSON and STAGA. Returns to scale in the U.S. Trucking Industry. The Southern Economic Journal, Volume 40 (January 1974).

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Appendix D
COSTS OF COMPLIANCE IN 1975 DOLLARS

From the wholesale price indices for trucks [1] given in Table D-1, the truck prices (computed from price increases and average truck prices given in Tables 6-7 and 6-4, respectively, in terms of 1973 dollars) can be inflated to 1975 dollars. The truck prices in 1975 dollars are given in Table D-2 for different regulatory levels when fan-off compliance testing is permitted.

Similarly, the changes in the average annual maintenance costs given in 1973 dollars in Table 6-17 with credit for exhaust gas seals can be inflated to 1975 dollars using the commodity price indices in Table D-1. The resulting estimates are given in Table D-3. When credit for savings from exhaust gas seals is not taken, the average annual maintenance costs in Table D-3 are increased by $65 for diesel trucks.

The average fuel costs per gallon are $0.60 for gasoline and $0.45 for diesel fuel in 1975 [2]. The changes in fuel costs given in Tables 6-14 and 6-15 were computed using 1973 fuel costs of $0.50 for gasoline and $0.30 for diesel fuel. With the 1975 fuel costs, the average changes in fuel costs given in Table D-4 are computed for when credit for savings from more efficient fans and fan clutches is taken. Without credit for these fan treatments, the results in Table D-5 are computed.

Table D-1
Price Indexes Used for Adjusting Truck Prices and Other Costs

Commodity Price Index for Transportation, 1967 = 100			
1972	1973	1974	1975 (estimated
119.9	123.9	137.7	147.5
Wholesale Price Index for Trucks, 1967 = 100			
1972	1973	1974	1975 (estimated)
121.1	123.0	136.9	149.0

Table D-2
Average Price of Trucks (1975 Dollars)

Type of Truck	Baseline	83 dBA	80 dBA	78 dBA	75 dBA
Medium gas	$ 7,070	$ 7,112	$ 7,288	$ 7,469	$ 7,875
Heavy gas	14,068	14,219	14,377	14,528	14,934
Medium diesel	8,916	9,432	9,945	10,199	10,883
Heavy diesel	31,021	31,452	31,734	32,063	32,672

Table D-3
Average Changes in Maintenance Costs with Credit for Savings for Exhaust Gas Seals (1975 Dollars)

Type of Truck	83 dBA	80 dBA	78 dBA	75 dBA
Medium gas	$ 11	$23	$108	$117
Heavy gas	23	45	131	162
Medium diesel	(7)	30	232	330
Heavy diesel	(24)	38	101	214

Table D-4
Average Changes in Fuel Costs with Credit for Savings for More Efficient Fans and Fan Clutches (1975 Dollars)

Type of Truck	83 dBA	80 dBA	78 dBA	75 dBA
Medium gas	$(53)	$(94)	$(125)	$(122)
Heavy gas	(307)	(306)	(306)	(301)
Medium diesel	(88)	(182)	(207)	(202)
Heavy diesel	(357)	(350)	(345)	(301)

Table D-5
Average Changes in Fuel Costs Without Credit for Savings
for More Efficient Fans and Fan Clutches (1975 Dollars)

Type of Truck	83 dBA	80 dBA	78 dBA	75 dBA
Medium gas	$0	$ 1	$ 1	$ 4
Heavy gas	1	2	2	7
Medium diesel	3	9	9	15
Heavy diesel	6	15	18	62

REFERENCES FOR APPENDIX D

[1] DEPARTMENT OF LABOR. Commodity and Wholesale Price Indexes, Department of Labor Statistics.

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Appendix E
A COMPUTER MODEL TO DETERMINE ECONOMIC COST OF NOISE REGULATION

Purpose of the Computer Model: A computer model has been developed for calculating the future stream of annual economic costs generated by:

1. The proposed regulation, and

2. The alternative regulatory options which were under consideration at EPA.

Statement of the Problem: Economic costs of a regulatory option are incurred in the year a noise standard takes affect and in subsequent years due to (1) purchases of new equipment and (2) the changes in operating costs of all trucks.

In the computer model the following calculations are made:

(a) *Capital Costs:* Capital costs consist of two parts – the cost of financing increased truck prices and the depreciation cost of the noise control equipment. The finance charges and the depreciation costs occur over the life of a truck. In order to calculate capital costs of a regulation in any given year, these costs must be computed and summed for *all* trucks operating in that year.

(b) *Operating Costs:* Calculations of the operating costs include the following:

 (i) The change in operating costs is composed of the incremental costs for newly purchased trucks in any year and for all trucks purchased earlier (under various noise regulations), that are still in service. The attrition rate increases with age.

 (ii) Like the attrition rate, the number of miles, travelled by a truck in any given year changes with age. In addition, annual mileage varies for each type of truck under consideration. For example, heavy diesel trucks travel greater distances than medium gasoline trucks. Calculation of the operating costs takes into account the changing annual mileage for the four categories of trucks.

(c) *Regulatory Levels and their Timing:* Calculations are performed for each option shown in Table E-1. Note that a regulatory option is a set of noise levels and the effective date. A change in either of the two factors generates a new option.

Table E-1
Sequence of Options

Regulatory Option Code	Effective Date of the Standard				
	1978	1982	1984	1986	1988
A	83	80	75	—	–
B	83	80	–	75	–
C	83	80	78	–	–
D	83	–	78	–	–
E	83	80	–	–	–
F	83	–	80	–	–
G	83	–	–	–	–
H	–	–	–	–	–
I	83	–	80	–	75
J	83	–	–	75	–
K	83	80	75 gas 78 diesel	–	–
L	83	80	75 gas only	–	–
M	83	80	75 medium 78 heavy	–	–
N	83	80	75 medium only	–	–

Description of model: RDP Inc. has developed a computer program to compute the cost of truck regulations in accordance with the model formulated by A. T. Kearney, Inc.* The salient features of this model are reviewed below.

*Certain modifications to the original equations were made by Bolt Beranek and Newman, Inc.

The basis of the model is the following concept: the economic cost of the noise regulations is equal to the number of trucks in each of several categories multiplied by the unit incremental cost (due to the regulations) for each of those categories. Mathematically,

$$A_i = \sum_{j=1}^{i} \sum_{m=1}^{4} P^i_{m,j} C^i_{m,j} \qquad \ldots(1)$$

where

A_i = Annual economic cost of noise regulations in year i,

i = Year under consideration,

j = year truck was built,

m = truck type:

m = 1 → medium gas

2 → heavy gas

3 → medium diesel

4 → heavy diesel

$P^i_{m,j}$ = Number of type m trucks produced in the year j which are in service in the year i, and

$C^i_{m,j}$ = Unit incremental cost due to noise regulation in the year i for truck type m produced in the year j.

There are then two questions to answer:

1. How many trucks are there in each category?

2. What are the costs associated with each category?

Considering question 1 first, we begin with a baseline population for each type of truck in some base year j_n and an expected growth rate for each truck type. We can then calculate a baseline forecast for truck population:

$$F_{m,j} = P_m (1 + G_m)^{j-j_B} \qquad \ldots (2)$$

where

$F_{m,j}$ = Baseline production forecast for type m truck in the year j,

P_m = Production of type m truck in the base year j_B,

G_m = Expected growth rate in production for type m truck, and

$j - j_B$ = Number of years between baseline year and model year j.

Equation (2) gives us the projected truck population in the absence of any noise regulations. It is expected that the regulations will increase truck prices and therefore lessen demand. A demand reduction factor can be calculated as follows:

$$E_{m,j} = N_m \left[\frac{T_{m,j} - T_m}{T_{m,j}} \right] \qquad \ldots (3)$$

where

$E_{m,j}$ = Demand reduction factor reflecting the price elasticity for type m truck produced in year j

$T_{m,j}$ = Price of type m truck produced in year j

T_m = Price of type m truck in the absence of regulations

N_m = Price elasticity factor for truck type m (See Appendix C).

In addition, truck population will be reduced by normal attrition. We therefore introduce an attrition factor

S_{i-j} = Percentage of original production of year j still in service in year i.

We are now in a position to answer the first question; how many trucks are there in each category?

$$P^i_{m,j} = F_{m,j} (1 + E_{m,j}) S_{i-j} \qquad \ldots (4)$$

where

$P^{i}_{m,j}$ = Population of type m trucks produced in year j in service in year i; and all other quantities have previously been defined.

We can now move on to the second question; what are the costs associated with each category? There are four types of costs included in the model: depreciation, capital costs (interest), and operating costs. We now consider the three cost categories in order.

A straight line depreciation model is used. That is, depreciation is taken as

$$D^{i}_{m,j} = \frac{1}{L} \quad (T_{m,j} - T_{m}) \qquad \ldots (5)$$

where

$D^{i}_{m,j}$ = Annual increased unit depreciation chargeable in year i to type m trucks produced in year j.

L = Economic life of truck.

The cost of capital is given by

$$I^{i}_{m,j} = R \ \{T_{m,j} - T_{m}\} \ \{1 - \frac{i-j}{L} \ \}\}$$

where

$I^{i}_{m,j}$ = Annual increased unit cost of capital (interest) chargeable in year i to the type m truck produced in year j

r = Cost of capital rate.

Note that equations (5) and (6) only apply to trucks which are less than L years old. For trucks older than L years, depreciation and cost of capital are zero.

Operating costs are computed as follows:

$$O_{m,j} = F_{m,j} M_{i-j,\, m} + \Delta_{m,j} \qquad \ldots (7)$$

where

$O^i_{m,j}$ = Change in annual operating costs per truck in year i for truck type m produced in year j

$F_{m,j}$ = Change in fuel costs per truck-mile for truck type m produced m year j,

$M_{i\text{-}j,m}$ = Annual mileage for truck type m, i-j years after production

$\Delta_{m,j}$ = Change in annual maintenance costs for truck type m produced in year j

The use of more efficient fans and thermostatically controlled fans as a means of reducing noise actually adds to vehicle horsepower since the power required to drive the fan is reduced. There is some question as to whether the fuel savings associated with more efficient fans and fan clutches should be included in the model. There, calculations were made with and without the costs and fuel savings from more efficient fan and fan clutches. Similarly, a question of whether the savings in maintenance costs associated with exhaust gas seals should be credited to the regulations. Therefore, calculations were made with and without costs and savings from exhaust gas seals.

We can now answer the second question, what are the costs associated with each category of truck?

$$C^i_{m,j} = D^i_{m,j} + I^i_{m,j} + O^i_{m,j} \qquad \ldots (8)$$

where all quantities have previously been defined. Equations (4) and (8) can then be fed into equation (1) to calculate the annual economic cost of the regulations.

Two additional quantities are calculated as well; present value of annual costs, and uniform annualized cost. Present value of annual costs is computed from

$$\sigma = \sum_{i=1}^{N} \frac{A_i}{(1+r)^i} \qquad \ldots (9)$$

where

α = Present value of costs.

N = Number of years for which calculation is done.

Uniform annualized cost may be defined by use of the following computational procedure. Let there be a sequence of annual costs (A_i) i = 1,2 . . ., N, which are not necessarily all equal. The present value of an annual cost is defined as that sum of money which, if it were available at the start of the monetary transaction and if it was invested at an interest rate (r) would just be sufficient to pay the costs (A_i) when it was due. The sum of the present values for all of the costs A_i (i = 1,2 . . . N) is the present value for the transaction. The uniform annualized cost is the annuity of level payment, taken over the same period of time as the original transaction, which has the same present value as the original transaction.

The uniform annualized cost is precisely defined by the following formula

$$\alpha = \frac{r}{1-(1+r)^{-n}} \sum_{i=1}^{i=N} \frac{A_i}{(1+r)^i} \qquad \ldots (10)$$

where

α = Uniform annualized cost,
A_i = Actual cost incurred in the i^{th} year,
r = Cost of capital or annual interest rate. Note: r is a fraction e.g., if the annual in interest rate on a percentage basis is 5 percent then r = 0.05 (/), and
N = Number of years which have elapsed from the start to the end of the entire transaction.

Since uniform annualized cost may not be entirely clear to all readers, an attempt has been made to provide, in addition to the mathematical definition above, some qualitative equivalent definition which are not mathematical. These are given below:

1. Uniform annualized cost is the constant annuity whose present value is the present value of the actual annual costs incurred over the period of time under consideration.

2. Uniform annualized costs are the equal annual annuity payments made on a hypothetical loan borrowed by the user of a product to pay for the additional annual operating, maintenance, and cr ital expenditures incurred over the life

of the product due to the application of noise abatement technology. The principal of this hypothetical loan is equal to the total present value of these initial and future expenditures.

3. The physical changes required to quiet a product generally cause the user of that product to incur three types of expenses; an initial "capital" expenditure on the quieting technology embodied in the product, and continuing additional operating and maintenance expenditures incurred over the entire life of the product. These induced expenditures are likely to change during the life of the product. In particular, the capital expenditures will probably all occur at the beginning of the product's life while annual operating expenditures could increase as the product gets older; so that the annual sum of all three types of expenditures will differ from year to year.

The concept of uniform annualized costs assumes that these expenditures are not made when they actually come due but rather are met by equal annual installments paid over the life of the product. The user of the product is viewed as initially borrowing a sum of money equal to the total present value of all these actual payments. That is, a sum of money which, if invested at some rate of interest, would yield enough money during the life of the product to just meet all of the induced expenses when they actually come due, with nothing left over at the end. The user conceptually pays back this hypothetical loan over the life of the product in equal annual installments. These payments include not only the original principal borrowed but also interest charges on the unpaid balance of the loan. That is, they are annuity payments. These equal annual expenditures are referred to as uniform annualized costs.

The net present value and uniform annualized costs are calculated for 1978, the first year in which a regulation takes effect, for the stream of costs through 1991.

The program outputs are given below.

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION A REGULATION SCHEDULE:

TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
	REGULATION LEVEL			
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	-	1984

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.3726530	0.9046451	0.1987334	0.1739199
1985	0.5526049	1.4572496	0.2981685	0.2544364
1986	0.7303897	2.1876392	0.3979543	0.3324357
1987	0.9043999	3.0920391	0.4971740	0.4072255
1988	1.0711746	4.1632147	0.5953825	0.4757949
1989	1.2317514	5.3949642	0.6913303	0.5404242
1990	1.3848009	6.7797642	0.7840837	0.6007196
1991	1.5298586	8.3096199	0.8732482	0.6566146
1992	1.6645098	9.9741278	0.9598635	0.7046499
1993	1.7936306	11.7677584	1.0434914	0.7501425
1994	1.9042778	13.6720343	1.1254129	0.7788659
1995	2.0147638	15.6867952	1.2058344	0.8089300
1996	2.1259384	17.8127289	1.2855387	0.8404006
1997	2.2381792	20.0509033	1.3648329	0.8733463
1998	2.3520927	22.4029999	1.4442530	0.9078392
1999	2.4685440	24.8715363	1.5245857	0.9439560
2000	2.5872936	27.4588318	1.6055174	0.9817746

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 3.329 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.452 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION A REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	-	1984

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.4662735	-2.5727997	-0.6749578	0.2086841
1985	-0.3849541	-2.9577532	-0.6787404	0.2937866
1986	-0.2973197	-3.2550726	-0.6733806	0.3760614
1987	-0.2064552	-3.4615278	[illegible]	[illegible]
1988	-0.1190234	-3.5805511	-0.6447574	0.5257346
1989	-0.0339372	-3.6144886	-0.6266618	0.5927247
1990	0.0468557	-3.5676327	-0.6085317	0.6553876
1991	0.1210173	-3.4466152	-0.5926425	0.7136609
1992	0.1854286	-3.2611866	-0.5786240	0.7640535
1993	0.2440563	-3.0171299	-0.5678950	0.8119518
1994	0.2836572	-2.7334728	-0.5593167	0.8429736
1995	0.3216739	-2.4117985	-0.5537705	0.8754445
1996	0.3587916	-2.0530071	-0.5506429	0.9094351
1997	0.3954821	-1.6575251	-0.5495368	0.9450199
1998	0.4314281	-1.2260971	-0.5508475	0.9822763
1999	0.4675788	-0.7585182	-0.5537080	1.0212870
2000	0.5030799	-0.2554383	-0.5590577	1.0621386

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -2.264 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.307 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS, FAN CLUTCHES, AND EXHAUST JOINTS

OPTION B REGULATION SHEDULE:

TRUCK TYPE	REGULATION LEVEL			
	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1986
HEAVY GAS	1978	1982	-	1986
MEDIUM DIESEL	1978	1982	-	1986
HEAVY DIESEL	1978	1982	-	1986

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.2433089	0.7753009	0.1279116	0.1153972
1985	0.2947701	1.0700703	0.1559333	0.1388370
1986	0.4838379	1.5539083	0.2599750	0.2233632
1987	0.6701189	2.2240276	0.3640601	0.3060585
1988	0.8509427	3.0749702	0.4681042	0.3828385
1989	1.0281668	4.1031380	0.5714253	0.4567437
1990	1.2014828	5.3046188	0.6739166	0.5275686
1991	1.3687143	6.6733294	0.7742095	0.5945088
1992	1.5241508	8.1974802	0.8714145	0.6527401
1993	1.6728592	9.8703356	0.9653698	0.7074928
1994	1.8163872	11.6867228	1.0568438	0.7595476
1995	1.9542980	13.6410189	1.1453705	0.8089300
1996	2.0728235	15.7138405	1.2324247	0.8404006
1997	2.1915894	17.9054260	1.3182430	0.8733463
1998	2.3112335	20.2166595	1.4033947	0.9078392
1999	2.4321632	22.6488190	1.4882069	0.9439560
2000	2.5552588	25.2040710	1.5734816	0.9817746

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.648 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.359 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION B REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1996
HEAVY GAS	1978	1982	-	1986
MEDIUM DIESEL	1978	1982	-	1986
HEAVY DIESEL	1978	1982	-	1986

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599399	0.1206604
1984	-0.5867161	-2.6932421	-0.7362130	0.1494968
1985	-0.6263728	-3.3196144	-0.8032663	0.1768935
1986	-0.5308416	-3.8504562	-0.7971151	0.2662740
1987	-0.4310814	-4.2815380	-0.7835906	0.3525099
1988	-0.3319429	-4.6134796	-0.7636800	0.4317375
1999	-0.2315748	-4.8450518	-0.7396826	0.5081080
1990	-0.1314394	-4.9764881	-0.7128575	0.5814187
1991	-0.0360892	-5.0125742	-0.6869488	0.6508605
1992	0.0481712	-4.9644003	-0.6633907	0.7115630
1993	0.1258942	-4.8385057	-0.6429299	0.7688253
1994	0.1981559	-4.6403494	-0.6252861	0.8234424
1995	0.2633600	-4.3769894	-0.6120839	0.8754445
1996	0.3074719	-4.0695171	-0.6019627	0.9094351
1997	0.3503360	-3.7191811	-0.5946826	0.9450199
1998	0.3919014	-3.3272800	-0.5903741	0.9822763
1999	0.4322831	-2.8949966	-0.5890035	1.0212870
2000	0.4718804	-2.4231167	-0.5902574	1.0621386

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -2.914 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.396 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS, FAN CLUTCHES, AND EXHAUST JOINTS

OPTION C REGULATION SCHEDULE:

TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
	REGULATION LEVEL			
MEDIUM GAS	1978	1982	1984	-
HEAVY GAS	1978	1982	1984	-
MEDIUM DIESEL	1978	1982	1984	-
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.2946081	0.8266001	0.1601758	0.1344321
1985	0.3974228	1.2240229	0.2209466	0.1764765
1986	0.4989691	1.7229919	0.2819707	0.2169987
1987	0.5982080	2.3211994	0.3425863	0.2556216
1988	0.6920010	3.0132008	0.4024007	0.2896000
1989	0.7824258	3.7956266	0.4606994	0.3217269
1990	0.8691187	4.6647415	0.5171008	0.3520202
1991	0.9516316	5.6163692	0.5711708	0.3804638
1992	1.0267048	6.6430721	0.6235904	0.4031186
1993	1.0994406	7.7425127	0.6741450	0.4252989
1994	1.1659002	8.9084101	0.7235123	0.4423923
1995	1.2321043	10.1405115	0.7718136	0.4602949
1996	1.2985668	11.4390793	0.8195230	0.4790459
1997	1.3654919	12.8045702	0.8668060	0.4986870
1998	1.4331379	14.2377081	0.9138767	0.5192630
1999	1.5020399	15.7397480	0.9612224	0.5408184
2000	1.5720682	17.3118134	1.0086641	0.5634032

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.332 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.317 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION C REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	1984	-
HEAVY GAS	1978	1982	1984	-
MEDIUM DIESEL	1978	1982	1984	-
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5471523	-2.6536779	-0.7166448	0.1694926
1985	-0.5454625	-3.1991405	-0.7618716	0.2164091
1986	-0.5361295	-3.7352705	-0.7976128	0.2614832
1987	-0.5217492	-4.2570190	-0.8260766	0.3043274
1988	-0.5087669	-4.7657852	-0.8496796	0.3409126
1989	-0.4951342	-5.2609186	-0.8707681	0.3756337
1990	-0.4818347	-5.7427511	-0.8903408	0.4085061
1991	-0.4711964	-6.2139473	-0.9107143	0.4395185
1992	-0.4672140	-6.6811571	-0.9319173	0.4647040
1993	-0.4657515	-7.1469049	-0.9551969	0.4894459
1994	-0.4711022	-7.6180067	-0.9800066	0.5089042
1995	-0.4780794	-8.0960836	-1.0073605	0.5292820
1996	-0.4863093	-8.5823889	-1.0369329	0.5506250
1997	-0.4955389	-9.0779276	-1.0685186	0.5729802
1998	-0.5064481	-9.5843735	-1.1028461	0.5963983
1999	-0.5183936	-10.1027632	-1.1393242	0.6209306
2000	-0.5321505	-10.6349115	-1.1787825	0.6466321

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.289 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.446 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION D REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	1984	-
HEAVY GAS	1978	-	1984	-
MEDIUM DIESEL	1978	-	1984	-
HEAVY DIESEL	1978	-	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1020972	0.3070349	0.0538969	0.0482004
1983	0.1216724	0.4287073	0.0647163	0.0569561
1984	0.2288572	0.6575644	0.1262628	0.1025942
1985	0.3349798	0.9925442	0.1881697	0.1468101
1986	0.4402972	1.4328413	0.2505576	0.1897399
1987	0.5439925	1.9768333	0.3129095	0.2310830
1988	0.6431913	2.6200247	0.3750420	0.2681491
1989	0.7395537	3.3595791	0.4360389	0.3035151
1990	0.8318354	4.1914139	0.4950384	0.3367982
1991	0.9195950	5.1110086	0.5516406	0.3679572
1992	1.0038586	6.1148643	0.6064084	0.3974540
1993	1.0842533	7.1991167	0.6589588	0.4252989
1994	1.1525278	8.3516407	0.7101404	0.4423923
1995	1.2203522	9.5719910	0.7600614	0.4602949
1996	1.2882404	10.8602285	0.8091962	0.4790459
1997	1.3562832	12.2165079	0.8575974	0.4986870
1998	1.4250202	13.6415272	0.9057589	0.5192630
1999	1.4949942	15.1365175	0.9541765	0.5408184
2000	1.5659361	16.7024384	1.0025320	0.5634032

GROWTH RATE FOR
  MEDIUM GAS: 0.014
  HEAVY GAS: -0.003
  MEDIUM DIESEL: 0.015
  HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.091 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.284 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION D REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	1984	-
HEAVY GAS	1978	-	1984	-
MEDIUM DIESEL	1978	-	1984	-
HEAVY DIESEL	1978	-	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4956881	-1.5813408	-0.5688847	0.0731967
1983	-0.5698557	-2.1511965	-0.6562667	0.0864112
1984	-0.5912590	-2.7324553	-0.7185845	0.1373253
1985	-0.5828347	-3.3152895	-0.7692702	0.1864359
1986	-0.5746250	-3.8899145	-0.8085675	0.2339427
1987	-0.5590950	-4.4490089	-0.8386306	0.2795354
1988	-0.5433272	-4.9923353	-0.8625679	0.3192404
1989	-0.5263994	-5.5187330	-0.8836336	0.3572341
1990	-0.5098908	-6.0286236	-0.9030182	0.3931269
1991	-0.4955776	-6.5241985	-0.9224601	0.4268830
1992	-0.4836746	-7.0078707	-0.9426578	0.4589839
1993	-0.4756669	-7.4835343	-0.9651126	0.4894459
1994	-0.4801612	-7.9636927	-0.9890655	0.5089042
1995	-0.4863849	-8.4500761	-1.0156660	0.5292820
1996	-0.4935910	-8.9436646	-1.0442152	0.5506250
1997	-0.5022735	-9.4459362	-1.0752535	0.5729802
1998	-0.5126356	-9.9585714	-1.1090336	0.5963983
1999	-0.5237609	-10.4823313	-1.1446915	0.6209306
2000	-0.5368164	-11.0191450	-1.1834498	0.6466321

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.430 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.466 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION E REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	-
HEAVY GAS	1978	1982	-	-
MEDIUM DIESEL	1978	1982	-	-
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.2433089	0.7753009	0.1279116	0.1153972
1985	0.2947701	1.0700703	0.1559333	0.1388370
1986	0.3448734	1.4149437	0.1836981	0.1611752
1987	0.3930255	1.8079700	0.2108389	0.1821865
1988	0.4365045	2.2444744	0.2372500	0.1992546
1989	0.4782615	2.7227354	0.2628415	0.2154202
1990	0.5187704	3.2415056	0.2878694	0.2309011
1991	0.5579194	3.7994251	0.3122117	0.2457076
1992	0.5919301	4.3913536	0.3362588	0.2556716
1993	0.6262379	5.0175915	0.3601295	0.2661085
1994	0.6609346	5.6785259	0.3838935	0.2770411
1995	0.6961797	6.3747025	0.4076851	0.2884946
1996	0.7321656	7.1068668	0.4316718	0.3004938
1997	0.7690842	7.8759480	0.4560179	0.3130662
1998	0.8068659	8.6828108	0.4806262	0.3262395
1999	0.8457096	9.5285206	0.5056655	0.3400437
2000	0.8857689	10.4142885	0.5312583	0.3545103

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 1.661 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.225 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION E REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	-
HEAVY GAS	1978	1982	-	-
MEDIUM DIESEL	1978	1982	-	-
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707539	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5867161	-2.6932421	-0.7362130	0.1494968
1985	-0.6263728	-3.3196144	-0.8032663	0.1768935
1986	-0.6608302	-3.9804449	-0.8637427	0.2029141
1987	-0.6916441	-4.6720858	-0.9189737	0.2273304
1988	-0.7242693	-5.3963528	-0.9705167	0.2462187
1989	-0.7552330	-6.1515856	-1.0195551	0.2643239
1990	-0.7847265	-6.9363089	-1.0665045	0.2817804
1991	-0.8147573	-7.7510653	-1.1133900	0.2986352
1992	-0.8497403	-8.6008053	-1.1604166	0.3106790
1993	-0.8847815	-9.4855862	-1.2080755	0.3232957
1994	-0.9201974	-10.4057808	-1.2567091	0.3365145
1995	-0.9566005	-11.3623810	-1.3069639	0.3503644
1996	-0.9941885	-12.3565664	-1.3590641	0.3648770
1997	-1.0324497	-13.3890123	-1.4125319	0.3800842
1998	-1.0723705	-14.4613819	-1.4683295	0.3960205
1999	-1.1138124	-15.5751953	-1.5265341	0.4127224
2000	-1.1570997	-16.7322845	-1.5873260	0.4302274

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.853 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.523 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION F REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1984	-	-
HEAVY GAS	1978	1984	-	-
MEDIUM DIESEL	1978	1984	-	-
HEAVY DIESEL	1978	1984	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1020972	0.3070349	0.0538969	0.0482004
1983	0.1216724	0.4287073	0.0647163	0.0569561
1984	0.1775580	0.6062653	0.0939986	0.0835593
1985	0.2323272	0.8385925	0.1231565	0.1091706
1986	0.2862016	1.1247940	0.1522850	0.1339164
1987	0.3388101	1.4636040	0.1811619	0.1576480
1988	0.3876951	1.8512993	0.2098913	0.1778037
1989	0.4353892	2.2866879	0.2381811	0.1972083
1990	0.4814858	2.7681742	0.2658071	0.2156789
1991	0.5258828	3.2940569	0.2926819	0.2332009
1992	0.5690833	3.8631401	0.3190766	0.2500070
1993	0.6110517	4.4741917	0.3449430	0.2661085
1994	0.6475627	5.1217527	0.3705215	0.2770411
1995	0.6844273	5.8061781	0.3959326	0.2884946
1996	0.7219391	6.5280161	0.4213452	0.3004938
1997	0.7598755	7.2878895	0.4468091	0.3130662
1998	0.7987484	8.0866337	0.4725087	0.3262395
1999	0.8386639	8.9252939	0.4986196	0.3400437
2000	0.8796367	9.8049307	0.5251264	0.3545103

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 1.420 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.193 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION F REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1984	-	-
HEAVY GAS	1978	1984	-	-
MEDIUM DIESEL	1978	1984	-	-
HEAVY DIESEL	1978	1984	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4956881	-1.5813408	-0.5688847	0.0731967
1983	-0.5698557	-2.1511965	-0.6562667	0.0864112
1984	-0.6208227	-2.7720194	-0.7381527	0.1173295
1985	-0.6637452	-3.4357643	-0.8106652	0.1469204
1986	-0.6993254	-4.1350899	-0.8746990	0.1753735
1987	-0.7289897	-4.8640776	-0.9315279	0.2025384
1988	-0.7588295	-5.6229067	-0.9834048	0.2245765
1989	-0.7864982	-6.4094038	-1.0324211	0.2459241
1990	-0.8127826	-7.2221851	-1.0791917	0.2664016
1991	-0.8391385	-8.0613203	-1.1251364	0.2859996
1992	-0.8662013	-8.9275179	-1.1711569	0.3049589
1993	-0.8946970	-9.8222113	-1.2179909	0.3232957
1994	-0.9292561	-10.7514668	-1.2657681	0.3365145
1995	-0.9649060	-11.7163696	-1.3152695	0.3503644
1996	-1.0014696	-12.7178383	-1.3663464	0.3648770
1997	-1.0391836	-13.7570219	-1.4192667	0.3800842
1998	-1.0785570	-14.8355761	-1.4745770	0.3960205
1999	-1.1191797	-15.9547548	-1.5319014	0.4127224
2000	-1.1617651	-17.1165161	-1.5919914	0.4302274

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.995 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.542 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION G REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	-	-
HEAVY GAS	1978	-	-	-
MEDIUM DIESEL	1978	-	-	-
HEAVY DIESEL	1978	-	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1020972	0.3070349	0.0538969	0.0482004
1983	0.1216724	0.4287073	0.0647163	0.0569561
1984	0.1403770	0.5690841	0.0751972	0.0651798
1985	0.1581289	0.7272128	0.0852742	0.0728546
1986	0.1751424	0.9023552	0.0950445	0.0800979
1987	0.1913186	1.0936737	0.1044112	0.0869072
1988	0.2044106	1.2980843	0.1135652	0.0908453
1989	0.2174853	1.5155687	0.1225093	0.0949758
1990	0.2306491	1.7462187	0.1313410	0.0993081
1991	0.2439251	1.9901428	0.1400728	0.1038523
1992	0.2574225	2.2475653	0.1488035	0.1086189
1993	0.2712509	2.5188169	0.1576321	0.1136190
1994	0.2853463	2.8041630	0.1664822	0.1188641
1995	0.2998190	3.1039820	0.1754524	0.1243665
1996	0.3146929	3.4186745	0.1845537	0.1301389
1997	0.3299912	3.7486658	0.1937964	0.1361948
1998	0.3457428	4.0944090	0.2031947	0.1425482
1999	0.3619714	4.4563780	0.2127576	0.1492140
2000	0.3787963	4.8351717	0.2225891	0.1562076

GROWTH RATE FOR
  MEDIUM GAS: 0.014
  HEAVY GAS: -0.003
  MEDIUM DIESEL: 0.015
  HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 0.938 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.127 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION G REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	-	-
HEAVY GAS	1978	-	-	-
MEDIUM DIESEL	1978	-	-	-
HEAVY DIESEL	1978	-	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4956381	-1.5813409	-0.5688847	0.0731967
1983	-0.5698557	-2.1511965	-0.6562667	0.0864112
1984	-0.6370222	-2.7882185	-0.7358141	0.0987915
1985	-0.6986188	-3.4868374	-0.8089315	0.1103132
1986	-0.7562360	-4.2430735	-0.8773929	0.1211569
1987	-0.8102174	-5.0532875	-0.9415373	0.1313200
1988	-0.8655273	-5.9188119	-1.0027170	0.1370993
1989	-0.9188460	-6.8377552	-1.0619869	0.1431416
1990	-0.9702341	-7.8079872	-1.1197252	0.1494912
1991	-1.0210915	-8.8290749	-1.1772432	0.1561526
1992	-1.0722437	-9.9013176	-1.2353849	0.1631415
1993	-1.1236792	-11.0249939	-1.2941532	0.1704741
1994	-1.1761866	-12.2011805	-1.3543549	0.1781676
1995	-1.2300291	-13.4312096	-1.4162693	0.1862397
1996	-1.2855234	-14.7167311	-1.4802313	0.1947095
1997	-1.3425426	-16.0592651	-1.5461388	0.2035965
1998	-1.4017372	-17.4609985	-1.6146584	0.2129217
1999	-1.4631004	-18.9241028	-1.6858063	0.2227069
2000	-1.5269938	-20.4510956	-1.7599669	0.2329748

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -4.273 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.580 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION I REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1984	-	1988
HEAVY GAS	1978	1984	-	1988
MEDIUM DIESEL	1978	1984	-	1988
HEAVY DIESEL	1978	1984	-	1988

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1020972	0.3070349	0.0538969	0.0482004
1983	0.1216724	0.4287073	0.0647163	0.0569561
1984	0.1775580	0.6062653	0.0939986	0.0835593
1985	0.2323272	0.8385925	0.1231565	0.1091706
1986	0.2862016	1.1247940	0.1522850	0.1339164
1987	0.3388101	1.4636040	0.1811619	0.1576480
1988	0.5371914	2.0007954	0.2921459	0.2450453
1989	0.7335667	2.7343616	0.4034419	0.3301245
1990	0.9275891	3.6619511	0.5148518	0.4127373
1991	1.1179790	4.7799292	0.6256506	0.4923323
1992	1.3044052	6.0843334	0.7357212	0.5686863
1993	1.4846077	7.5689402	0.8436715	0.6409410
1994	1.6522827	9.2212219	0.9483668	0.7039219
1995	1.8128576	11.0340786	1.0496349	0.7632269
1996	1.9680882	13.0021659	1.1483984	0.8196933
1997	2.1174049	15.1195688	1.2440596	0.8733463
1998	2.2460527	17.3656158	1.3382149	0.9078392
1999	2.3750744	19.7406921	1.4311180	0.9439560
2000	2.5052462	22.2459259	1.5234709	0.9817746

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 1.896 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.257 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION I REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1984	-	1988
HEAVY GAS	1978	1984	-	1988
MEDIUM DIESEL	1978	1984	-	1988
HEAVY DIESEL	1978	1984	-	1988

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4956881	-1.5813408	-0.5688847	0.0731967
1983	-0.5698557	-2.1511965	-0.6562667	0.0864112
1984	-0.6208227	-2.7720194	-0.7381527	0.1173295
1985	-0.6637452	-3.4357643	-0.8106652	0.1469204
1986	-0.6993254	-4.1350899	-0.8746990	0.1753735
1987	-0.7289897	-4.8640776	-0.9315279	0.2025384
1988	-0.6183662	-5.4824419	-0.9108602	0.2924956
1989	-0.5049308	-5.9873724	-0.8350870	0.3301574
1990	-0.3888417	-6.3762140	-0.8542190	0.4653793
1991	-0.2732772	-6.6494913	-0.8208849	0.5476096
1992	-0.1602126	-6.8097019	-0.7868403	0.6266294
1993	-0.0530904	-6.8627901	-0.7546613	0.7015723
1994	0.0414217	-6.8213673	-0.7258078	0.7672302
1995	0.1279407	-6.6934242	-0.7013181	0.8292598
1996	0.2081446	-6.4852781	-0.6803666	0.8885123
1997	0.2807603	-6.2045183	-0.6642578	0.9450199
1998	0.3304340	-5.8740816	-0.6518407	0.9822763
1999	0.3783063	-5.4957752	-0.6429903	1.0212970
2000	0.4246635	-5.0711098	-0.6374743	1.0621386

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.543 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.481 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION J REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	-	1986
HEAVY GAS	1978	-	-	1986
MEDIUM DIESEL	1978	-	-	1986
HEAVY DIESEL	1978	-	-	1986

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1020972	0.3070349	0.0538969	0.0482004
1983	0.1216724	0.4287073	0.0647163	0.0569561
1984	0.1403770	0.5690841	0.0751972	0.0651798
1985	0.1581289	0.7272128	0.0852743	0.0728546
1986	0.3542402	1.0814524	0.1917441	0.1624960
1987	0.5485317	1.6299539	0.2987937	0.2437379
1988	0.7388188	2.3688030	0.4066342	0.3321848
1989	0.9267817	3.2955847	0.5145387	0.4122429
1990	1.1115112	4.4070950	0.6221473	0.4893655
1991	1.2903900	5.6974821	0.7279032	0.5624908
1992	1.4610405	7.1585217	0.8302771	0.6307676
1993	1.6230679	8.7815905	0.9289787	0.6940938
1994	1.7782888	10.5598764	1.0248165	0.7534771
1995	1.9260578	12.4859343	1.1171303	0.8089200
1996	2.0479794	14.5339146	1.2075806	0.8404006
1997	2.1696215	16.7035217	1.2962751	0.8733463
1998	2.2919054	18.9954224	1.3840675	0.9078392
1999	2.4151220	21.4105530	1.4711657	0.9439560
2000	2.5403147	23.9508667	1.5585364	0.9817746

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.211 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.300 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS.
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION J REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	-	-	1986
HEAVY GAS	1978	-	-	1986
MEDIUM DIESEL	1978	-	-	1986
HEAVY DIESEL	1978	-	-	1986

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4956881	-1.5813408	-0.5688847	0.0731967
1983	-0.5698557	-2.1511965	-0.6562667	0.0864112
1984	-0.6370222	-2.7882185	-0.7358141	0.0987915
1985	-0.6986188	-3.4868374	-0.8089315	0.1103132
1986	-0.6077017	-4.0945387	-0.8120527	0.2043514
1987	-0.5099968	-4.6045341	-0.8056768	0.2956802
1988	-0.4090490	-5.0135813	-0.7896776	0.3806285
1989	-0.3039892	-5.3175659	-0.7671971	0.4632092
1990	-0.1975132	-5.5150795	-0.7403881	0.5428749
1991	-0.0948073	-5.6098852	-0.7133647	0.6185582
1992	0.0009485	-5.6089354	-0.6884554	0.6894049
1993	0.0892565	-5.5196753	-0.6660621	0.7553195
1994	0.1709363	-5.3487368	-0.6423897	0.8173263
1995	0.2439764	-5.1047583	-0.6314678	0.8754445
1996	0.2900994	-4.8146553	-0.6193346	0.9094351
1997	0.3343803	-4.4802742	-0.6106383	0.9450199
1998	0.3776294	-4.1026449	-0.6046458	0.9822763
1999	0.4194588	-3.6831856	-0.6018280	1.0212870
2000	0.4603837	-3.2228022	-0.6017541	1.0621386

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.170 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.430 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION K REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	1984	-
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409946	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365352	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.3140994	0.8460915	0.1633594	0.1507398
1985	0.4354258	1.2815170	0.2271179	0.2083080
1986	0.5544642	1.8359814	0.2908966	0.2635780
1987	0.6700710	2.5060520	0.3540295	0.3160417
1988	0.7790354	3.2850876	0.4161907	0.3628470
1989	0.8832455	4.1683331	0.4766691	0.4065799
1990	0.9821458	5.1504774	0.5350515	0.4470978
1991	1.0752535	6.2257309	0.5908805	0.4843773
1992	1.1595631	7.3852921	0.6448755	0.5146926
1993	1.2401962	8.6254873	0.6968309	0.5433692
1994	1.3092794	9.9347658	0.7474465	0.5618347
1995	1.3780060	11.3127708	0.7968773	0.5811300
1996	1.4468908	12.7596617	0.8455985	0.6012936
1997	1.5161619	14.2758207	0.8937943	0.6223680
1998	1.5861015	15.8619194	0.9417031	0.6443980
1999	1.6572475	17.5191650	0.9898171	0.6674291
2000	1.7294693	19.2486267	1.0379572	0.6915107

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.560 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.347 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION K REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	1984	-
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721409	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5251973	-2.6317234	-0.7108213	0.1856243
1985	-0.5028592	-3.1345825	-0.7507563	0.2478969
1986	-0.4743145	-3.6088972	-0.7818736	0.3075594
1987	-0.4421808	-4.0510778	-0.8062763	0.3640952
1988	-0.4128745	-4.4639511	-0.8262433	0.4133688
1989	-0.3844516	-4.8484020	-0.8440217	0.4595706
1990	-0.3580843	-5.2064829	-0.8606410	0.5025566
1991	-0.3361372	-5.5426168	-0.8784468	0.5423099
1992	-0.3223214	-5.8649349	-0.8973936	0.5750730
1993	-0.3124264	-6.1773615	-0.9186667	0.6062407
1994	-0.3146603	-6.4920206	-0.9417167	0.6270564
1995	-0.3186637	-6.8106813	-0.9674749	0.6488115
1996	-0.3240921	-7.1347723	-0.9956434	0.6715519
1997	-0.3306250	-7.4653973	-1.0259495	0.6953251
1998	-0.3389074	-7.8043051	-1.0590878	0.7201815
1999	-0.3483195	-8.1526203	-1.0944920	0.7461729
2000	-0.3596063	-8.5122252	-1.1329617	0.7733555

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.039 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.412 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION L REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	-	-
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.2876974	0.8196895	0.1496273	0.1380700
1985	0.3822907	1.2019796	0.1991979	0.1830931
1986	0.4742341	1.6762142	0.2482986	0.2259359
1987	0.5625948	2.2388086	0.2964032	0.2661918
1988	0.6442484	2.8831368	0.3432565	0.3010744
1989	0.7218015	3.6049585	0.3884078	0.3333972
1990	0.7947934	4.3997507	0.4317017	0.3630947
1991	0.8629819	5.2627287	0.4727972	0.3901885
1992	0.9230935	6.1858196	0.5122929	0.4108047
1993	0.9803922	7.1662092	0.5501202	0.4302763
1994	1.0298424	8.1960506	0.5867254	0.4431193
1995	1.0787754	9.2748260	0.6222664	0.4565110
1996	1.1275606	10.4023857	0.6570844	0.4704770
1997	1.1764021	11.5787849	0.6913574	0.4850447
1998	1.2254295	12.8042145	0.7251868	0.5002424
1999	1.2750282	14.0792418	0.7589263	0.5161008
2000	1.3251581	15.4043961	0.7925061	0.5326507

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.205 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.299 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION L REGULATION SCHEDULE:

TRUCK TYPE	REGULATION LEVEL 83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	1984
MEDIUM DIESEL	1978	1982	-	-
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707529	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5538099	-2.6603355	-0.7268277	0.1730150
1985	-0.5603318	-3.2206678	-0.7831401	0.2228083
1986	-0.5609231	-3.7815905	-0.8310287	0.2701061
1987	-0.5579714	-4.3395596	-0.8724664	0.3144947
1988	-0.5577247	-4.8972836	-0.9096494	0.3519255
1989	-0.5577940	-5.4550772	-0.9445475	0.3867535
1990	-0.5589414	-6.0140171	-0.9779151	0.4189739
1991	-0.5634414	-6.5774546	-1.0120316	0.4485908
1992	-0.5752901	-7.1527424	-1.0469933	0.4717038
1993	-0.5901353	-7.7428770	-1.0838461	0.4937116
1994	-0.6133911	-8.3562651	-1.1223221	0.5089321
1995	-0.6385510	-8.9948158	-1.1633635	0.5248135
1996	-0.6654326	-9.6602478	-1.2068186	0.5413872
1997	-0.6937594	-10.3540039	-1.2524433	0.5586846
1998	-0.7243387	-11.0783405	-1.3010798	0.5767421
1999	-0.7567188	-11.8350554	-1.3523140	0.5955960
2000	-0.7915612	-12.6266155	-1.4068451	0.6152842

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.419 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.464 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION M REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	1984	-
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049379	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.3109542	0.8429463	0.1623694	0.1485848
1985	0.4293294	1.2722750	0.2251914	0.2041382
1986	0.5456066	1.8178816	0.2880763	0.2575309
1987	0.6586665	2.4765482	0.3503962	0.3082706
1988	0.7653071	3.2418556	0.4117926	0.3535165
1989	0.8674483	4.1093035	0.4715709	0.3958304
1990	0.9645598	5.0738621	0.5293240	0.4352381
1991	1.0561686	6.1300278	0.5846087	0.4715640
1992	1.1392221	7.2692490	0.6381266	0.5011005
1993	1.2188501	8.4880991	0.6896845	0.5291694
1994	1.2876749	9.7757711	0.7399595	0.5477191
1995	1.3561974	11.1319695	0.7891005	0.5670989
1996	1.4249239	12.5568895	0.8375792	0.5873471
1997	1.4940796	14.0509672	0.8855746	0.6085069
1998	1.5639400	15.6149063	0.9333178	0.6306227
1999	1.6350307	17.2499237	0.9812897	0.6537395
2000	1.7072325	18.9571686	1.0293236	0.6779077

GROWTH RATE FOR
  MEDIUM GAS: 0.014
  HEAVY GAS: -0.003
  MEDIUM DIESEL: 0.015
  HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.584 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.343 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION M REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	1984	-
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	1984	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5287439	-2.6352701	-0.7122322	0.1834885
1985	-0.5097008	-3.1449709	-0.7534653	0.2437643
1986	-0.4842040	-3.6291742	-0.7857702	0.3015654
1987	-0.4548451	-4.0840197	-0.8112383	0.3563932
1988	-0.4280466	-4.5120630	-0.8321679	0.4041213
1989	-0.4018429	-4.9139051	-0.8509088	0.4499661
1990	-0.3773937	-5.2912979	-0.8681958	0.4908019
1991	-0.3570406	-5.6483383	-0.8866498	0.5296094
1992	-0.3445578	-5.9928942	-0.9061576	0.5616007
1993	-0.3357186	-6.3286104	-0.9278840	0.5921659
1994	-0.3382533	-6.6668625	-0.9513175	0.6130644
1995	-0.3424909	-7.0093489	-0.9773929	0.6349025
1996	-0.3480973	-7.3574438	-1.0058231	0.6577267
1997	-0.3547553	-7.7121983	-1.0363398	0.6815836
1998	-0.3631270	-8.0753250	-1.0696507	0.7065247
1999	-0.3725947	-8.4479179	-1.1051950	0.7326006
2000	-0.3839037	-8.8318195	-1.1437712	0.7598681

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.078 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.418 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITHOUT CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION N REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	-
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	0.0204810	0.0204810	0.0104830	0.0099980
1979	0.0409846	0.0614656	0.0211400	0.0198446
1980	0.0615281	0.1229937	0.0319831	0.0295450
1981	0.0819441	0.2049378	0.0429245	0.0390197
1982	0.1365852	0.3415229	0.0712225	0.0653626
1983	0.1904693	0.5319920	0.0996146	0.0908546
1984	0.2815419	0.8135339	0.1464452	0.1350965
1985	0.3702648	1.1837978	0.1929252	0.1773397
1986	0.4566180	1.6404161	0.2390260	0.2175925
1987	0.5397210	2.1801376	0.2842514	0.2554695
1988	0.6165844	2.7967215	0.3283653	0.2882214
1989	0.6895989	3.4863205	0.3709670	0.3186359
1990	0.7586805	4.2450008	0.4119503	0.3467330
1991	0.8235167	5.0685167	0.4510093	0.3725112
1992	0.8807513	5.9492674	0.4887016	0.3920537
1993	0.9356748	6.8849411	0.5249917	0.4106874
1994	0.9839022	7.8688412	0.5602593	0.4236472
1995	1.0318069	8.9006481	0.5946552	0.4371561
1996	1.0797272	9.9803743	0.6284912	0.4512402
1997	1.1278658	11.1082373	0.6619410	0.4659261
1998	1.1763191	12.2845545	0.6950771	0.4812428
1999	1.2254419	13.5099964	0.7282201	0.4972206
2000	1.2752218	14.7852163	0.7613311	0.5138909

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = 2.132 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = 0.289 BILLION DOLLARS

PROGRAM TO COMPUTE COST OF NOISE REGULATIONS

ASSUMING FAN-OFF COMPLIANCE TESTING
WITH CREDIT FOR COST AND SAVINGS FOR MORE EFFICIENT FANS,
FAN CLUTCHES, AND EXHAUST JOINTS

OPTION N REGULATION SCHEDULE:

	REGULATION LEVEL			
TRUCK TYPE	83 DBA	80 DBA	78 DBA	75 DBA
MEDIUM GAS	1978	1982	-	1984
HEAVY GAS	1978	1982	-	-
MEDIUM DIESEL	1978	1982	-	1984
HEAVY DIESEL	1978	1982	-	-

ALL FIGURES IN BILLIONS OF DOLLARS

YEAR	TOTAL	CUM TOT	OP & MNT	CAPITAL
1975	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0
1978	-0.1181672	-0.1181672	-0.1334054	0.0152381
1979	-0.2271118	-0.3452789	-0.2573302	0.0302184
1980	-0.3258045	-0.6710835	-0.3707538	0.0449492
1981	-0.4145692	-1.0856524	-0.4738787	0.0593097
1982	-0.4815935	-1.5672455	-0.5721408	0.0905470
1983	-0.5392798	-2.1065254	-0.6599398	0.1206604
1984	-0.5605813	-2.6671076	-0.7306524	0.1700709
1985	-0.5735050	-3.2406120	-0.7906111	0.2171062
1986	-0.5801346	-3.8207464	-0.8419714	0.2618369
1987	-0.5826062	-4.4033521	-0.8866742	0.3033676
1988	-0.5877478	-4.9912987	-0.9269133	0.3391662
1989	-0.5925020	-5.5837975	-0.9646246	0.3721223
1990	-0.5977705	-6.1815681	-1.0005264	0.4027563
1991	-0.6057827	-6.7873497	-1.0368509	0.4310691
1992	-0.6206402	-7.4079885	-1.0737562	0.4531174
1993	-0.6379538	-8.0459404	-1.1122475	0.4742942
1994	-0.6625136	-8.7084522	-1.1521425	0.4896302
1995	-0.6887631	-9.3972149	-1.1943884	0.5056269
1996	-0.7165550	-10.1137686	-1.2388706	0.5223165
1997	-0.7456172	-10.8593845	-1.2853470	0.5397309
1998	-0.7768002	-11.6361828	-1.3347044	0.5579054
1999	-0.8096752	-12.4458551	-1.3865519	0.5768770
2000	-0.8448834	-13.2907372	-1.4415655	0.5966835

GROWTH RATE FOR
MEDIUM GAS: 0.014
HEAVY GAS: -0.003
MEDIUM DIESEL: 0.015
HEAVY DIESEL: 0.050

COST OF CAPITAL RATE: 0.10

DEPRECIABLE TRUCK LIFE: 10.0 YEARS
STRAIGHT LINE DEPRECIATION USED

PRESENT VALUE OF ANNUAL COSTS (1978 - 1991) = -3.498 BILLION DOLLARS

UNIFORM ANNUALIZED COST (1978 - 1991) = -0.475 BILLION DOLLARS

Appendix F
NET OPERATING INCOME DEFINED

Net Operating Income is computed as in Trinc's Blue Book [1]. Numbers in parentheses indicate the numbers in 1975 edition.

Net Operating Income = Operating Revenues (14) Minus Total Operating Expenses (21).

Total Operating Expenses (21) consist of the following:

- Salaries of Officers and Supervisory Staff (26)
- Salaries and Wages (27)
- Miscellaneous Paid Time Off (30)
- Other Fringe Benefits (31)
- Operating Supplies and Expenses
  Fuel, Oil, Tires, etc. (33)
- General Supplies and Expenses (37)
- Operating Tax and Licenses (38)
- Insurance (41)
- Communications and Utilities (45)
- Depreciation and Amortization (46)
- Revenue Equipment Rents and Purchased Transportation (48)
- Building and Office Equipment Rents (51)
- Gain or Loss on Disposal of Operating Assets (52)

- Miscellaneous Expenses (53)

All items listed above are attributable to the following activities. Trinc's gives this breakdown also.

- Linehaul (54)
- Pickup and Delivery (55)
- Billing and Collecting (56)
- Platform (57)
- Terminal (58)
- Maintenance (59)
- Traffic and Sales (60)
- Insurance and Safety (61)
- General Administrative (62)

REFERENCES FOR APPENDIX F

[1] TRINC TRANSPORTATION CONSULTANTS. TRINC's Blue Book of the Trucking Industry, published annually by TRINC Transportation Consultants, Division of Dun & Bradstreet, Inc.

Appendix G
METHOD FOR COMPUTING IMPACT ON A SPECIFIC SECTOR OF THE TRUCKING INDUSTRY

Table G.1 gives the total annual costs by truck type for all purchasers of trucks. To adjust for the different mixes purchased by various sectors, we compute the following equation for a given year for each type of truck.

$$C_{tj} = \frac{S_j}{B_j} \; M \; C_j \qquad \ldots (G\text{-}1)$$

where

C_{tj} is the total annual costs for truck type j,

S_j is the sector percentage for the particular year in question,

B_j is the baseline percentage for that year,

M is the market share and

C_j is the costs for truck type j.

Example: The For-Hire Sector

The projected truck mix* for the for-hire sector is

Medium Gasoline	Heavy Gasoline	Medium Diesel	Heavy Diesel
32.68%	19.21%	2.36%	45.75%

This is substantially different from the total population given in Table G.2 [1]. Adjustments factors for the for-hire sector are given in Table G.3. The projected market share of trucks purchased by the for-hire sector is 50.6 percent.† The noise-control regulation itself may cause a change in purchase-mix due to the use of thermostatically controlled fans and the resulting savings. Accurate figures of the market share and purchase-mix in the for-hire industry are difficult to obtain.

*These figures assume that new trucks are purchased in the same proportion as those presently owned by a particular sector. The trend toward heavier diesel trucks may change these numbers. The source for present ownership is the 1972 Census of Transportation, Truck Inventory, and Use Survey.

†See Table 7.18 for 1980 Projected Market Share. It is assumed that trucks are purchased in proportion to revenue share.

Table G.1
Total Annual Costs by Truck Type (Millions of 1975 $)

Truck Type	Without Fan Savings			With Fan Savings		
	1981	1991	2000	1981	1991	2000
Option A:						
Medium gas	11.4	350.5	493.0	(66.9)	41.2	106.8
Heavy gas.........	3.9	70.6	88.7	(63.9)	(42.1)	(25.6)
Medium diesel	1.6	15.0	21.2	(.4)	7.8	12.1
Heavy diesel.......	65.1	1093.8	1984.5	(283.4)	114.2	409.7
Option C:						
Medium gas	11.4	249.7	363.2	(66.9)	(68.9)	(35.5)
Heavy gas.........	3.9	47.7	61.0	(63.9)	(67.1)	(55.7)
Medium diesel	1.6	11.2	15.7	(.4)	3.7	6.2
Heavy diesel.......	65.1	643.0	1132.1	(283.4)	(338.9)	(447.1)
Option E:						
Medium gas	11.4	93.6	116.9	(66.9)	(159.4)	(192.4)
Heavy gas.........	3.9	22.4	25.4	(63.9)	(92.9)	(91.9)
Medium diesel	1.6	6.3	7.8	(.4)	(.6)	(.9)
Heavy diesel.......	65.1	435.6	735.7	(283.4)	(561.9)	(871.9)
Option N:						
Medium gas	11.4	350.5	493.0	(66.9)	41.2	106.8
Heavy gas.........	3.9	22.4	25.4	(63.9)	(92.9)	(91.9)
Medium diesel	1.6	15.0	21.2	(.4)	7.8	12.1
Heavy diesel.......	65.1	435.6	735.7	(283.4)	(561.9)	(871.9)

Table G.2
Baseline Sales Projection Resulting Truck Mix

Truck Purchase Mix Used	Percent		
	1983	1985	1990
Medium gasoline	45.40	44.05	40.58
Heavy gasoline	7.85	7.37	6.24
Medium diesel	.69	.67	.62
Heavy diesel...........	46.00	47.92	52.56
	100	100	100

Table G.3
Adjustment Factors for the For-Hire Sector,
Using 1991 Baseline Mix*

Medium gasoline	32.68/40.58:	.8053
Heavy gasoline	19.21/6.24 :	3.0785
Medium diesel	2.36/ .62 :	3.8065
Heavy diesel	45.75/52.56:	.8704

*This is slightly inaccurate as this mix is not adjusted for the elasticity of demand.

Table G.4 shows the total annual costs for the for-hire sector. Any one company will differ from the aggregate. Tables G.5 and G.6 show these costs as a percentage of for-hire revenues and operating income, respectively.

Summary

To assess the impact of the regulation on any group with a different purchase mix, it is necessary only to recompute the costs using equation (G-1). This is also true if we

Table G.4
Total Annual Costs for the For-Hire Sector Adjusted for Truck-Mix and Market Share in 1990 and 2000 (Millions of 1975 $)

	Without Credit for Savings		With Credit for Savings	
	1991	2000	1991	2000
Option A	763.4	1253.9	32.7	207.4
Option C	480.8	771.9	(274.7)	(136.6)
Option E	277.0	426.2	(458.3)	(607.3)
Option N	398.4	605.3	(360.4)	(460.3)

wish to adjust the mix of the total population shown in Table A.21*. In this case the equation would be

$$C_t = \sum_{j=1}^{4} \left(\frac{F_j}{B_j}\right) C_{tj} \qquad \text{... (G-2)}$$

where

C_t is the total costs for all four types of trucks for a given year, and

F_j is the forecast percent of sales for each truck type j.

It is critical to remember that certain sectors will experience a more than average share of savings while others will experience more than average costs. Table G.7 shows the mix by sector of present truck ownership. These percentages can be used to compute a sector's specific costs, assuming that trucks are purchased in the same proportion that they are owned.

*There are some indications that the mix chosen by A. T. Kearney [1] is not representative.

Table G-5
Total Annual Costs as a Percentage of Revenues*
For the For-Hire Sector

	Without Credit for Savings		With Credit for Savings	
	1991	2000	1991	2000
Option A	1.298	1.663	.056	.275
Option C	.818	1.024	(.467)	(.181)
Option E	.471	.565	(.779)	(.805)
Option N	.678	.803	(.613)	(.610)

*Based on Table 7.23

Table G-6
Total Annual Costs as a Percentage of Operating Income*

	Without Credit for Savings		With Credit for Savings	
	1991	2000	1991	2000
Option A	27.33	35.01	1.18	5.79
Option C	17.22	22.56	(9.83	(3.81)
Option E	9.92	11.89	(16.40)	(16.95)
Option N	14.27	16.90	(12.90)	(12.84)

*Assumes Operating Income is 4.75%

Table G-7
Medium and Heavy Truck Mix by Sector

Sector	Medium Gas	Medium Diesel	Heavy Gas	Heavy Diesel	Total Percent
Agriculture	87.59	.41	9.61	2.39	100
Forestry and Lumbering	52.99	.62	24.29	22.09	100
Mining	49.47	1.23	24.07	25.24	100
Construction	11.87	4.52	48.94	34.68	100
Manufacturing	47.82	1.90	20.79	29.49	100
Wholesale and Retail	72.70	.15	16.53	10.62	100
For Hire	32.68	2.36	19.21	45.75	100
Personal Transportation	96.12	0	3.88	0	100
Utilities	79.66	1.91	17.18	2.98	100
Services	87.38	2.24	7.57	2.8	100
All Other	71.85	4.15	13.14	10.87	100

*Source: Based on 1972 Census of Transportation Truck Use and Inventory Vol. II

REFERENCES FOR APPENDIX G

[1] KEARNEY, INC, A. T. A study to determine the economic impact of noise emission standard in the medium and heavy duty truck industry (EPA Contract No. 68-01-154), A. T. Kearney, Inc. (1974).

Appendix H
COST ANALYSIS OF PRODUCTION VERIFICATION AND SELECTIVE ENFORCEMENT AUDITING FOR THE MEDIUM AND HEAVY DUTY TRUCK INDUSTRY

An analysis has been performed to estimate the costs associated with typical manufacturer production verification testing and selective enforcement audit testing.

For the analysis, it was assumed that most of the testing would be done at the manufacturer's facility. However, because some manufacturers may prefer not to construct a test facility, an EPA facility will be available for their use at a fee which will cover actual costs incurred by the government. Data gathered from manufacturers and the assumptions listed in Table H-1 served as the basis for the analysis.

From this analysis, it has been projected that the total cost to the industry for production verification testing during the first year of compliance will range from $64,600, if all testing is done at manufacturer's test facilities, to $99,600 if all testing is done at the EPA test facility. The true figure should lie somewhere between these two values. In subsequent years, this figure can be expected to decrease due to the fact that manufacturers may be able to utilize the initial production verification report for at least several models, when no change has been made in the vehicle for the next model year.

The individual yearly cost figures for production verification testing at the manufacturer's facility range from a high of $12,000 to a low of $4,000 with an average value of $8075. For production verification testing at the EPA test facility, the breakdown by individual companies ranges from $22,600 to $4,700 with an average value of $12,450.

Selective enforcement audit testing will be conducted by the manufacturer both on his own initiative and upon request by EPA. *Costs associated with testing requested by EPA* conducted at the manufacturer's facility are estimated to total $90,000 for the industry as a whole. This breaks down to a range of $24,000 to $2,000, with an industry average of $11,250.

Manufacturers may be expected to utilize the EPA test facility to conduct selective audit testing on their own request, primarily to determine the level of performance of their products at the EPA facility. Costs associated with this testing, including transportation of the test vehicles to the facility, are estimated to total $130,550 for the industry during the

Table H-1
Explanatory Notes

Report Preparation Costs

All report costs are based on $100/test (1 day at $25k per man year)

Transportation Costs

(For two products)

Fixed

$30.00 (Basic cost of short haul)

Variable

16 cents/mile-driver ($8.00/hr or $16.00/100 miles)

20 cents/mile-truck (12 cents/mi. for fuel, 8 cents/miles maintenance + depreciation)

36 cents/mile = total variable cost

Summary

$30.00 + $.36/miles (transport 2 products)

$15.00 + $.18/miles (transport 1 product)

Cost of Testing

The cost of conducting the measurement methodology is estimated to be approximately $100.

Test Requests

The number of test requests issued to the medium and heavy truck industry each year is estimated at 45.

first year of compliance. The breakdown within the industry ranges from a high of $36,319, to a low of $2,750, with an value of $16,319. These costs can be expected to decrease somewhat following the first year the regulations are effective, as manufacturers become more familiar with the compliance scheme, the production variance of their products, and the correlation of results at their facility with those at the EPA facility.

Finally, based on EPA requesting that SEA of products be conducted at the EPA test facility, the industry total is estimated at $40,550 per year for such testing (cost of transportation only, since EPA would conduct the test at its own expense). Individual manufacturer costs range from a high of $14,500 to a low of $750 with an average of $5,069.

Table H-2 summarizes the estimates.

Table H-2
Production Verification

	Manufacturer Facility	EPA Facility*
Total	$64,600	$99,600
Average	8,075	12,450
High	12,000	22,600
Low	4,000	4,700

Selective Enforcement Auditing

	Manufacturer Facility	EPA Facility*	EPA Facility**
Total	$90,000	$130,550	$40,550
Average	11,250	16,319	5,069
High	24,000	36,500	14,500
Low	2,000	2,750	750

*Manufacturers request.

**EPA's request.

Appendix I
SUMMARY OF FAN CLUTCH FIELD TESTS
(Excerpt for Docket Submission T104, Attachment B, Docket No. ONAC 74-2, U.S. Department of Transportation)

The enclosed results summarize the fan clutch data accumulated through September 1974. Separate results are given for the on-off type clutches and the modulating type since the data obtained from these units are in a different format.

For the on-off units, the annual average total fan-on time is less than 3 percent. For both types of clutches, the annual average significant fan-on time (from a noise point of view) is low 1 percent. These results are based on more than 30,000 hours of engine operation representing nearly 1,100,000 vehicle miles on 24 trucks.

This summary supersedes the earlier projections since many of the units have now been in service for at least twelve months.

Data Acquisition

Clutches and data acquisition equipment were installed in 24 vehicles. Sixteen of these units were of the on-off type, while the other eight were modulated drives. The fleets and their operation are described in Table I-1.

For the on-off clutches, hour meters recorded the engine operating time as well as the operating time of the fan. This data was used directly to obtain the "total" fan-on percent. However, the fan is not a significant noise contributor all that time since many of the clutch engagements occur at a low engine rpm. To determine the "significant" fan-on time (from a noise point of view) a multi-channel tachograph recording is used. One channel displays the engine rpm while an event marker indicates the clutch engagements. All clutch engagements above 1600 engine rpm were considered significant while those below 1600 rpm were not. This engine rpm was selected as the cut-off since the fan noise would be approximately 10 dB below its maximum level at this speed.

For the modulating type fan clutch, a strip chart recording was made which contained engine rpm, fan rpm, coolant temperature and ambient temperature as a function of time. This recording was used to obtain the "significant fan-on time" (defined as the time the fan speed exceeded two-thirds of its maximum possible speed) as well as the total engine time.

Table I-1
Fan Clutch Installations
DOT Fan Clutch Program

Unit	Type	No. Installed	Truck/Engine	Fleet	Location	Operation
Horton	On-Off	3	F-4370/NTC290/335	Farmland Industries	Omaha, Nebraska	Tanker, Grain
Horton	On-Off	2	COF4070A/8V71N55	Ryder Truck Lines	Jacksonville, Florida	Van, High Cube
Schwitzer	On-Off	4	F4370/NTC350	Capitol-Rent-A Truck/Hinky Dinky	Omaha, Nebraska	Van, High Cube Groceries
Schwitzer	On-Off	4	CO4070A/8V71&T	O N C	Los Angeles, California	Doubles, Common Carrier
Rockford	Modulated	1	F5070/Super250/270	Bairstow Inc.	Hammond, Indiana	Dump Trailer Urban Area
Rockford	Modulated	4	COF4070A/8V71N65	Leaseway Inc./ Cotter & Co.	Chicago, Illinois	Van, High Cube Hardware
Rockford	Modulated	2	COF4070A/Super 250	Arrow Motor Transit	Chicago, Illinois	Van, High Cube Vehicle Parts
Rockford	Modulated	1	COF4070A/8V71N65	Clinton Electronics	Rockford, Illinois	Van, High Cube

Data was reported at one week periods, which were grouped into 2 or 3 month intervals for ease of analysis. Instrumentation problems prohibited all of the data from being included in the analysis. Generally, data from 8 to 10 of the on-off units and 5 to 8 of the modulated drives were used to establish the average time in each interval.

Results

The resulting fan clutch operating time is shown in Figure I-1 and I-2. The annual average total fan-on time for the on-off clutch is slightly under 3 percent. There is a trend toward increased total fan-on time during the warmer months. Significant fan time is below 1 percent and does not appear to change with the season of the year.

The modulated fan drive shows no significant fan time during the greater part of the year. Even during the warmer months, the significant fan time is below 1 percent. The range of fan-on time for each of the individual fleets is listed below.

Farmland Industries with Horton On-Off Clutches

Based on a 11-to 12-month operating period, the annual average total fan-on time ranged from 4 to 9 percent for three trucks. For the majority of the one week reporting periods, the total fan-on time occurred between 0 and 20 percent. The maximum it reached for any one truck was 41 percent during mid-July. Most of the fan engagements occurred at low engine speeds so that significant fan-on ranged between 0 and 5 percent for even the most severe periods.

Ryder Truck Lines with Horton On-Off Clutches

Based on a 12-month operating period with two trucks, the annual average total fan-on time was 2 percent and 7 percent for each truck, respectively. The range for the individual weekly reporting periods was from 0 to 17 percent with the peak period distributed randomly throughout the year. Significant fan-on time ranged from 0 to 10 percent.

Capitol Rent-a-Truck with Schwitzer On-Off Clutches

Data for 12 months indicates that the annual average total fan-on time was 1 or 2 percent for the four trucks. The total fan-on time for the weekly reporting periods range from 0 to 6 percent with the maximum generally occurring in mid-July. Significant fan-on time ranged between 0 and 1-1/2 percent.

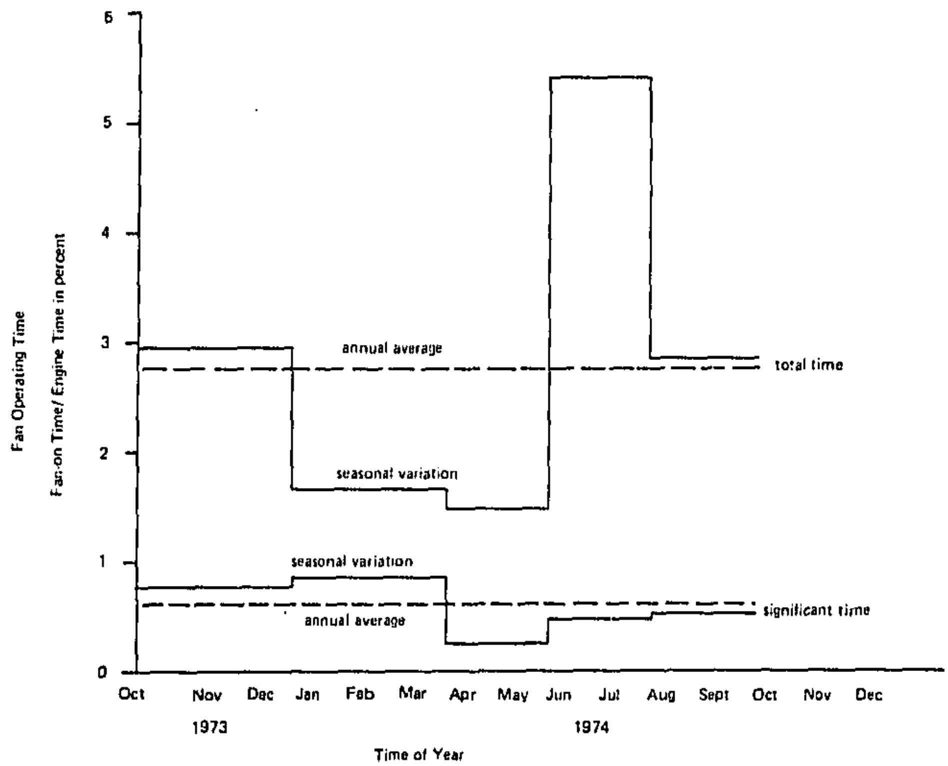

Figure I-1. Operating Time for On-Off Fan Clutch

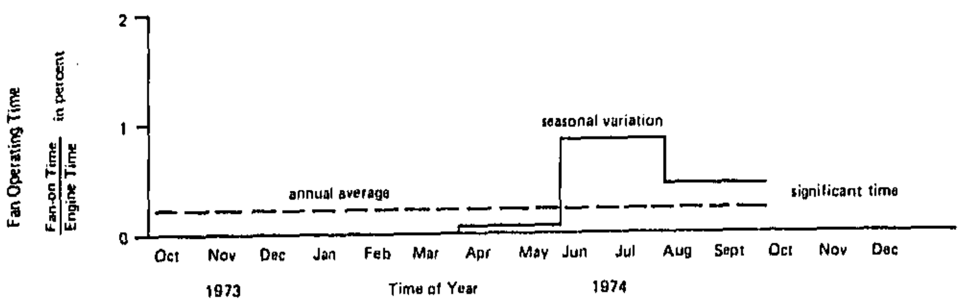

Figure I-2. Operating Time for Modulated Fan Clutch

ONC with Schwitzer On-Off Clutches

The data received from the four trucks in this fleet was somewhat inconsistant due to instrumentation problems. The total fan-on time for weekly reporting periods ranged between 0 and 8 percent with the peak periods distributed throughout the year. Significant fan-on time ranged from 0 to 6 percent.

Bairstow Inc. with Rockford Modulating Clutch

After 12 months of operation on the truck, the highest fan speed achieved was 900 rpm. Since this was well below the cut off speed of 1300 rpm, this unit had 0 percent significant fan-on time.

Leaseway, Inc. with Rockford Modulating Clutches

In the 7 month period from March through September, 1974, the fan speed exceeded 1600 rpm for about 1-1/3 hours out of a total of 4025 engine hours for the four trucks (0.03 percent significant fan time). For the individual, one week reporting periods, the significant fan-on time was near zero except on one truck during the week of August 31 to September 7 where it reached 5 percent.

Arrow Motor Transit with Rockford Modulating Clutches

Two trucks in this fleet were equipped with Rockford clutches. In the 8-month period from February through September, 1974, the fan speed on one truck exceed 1300 rpm for 9-1/2 hours out of a total of 1608 engine hours (0.6 percent significant fan-on time). For the individual, one-week reporting periods, the significant fan-on time was near zero except for the two week period from July 6 through July 20 where it reached 8 percent.

The second truck, which was identical to the first one, showed significant fan-on times as high as 41 percent during the periods from mid-June until mid-September. This unusually high operating time has not been explained; however, it undoubtedly indicates a defective cooling system. This truck has not been included in the summary.

Clinton Electronics with Rockford Modulating Clutch

In the 4-month period from June through September 1974, this one truck has accumulated 9 hours of significant fan-on time (above 1600 rpm) out of 448 engine hours (2 percent significant fan-on time). During the individual, one week reporting periods, the significant fan-on was normally near 0 percent except for the period from June 29 through July 10, where it reached 8 percent.

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