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# REVISED ANALYSIS OF THE BENEFITS AND COSTS OF THE 80 dB NOISE EMISSION REGULATION FOR MEDIUM AND HEAVY TRUCKS

Environmental Protection Agency
Office of Noise Abatement and Control
Standards and Regulations Division
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## Introduction

The Agency has committed to review the medium and heavy truck noise emission regulation. This commitment was developed in the context of Secretary Lewis' Task Force on the automotive industry earlier this year.

This report presents the results of an updated analysis of the benefits and costs of the 80 dB noise emission regulation for medium and heavy trucks which was originally promulgated in April 1976 (41 FR 15538 - see attached Appendix). The 80 dB regulation is scheduled to become effective January 1, 1983.

In updating the analysis, the Agency relied largely on data supplied by the truck industry. Other cost data were derived from the Agency's first-hand experience in quieting and operating trucks in its Quiet Truck Demonstration Program. We developed improved estimates of the health and welfare benefits of the 80 dB regulation by performing computations using the Agency's surface transportation noise computer program which models the Nation's roadway system and population. The relative economic impact of the 80 dB regulation was determined in terms of uniform annualized cost which represents the equal annual (annuity) payments made on a hypothetical loan borrowed by truck users to pay for the anticipated additional capital expenditures and operating costs resulting from compliance with the 80 dB regulation.

## Background

During consideration of the Noise Control Act of 1972, the truck industry lobbied Congress very heavily to obtain relief from an increasing proliferation of differing noise emission standards by States and local governments. These local regulations affected both manufacturers of new trucks and users of these trucks.

The intent and ultimate effect of regulations promulgated by the Agency under Section 17 of the Noise Control Act was to provide preemption of State and local noise limits for trucks engaged in interstate commerce and afford interstate motor carriers uniformity of treatment on a nationwide scale while giving some protection to citizens from the noise of these vehicles. However, the establishment of not-to-exceed noise emission levels for in-use trucks engaged in interstate commerce was necessarily restricted because of the age range of the trucks (from new to approximately 25 years) which are typically used in interstate transport. Therefore, this "in-use" regulation (Section 17) served primarily as a cap on their maximum noise emissions by basically eliminating the use of pocket retread tires which were a major source of truck noise, and ensured that trucks did not operate on the Nation's highways with defective exhaust systems. EPA studies showed that further reductions for interstate motor carriers would require costly noise abatement retrofits to in-use vehicles, even though many of these vehicles had limited remaining useful lives.

It was evident from EPA's studies that the most cost-effective way to provide the Nation's population with the protection they desired and sought through State and local ordinances, and yet avoid unreasonable cost burdens on the Nation's interstate motor carriers and consumers, was to insure that noise abatement features were designed into trucks rather than added on at some later date. Congress had recognized the need for such an approach to noise abatement in their writing of Section 6 of the Noise Control Act. Section 6 directs the Administrator of EPA to issue not-to-exceed noise emission regulations for newly-manufactured products entering commerce; surface transportation vehicles are specifically identified. Thus, in promulgating emission limits for newly-manufactured medium and heavy trucks, the Agency intended to provide protection to the Nation's population from the single most pervasive noise source that could jeopardize their health and welfare while at the same time affording the trucking industry (manufacturers and users) the protection of uniform regulatory treatment across State lines.

Section 6 of the Noise Control Act directs the Administrator to set emission standards protective of public health and welfare based on best available technology, giving consideration to costs. The Agency determined that the most cost-effective reductions in the noise emissions of newly-manufactured trucks would be achieved through incremental reductions commensurate with most truck manufacturers' four year design cycle. Although noise abatement technology was available in 1975 to produce a 75 decibel truck, the Administrator elected to defer the establishment of this stringent level until the Agency could assess the attendant costs with a higher level of confidence based on the industry's experience in reducing the noise level of trucks to the less stringent intermediate levels. Consequently, the Administrator established the first level of noise reduction at 83 decibels, to be effective January 1, 1978. This level was approximately 2 dB below the average noise level of the truck fleet in existence in 1974. Essentially, the 83 dB regulation did little more than induce all manufacturers to install moderately improved mufflers.

The second level of stringency was set at 80 decibels to become effective January 1, 1982. The 3 dB reduction in emission levels from 83 dB to 80 dB is equivalent to reducing truck traffic by 50 percent. The industry was generally supportive of the regulation since it was less stringent than noise emission levels being imposed by many State and local governments. The Agency indicated in the regulation that a more stringent level (such as 75 dB) would be promulgated in time for the 1985 model trucks based on a reassessment by the Agency of available technology and attendant costs.

The promulgation of the Interstate Motor Carrier Noise Emission Regulation (40 CFR 202, Subparts A & B) has preempted State and local governments from enforcing in-use noise emission levels on interstate motor carriers that are different from the Federal levels. Similarly, the Federal noise emission regulation for newly-manufactured medium and heavy trucks (40 CFR 205, Subparts A & B) preempts all State and local regulations that are not identical to the Federal rule.

In the summer of 1980, former President Carter invited the automotive and truck industry to identify those Federal regulations which they believed would have an adverse economic effect on their industries. The 80 dB noise emission regulation for medium and heavy trucks, which was to become effective January 1, 1982, was identified by several truck manufacturers as being potentially burdensome. Truck manufacturers were already complying with the 83 dB limit which had become effective in 1978. By November 1980 the Agency had received three requests to defer the effective date of the 80 dB regulation by two to three years. The Agency also received two formal petitions requesting that the 80 dB regulation be rescinded. Such action would permit the noise level of the Nation's working truck fleet to remain essentially at the 83 dB level, not far below the pre-regulation level of 1974. After careful review of the data submitted by the manufacturers in support of their requests, former Administrator Costle determined that:

- The costs attendant to the 80 dB regulation were commensurate with the anticipated benefits to public health and welfare.
- The industry had not made an adequate case for rescission of the regulation.
- Economic forecasts and market projections based on truck industry statistics did not dictate a need for extensive delays in the effective date of the 80 dB regulation.

However, in light of the depressed economic condition of the automotive industry as a whole and the reduction in truck sales during the 1979-1980 time frame, a decision was made to defer the effective date of the 80 dB regulation by one year until January 1, 1983. In light of economic forecasts that predicted a significant gain in truck sales in 1983, it was believed that this additional year would provide time to the industry to recover and ease possible cash-flow problems that several manufacturers might encounter in gearing up in 1981 to meet the January 1, 1982 effective date.

The one-year deferral was accompanied by a 90-day public comment period which closed on April 24. On March 19, in conformity with commitments made to Secretary Lewis' Task Force, a second notice was published in the Federal Register that expanded the solicitation for comments to the deferral notice to include comments concerning the possible rescission of the 80 dB regulation.

The comments received in response to the most recent Federal Register solicitation break neatly into two opposing groups:

(1) Manufacturers generally contend that the 80 dB regulation should be rescinded on the basis that the regulation is not cost-effective. However, the majority of manufacturers support the existing 83 dB truck noise emission regulation because of the preemption that the Federal regulation provides over 10 State and local jurisdictions which, prior to issuance of the Federal rule, had differing noise emission standards for trucks.

(2) State and local governments strongly supported the 80 dB regulation and, in some cases, recommended even more stringent regulatory levels. Two States recommended that in the event of rescission of the 80 dB regulation, the entire Federal truck noise regulation should be rescinded, thereby returning to the States the authority to set their own noise standards for trucks.

Agency Analysis

Prior to the promulgation of the Federal medium and heavy truck noise emission regulation in January 1976, the Agency carried out, over a period of two years, an extensive analytical prediction of the Nation's population that is adversely affected by medium and heavy truck noise. Investigations and analyses were also completed on the levels of technology attendant to noise reductions that are requisite to the protection of public health and welfare, the costs associated with various levels of reduction and the potential economic effects on the industry and the general public.

In response to initial industry requests for deferral and rescission of the 80 dB regulation, the Agency's 1974-75 analyses were updated in December of 1980. After Mr. Costle's decision to defer the effective date of the regulation by one year, further updates of the anticipated costs and potential economic effects of the 80 dB regulation were carried out incorporating new information from industry and from the Agency's on-going Quiet Heavy Truck Demonstration Program. The details of these updated analyses and the assessment of the cost-effectiveness of the 80 dB regulation are presented in the following sections.

Health and Welfare Benefits from the 80 dB Truck Regulation

Through the use of an extensive computer model* that permits assessment of traffic noise impacts by considering the Nation's roadway system and attendant population distribution, the Agency estimates that in the absence of any regulations or controls, in excess of 95 million persons would currently be exposed to levels of noise from traffic that can jeopardize their health and welfare, and that by the year 2000, in excess of 157 million would be so exposed.

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* This model was developed with assistance from the Department of Transportation and the Federal Highway Administration.

In order to quantitatively assess the potentially adverse impact of truck noise and the effectiveness of possible noise emission regulations, the Agency employs the Level-Weighted Population (LWP) descriptor as a measure of noise impacts. LWP expresses in a single number both the extent and severity of noise impact. The extent of impact refers to the number of people who are adversely affected, while the severity represents the degree to which each person is affected. Therefore, LWP provides a simple method to compare benefits of different noise reduction options. This method is recommended by the National Academy of Sciences for use in noise impact assessments [1].

In 1973, pursuant to a directive from Congress [2] and based on a large body of evidence, the Agency determined [3] that a day-night sound level ($L_{dn}$) value of 55 dB represents the lower threshold of noise that can jeopardize the health and welfare of people. Above this level, noise may be a cause of adverse physiological and psychological effects. These effects also often result in personal annoyance and community reaction. Above an $L_{dn}$ value of 75 dB, noise can cause hearing loss. Although studies indicate a link between noise and cardiovascular disease, research has not yet reached the point where we can determine a quantitative dose-response relationship, i.e., what cardiovascular effects occur at what levels of noise. Consequently, these effects are not considered in this analysis.

Computation of the LWP is based on combining the number of people exposed to noise levels above $L_{dn}$ of 55 dB with the degree of impact at different noise levels. For day-night sound levels below 55 dB, it is assumed that no adverse impact occurs. "Full" impact is assumed to occur at a 75 dB day-night sound level. Figure 1 is a pictorial representation of the LWP principle. The circle represents a source which emits noise to a populated area represented by the figures. The partial shading represents degrees of

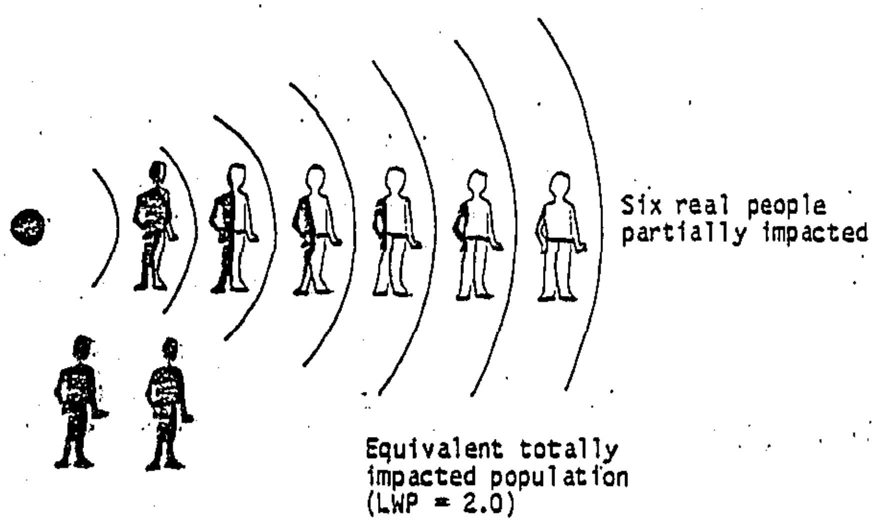



Figure 1. LEVEL-WEIGHTED POPULATION: A METHOD TO ACCOUNT FOR THE EXTENT AND SEVERITY OF NOISE IMPACT

partial impact from the noise source. Those people closest to the noise source are more severely impacted than those at greater distances. The partial impacts are then summed to give the equivalent population that is fully impacted by noise. In this example, six real people are adversely affected to varying degrees (partially shaded) by the noise. The sum of these partial impacts is equated to a Level-Weighted Population that is represented by the two totally shaded figures.

The potentially adverse impacts of surface transportation noise and the potential benefits from noise emission regulations are assessed through the use of the computer model mentioned earlier. The model allows the determination of noise impacts (in terms of LWP) by vehicle type (i.e., automobiles, medium and heavy trucks, buses, and motorcycles) as a function of time, taking into account the location of people in the vicinity of these roads, and the anticipated growth in both the Nation's population and new vehicle sales. Computations based on this model enable us to determine the potential reductions in LWP (the benefits) for selected regulatory options.

In the absence of noise emission regulations to control surface transportation noise, the number of people exposed to day-night sound levels above $L_{dn}$ of 55 dB (the level above which people are adversely affected by noise) is expected to grow dramatically with time. By the year 2000, the Nation's population is anticipated to increase by 22.5%. Because of the concurrent expected growth in traffic, the population exposed to levels in excess of 55 dB would be expected to increase by 65% over those similarly exposed in 1980; the corresponding increase in LWP would be 73.1%. Thus, without controls on the noise emission of vehicles or an increased application of noise attenuating devices, i.e., highway noise barriers and improved noise insulation of personal dwellings, it is clearly evident that the surface transportation noise impact would continually worsen.

Within the fleet of vehicles operating on the Nation's roadways, medium and heavy trucks (trucks over 10,000 lbs. Gross Vehicle Weight Rating, GVWR) constitute the primary source of traffic noise. Today, noise impacts from trucks account for approximately 73 percent of those people exposed to day-night sound levels above 55 dB. The large contribution that trucks make to the national noise impact results from their high noise emissions compared to those of other vehicles. For example, Federal Highway Administration data [4] show that, under cruising conditions, a medium truck is equivalent in noise intensity to approximately 10 automobiles, while a heavy truck is equivalent to roughly 32 automobiles. Under low speed acceleration conditions, a medium truck can be equivalent in noise intensity to 35 automobiles, while a heavy truck can be equivalent to 200 automobiles.

To control the growth of the surface transportation noise problem, the Agency, in 1975, promulgated a two-phase noise emission regulation for medium and heavy trucks. The first phase limited truck noise emissions to 83 dB and became effective January 1, 1978. The second phase, originally scheduled to become effective January 1, 1982, but recently deferred to January 1, 1983, limits truck noise emissions to 80 dB. Because decibels are logarithmic in nature, a seemingly small decrease of 3 dB actually is equivalent to a halving of the total intensity from the noise source.

In the year 2000, we estimate that 157.5 million people would have been exposed to day-night average sound levels ($L_{dn}$) above 55 decibels in the absence of a regulation. The 83 dB regulation is expected to reduce the number of people so impacted by 21.6 million, to 135.9 million; a reduction of 13.7%. With an 80 dB regulation in place, the number of people exposed to $L_{dn}$ above 55 dB is estimated to be 126 million, a reduction of an additional 9.3 million impacted people, or 43 percent improvement in reduction obtained with the 83 dB standard. These results are summarized in Table Ia.

In terms of Level-Weighted Population, the baseline LWP in 2000 in the absence of a regulation is estimated to be 52 million. The 83 dB regulation is expected to reduce the LWP in 2000 by 10.0 million, a reduction of 19.0 percent. With an 80 dB standard, the Level-Weighted Population is expected to decrease an additional 4.4 million, or 44 percent as much reduction in LWP as the 83 dB regulation provides; see Table Ib.

Figure 2 shows how the effectiveness of the truck noise regulation will increase with time. The area between the 83/80 dB and 83 dB benefit curves represents the incremental benefits that would accrue from the 80 dB regulation.

Technology Requirements for the 80 dB Regulation

The availability of noise control technology for manufacturers to comply with the 80 dB noise emission regulation is not an issue. That manufacturers are capable of producing trucks that comply with the 80 dB regulation has been supported in written submittals to the Agency by all of the major truck manufacturers [5] and has been verified by the Agency in its Quiet Truck Demonstration Program [6].

In general, the quieting treatments that we expect to be applied to comply with the 80 dB regulation consist of one or combinations of the following treatments: higher performance mufflers, engine shields, transmission covers, and air intake modifications. The exact treatment or combination of treatments depends on the type of truck and its specific engine and drive-train configuration.

TABLE Ia AND Ib
BENEFITS OF THE 83 AND 80 dB
TRUCK NOISE EMISSION REGULATIONS

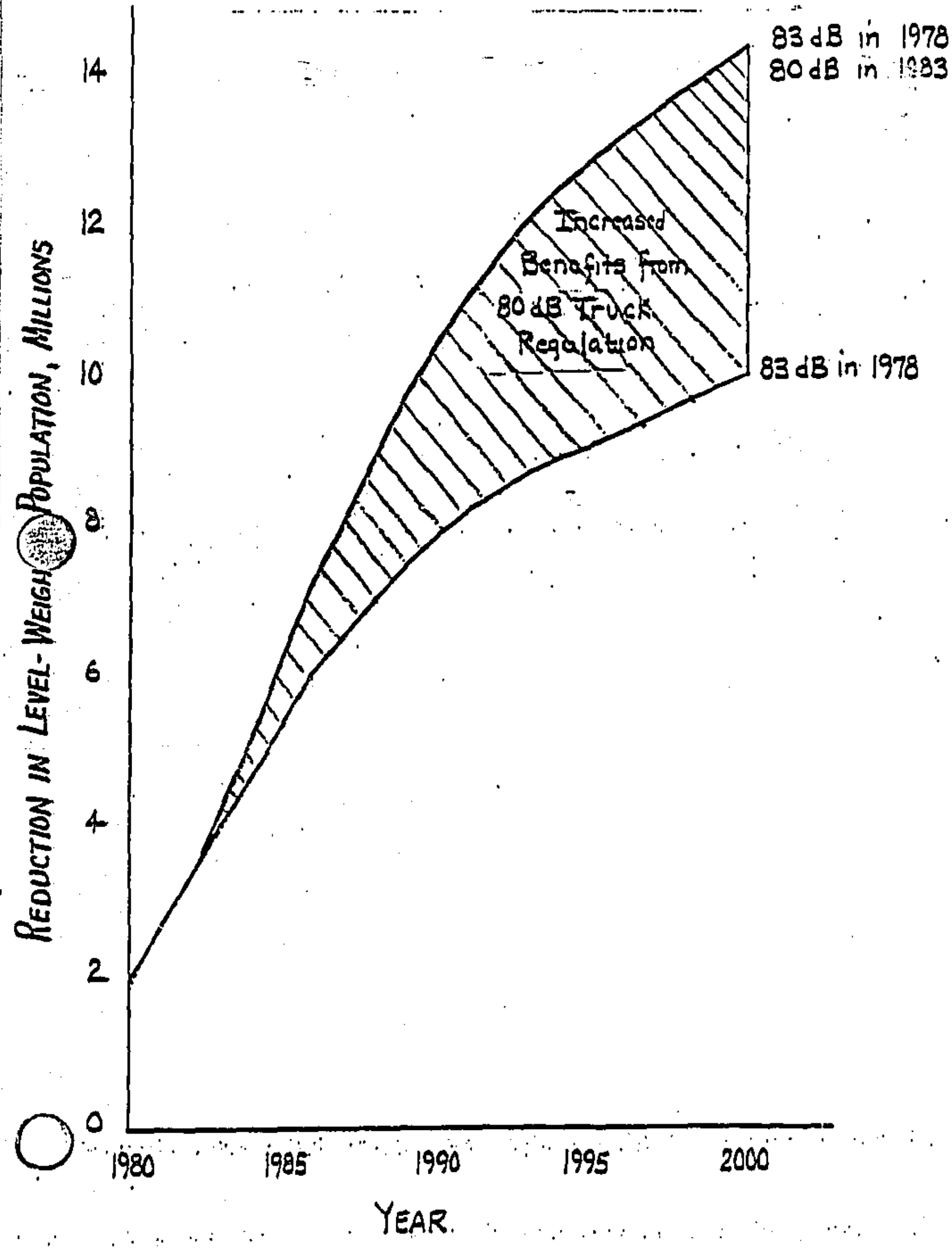
Ia. Population Exposed to $L_{dn}$ > 55 dB

| Regulation | Population Exposed $L_{dn}$ > 55, Millions in year 2000 | Reduction in Population Exposed, Millions from No Regulation | % Reduction | Incremental % Reduction in Population Exposed |
|---|---|---|---|---|
| Unregulated | 157.48 | - | - | - |
| 83 dB | 135.93 | 21.55 | 13.7% | - |
| 80 dB | 126.68 | 30.80 | 19.6% | 42.9% |

Ib. Level-Weighted Population

| Regulation | LWP, Millions in year 2000 | Reduction in LWP, Millions | % Reduction from no regulation | Incremental % Reduction in LWP |
|---|---|---|---|---|
| Unregulated | 52.76 | - | - | - |
| 83 dB | 42.76 | 10.04 | 19.0% | - |
| 80 dB | 38.37 | 14.43 | 27.3% | 43.7% |

FIGURE 2. COMPARISON OF THE BENEFITS, MEASURED IN TERMS OF REDUCTION IN THE LEVEL-WEIGHTED POPULATION FOR THE 83 AND 80 dB TRUCK NOISE EMISSION REGULATIONS



## Updated Vehicle Quieting Costs for Compliance with the 80 dB Regulation

For the purpose of determining quieting costs and performing economic impact assessments for truck emission regulations, the Agency groups trucks by gross vehicle weight rating (GVWR) into medium trucks (10,000 - 26,000 lbs. GVWR) and heavy trucks (>26,000 lbs GVWR). Each weight group is then further subdivided by engine type into either gasoline or diesel-powered trucks. The objective of classifying trucks by weight and engine type is to form truck groups that perform similar in-use functions, require similar noise control technology and thus have similar quieting costs.

Table II presents truck price increases that manufacturers have stated they expect to result from compliance with the 80 dB regulation [5]. Based on these costs and 1979 new vehicle sales for each manufacturer, a sales-weighted price increase was determined for each truck category except heavy gasoline. Lacking specific data from manufacturers on quieting costs for heavy gasoline trucks, the $269 cost figure reported in Table II was developed by updating the 1975 Agency cost estimate as reported in the Agency's Background Document [7] which presents the regulatory analysis attendant to the regulation.

In computing the sales-weighted price increase from the manufacturer's data, the Ford estimate of $1130 for the heavy diesel was not included. The Ford estimate is clearly out-of-line with other industry data. Ford has communicated to the Agency that these costs represent an absolute worst-case estimate and are not representative of their anticipated typical price increase across their full line of heavy diesel trucks.

The Agency estimates a sales-weighted price increase of $345 per heavy diesel truck to meet an 80 dB regulation. This estimate is derived from the costs required to quiet the four heavy diesel trucks in our Quiet Truck Demonstration Program. These trucks were selected for their diverse con-

TABLE II. COMPARISON OF MANUFACTURER'S [5] AND EPA TRUCK PRICE INCREASES TO COMPLY WITH THE 80 dB NOISE EMISSION REGULATION

Estimated Price Increases for New Trucks: Data Submitted to EPA by Truck Manufacturers

| Truck Category | International Harvester | Mack | GMC | Freightliner | Peterbilt | Ford | Volvo | Sales-Weighted Average Based on Manufacturer's Data | EPA Rev Estimate $1980 |
|---|---|---|---|---|---|---|---|---|---|
| Medium Gasoline | $142 | - | $ 50 | - | - | $ 166 | - | $105 | $105 |
| Heavy Gasoline | - | - | - | - | - | - | - | - | $269 |
| Medium Diesel | $387 | - | $300 | - | - | $ 517 | $240 | $405 | $405 |
| Heavy Diesel | $379 | $400 to $500 | $415 | $546 to $563 | $540 | $1130 | $150 | $437 | $345 |
| Sales-Weighted Price Increase, all trucks | - | - | $365 | - | - | - | - | $322 | $279 |

Note: A blank space ( - ) indicates that information was not supplied by the manufacturer figurations. The techniques used to quiet these trucks to their target level of 72 dB (to meet a 75 dB regulation) are similar to, but more extensive than, those needed for the truck that will meet the 80 dB regulation. We have used a straight-line interpolation of dollars per decibel reduction and have sales-weighted these costs to estimate the 80 dB quieting costs. We believe this is an appropriate and conservative approach since it apportions higher costs to quiet across all trucks, not just a select few; nor does it take credit for the relatively large number of heavy diesel trucks that can meet the 80 dB level with very minor changes. Our $345 estimate includes both manufacturer and dealer mark-ups but does not include any reductions that could be anticipated as the result of production efficiencies. We believe the EPA revised estimate for heavy diesel trucks to be an accurate representation of the price increase that can be anticipated due to the 80 dB regulation since it is based on our "hands-on" experience. We view the industry estimates as more representative of their upper price limit and thus not typical of the fleet average. In estimating the potential economic effects of the 80 dB regulation, we have used our estimated price increases as presented in the last column of Table II.

Table III presents the new estimated truck price increase in relation to the average truck sale price for each of the truck categories. Potential price increases range from 0.6 percent for heavy diesels to 2.5 percent for the medium diesel truck. For all trucks, compliance with the 80 dB regulation could result in an average increase in truck prices of less than 0.9 percent.

<u>Changes in Truck Operating Costs Expected to Result from the 80 dB Regulation</u>

Compliance with the 80 dB noise emission regulation may affect truck operating costs through changes in performance and increases in vehicle

TABLE III. ESTIMATED INCREASE IN TRUCK PRICES DUE TO COMPLIANCE WITH 80 dB NOISE EMISSION REGULATION (1980 dollars)

| Vehicle Category | Average Price | Price Increase due to 80 dB Regulation | Percentage Price Increase |
|---|---|---|---|
| Medium Gasoline | $12,083 | $105 | 0.87% |
| Heavy Gasoline | $24,157 | $269 | 1.11% |
| Medium Diesel | $16,024 | $405 | 2.53% |
| Heavy Diesel | $53,434 | $345 | 0.61% |
| Sales-Weighted Average, all Trucks | $32,343 | $279 | 0.86% |

maintenance costs. Although the Agency's experience in the Quiet Truck Demonstration Program indicates no identifiable changes in truck performance, we have taken a conservative approach by including fuel cost increases that potentially could result from minor changes in vehicle weight from the application of noise treatments, and from potential changes in exhaust system back pressure associated with the use of higher performance mufflers. Increases in maintenance costs are expected to occur as a result of additional labor time needed to remove and replace noise treatments during normal maintenance and from the higher replacement cost of an acoustically superior muffler over the cost of a normal muffler.

The additional labor for panel removal and reinstallment has been estimated from the detailed service records of private carriers using EPA's demonstration quiet trucks in actual road service. These very quiet trucks are fitted with flow-through enclosures consisting of side and bottom panels in order to meet the 72 dB design target. Although some trucks will need shielding to meet an 80 dB regulation, they will not need a complete flow-through enclosure, and many will not need shields at all. Therefore, the service time estimate of one hour and 15 minutes per year for the EPA quiet truck has been adjusted to 15 minutes to reflect the much reduced use of this level of quieting technology to meet the 80 dB level. Accordingly, the service cost increase, using an industry labor rate of $25/hour is considered conservative.

The incremental increases in muffler costs were obtained from muffler manufacturers' pricing information [5], as was the muffler useful life of 4 years for diesel and 2 years for gasoline engines. These useful life figures were used to prorate the incremental costs of the quieter mufflers.

It should be noted that the truck manufacturers submitted significantly higher estimates of maintenance cost increases, but provided no substantiating data. One manufacturer indicated that estimates were based on the maintenance costs associated with a "quieted" truck operated by United Parcel Service (UPS). The acoustical treatment used in that truck relied on considerable use of glass fiber "sound insulation" blankets which have the serious disadvantage of absorbing flammable fluids inevitably present in the engine compartment. The maintenance costs for this treatment would bear no relation to the maintenance costs associated with the more practical and cost-efficient treatment used in the Agency's demonstration program and considered in this analysis. The technical availability and production feasibility of this noise abatement treatment to meet a 72 dB design target is attested to by industry's continuing engineering critique of and participation in EPA's Quiet Truck Demonstration Program. The industry's trade press* has stated that EPA's quiet truck program "represented relatively little in the way of new technology," and an official of one major truck manufacturer stated that EPA's noise abatement techniques were "nothing we didn't do five to seven years ago."

Table IV presents our estimates of the average annual increase in operating costs by truck category as computed over the economic life of the truck (10 yrs.). On the average, the 80 dB regulation is expected to increase average annual operating costs by 0.07% (less than one tenth of one percent).

## Economic Impact of the 80 dB Truck Noise Emission Regulation

The economic impact of the 80 dB truck noise emission regulation, as measured by the uniform annualized cost for the period 1980 to 2000, has been updated to include our most recent estimates of noise treatment and operating

* "Heavy Duty Trucking," March 1981, page 35.

TABLE IV. CHANGES IN AVERAGE ANNUAL OPERATING COSTS DUE TO THE 80 dB TRUCK NOISE EMISSION REGULATION (1980 Dollars)

| Truck Category | Average Annual Mileage | Average Annual Operating Costs | Average Annual Cost Increases due to 80 dB Regulation | | Average Annual Percentage Increase in Operating Costs |
|---|---|---|---|---|---|
| | | | Fuel | Maintenance | |
| Medium Gasoline | 12,400 | $25,060 | $ 4 | $12 | 0.064% |
| Heavy Gasoline | 19,100 | $38,601 | $ 5 | $17 | 0.057% |
| Medium Diesel | 19,000 | $38,399 | $23 | $18 | 0.107% |
| Heavy Diesel | 49,300 | $99,635 | $37 | $24 | 0.061% |
| Average, All Trucks | 31,050 | $62,747 | $23 | $19 | 0.067% |

costs. Included in the uniform annualized costs are capital costs for quieting treatments, depreciation, interest payments (the cost of capital) and operating costs. While our uniform annualized cost estimate does not reflect actual costs to manufacturers, dealers, users, or consumers (since the ability to pass through price increases, investment credits, and taxing schemes is not taken into account), it may be roughly interpreted as the annual "societal" cost of the regulation. Thus, uniform annualized costs are useful for comparing the relative costs of selected regulatory options.

To assess the relative costs and effectiveness of the 80 dB regulation, uniform annualized costs and benefits have been determined for 83 dB, 80 dB, and 75 dB truck noise emission regulations. A 75 dB regulation was included for the purpose of this analysis as representing current available technology (equivalent to a design limit of 72 dB, the level achieved by the Quiet Truck Demonstration Program) and was assumed to go into effect in 1987 to permit one full truck design cycle beyond the current 1983 effective date of the 80 dB regulation.

Costs for the 83 dB and 75 dB regulation are based in part on original data reported in the Background Document for the Truck Noise Emission Regulation. We have updated these costs from 1975 dollars to 1980 dollars by the application of appropriate economic indices [8] as supplied to the Agency by the Bureau of Labor Statistics. We have adjusted estimates of attendant quieting and operating costs to reflect industry data and our experience in the Quiet Truck Demonstration Program. Market share by vehicle category and overall fleet growth are based on industry sources and independent econometric projections.

Using the current 83 dB regulation (which the industry has praised for its cost-effectiveness) as a base for comparison, Table V presents the relative cost-effectiveness of the 83, 80 and 75 dB noise regulations. The data in Table V was computed by determining the incremental costs of each option and the incremental benefits over the time period 1982 to 2000.

Costs and Effectiveness of Alternative Strategies for Traffic Noise Control

Table VI presents our analysis of the relative costs and benefits of two alternative strategies for traffic noise control, i.e., using traffic noise barriers or noise insulation of dwellings. From our analysis presented below, barriers are approximately 2.5 times more costly per LWP than the 80 dB truck noise regulation and insulation of dwellings is 2.8 times as costly.

Given the severe limitations on the practical application of barriers, we believe that barriers are not a reasonable alternative to the 80 dB regulation. Insulating dwellings to protect residents from traffic noise appears to be even less attractive, taking into account the fact that the relative cost is 2.8 times that of the 80 dB standard and that dwelling insulation provides no protection to people outdoors.

Traffic Noise Barriers. To date, approximately 184 miles of barriers have been constructed in the United States for the purpose of traffic noise control at a cost of $103.6 million. This expenditure is equivalent to $107 per linear foot or approximately $565,000 per mile. The Federal Highway Administration (FHWA) estimates that an additional $539 million will be spent on barrier construction by the year 2000.

Barriers reduce traffic noise by simply blocking the path of noise, creating a "noise shadow" for the people being protected. Barriers are typically designed to provide a 10 dB reduction in noise levels for the first

TABLE V. COMPARISON OF THE RELATIVE COST-EFFECTIVENESS OF 83, 80 and 75 dB TRUCK NOISE EMISSION REGULATIONS (1980 Dollars)

| Regulatory Level | Incremental Uniform Annualized Cost, (1980-2000) Millions | Average Annual Incremental Reductions in LWP, (1980-2000) Millions/Year | Cost-Effectiveness Relative to 83 dB Regulation |
|---|---|---|---|
| 83 dB | 328.4[1] | 7.24[1] | 100% |
| 80 dB (1983) | 133.2[2] | 2.34[2] | 79.7% |
| 75 dB (1987) | 395.8[2] | 3.55[2] | 40.7% |

1. Incremental Costs and Benefits calculated relative to the unregulated truck.
2. Incremental Costs and Benefits calculated relative to the 83 dB truck regulation.

TABLE VI. COMPARISON OF THE RELATIVE COST-EFFECTIVENESS OF THE 80 dB TRUCK NOISE REGULATION, TRAFFIC NOISE BARRIERS, AND NOISE INSULATION OF DWELLINGS

| Control Measures | Uniform Annualized Cost, 1980-2000 ($1980) | Average Annual Reduction in LWP (1980-2000) | Cost per LWP | Relative Cost Effectiveness Compared to 80 dB Regulation |
|---|---|---|---|---|
| 80 dB Regulation | $133.2 M | 2.34 M | $ 56.92 | Baseline |
| Noise Barriers | 29,596[1] per mile of barrier | 208 per mile of barrier | $140.27 | 2.46 |
| Insulation | $374.0 M | 2.34 M | $159.83 | 2.81 |

1 The Uniform Annualized Cost for noise barriers is based on initial cost of $565,000 per mile of barrier which is then discounted and financed over the period 1980 to 2000.

row of houses behind the barrier. While houses behind the first row do receive some degree of protection from the barrier, it is significantly reduced from that of the first row and is generally not a factor taken into account in the design of the barrier or the decision to build. FHWA estimates that in over 90 percent of the cases to date, barriers have been designed and constructed to protect single family or town house dwellings.

For the purposes of this analysis, we have assumed a 50 foot frontage per dwelling with 4 occupants per dwelling. On this basis, approximately 422 people per mile of barrier are assumed to receive a 10 dB reduction in traffic noise. As a general rule, the construction of barriers is considered when traffic noise levels are in the 73-75 dB range. This is equivalent to an $L_{dn}$ of approximately 72.9 dB. Applying the 10 dB assumed reduction in noise level through use of the barrier reduces the day-night noise level to approximately 62.9 dB. In terms of the reduction in the Level-Weighted Population, each mile of barrrier is expected to reduce LWP from 378 per mile to 167 per mile.

Using historical data from the Department of Transportation which shows that barriers on the average cost $565,000 per mile, the uniform annualized cost is $29,596 per year, per mile of barrier. This leads to a cost-effectiveness of approximately $140.27 per LWP. Comparing this to the cost-effectiveness of the 80 dB truck regulation ($56.92), barriers are about 2.5 times as costly. It should be noted that this analysis has not considered the maintenance costs associated with barriers. While barriers themselves generally require little maintenance there has been a problem with graffiti which has to be periodically removed. Barriers also complicate normal highway maintenance, i.e., grass mowing and snow removal operations. Thus, the above analysis is somewhat conservative with respect to true barrier costs.

In addition to the high cost per LWP associated with barriers, the general applicability of barriers as a possible alternative to source regulation is severely constrained by the limited situations in which barriers are effective in reducing traffic noise. Site geometry and topography eliminate barriers as a control strategy at many sites, particularly in urban environments. Barriers provide virtually no protection to people living above the ground floor. Safety considerations such as proximity to the roadway and site distance requirements also act to restrict the use of barriers. Thus, barriers tend to be useful only in high-speed freeway situations in which right-of-way problems are minimal. With available data, it is not possible to estimate the number of sites and population that could be afforded protection by a nationwide barrier construction program.

<u>Noise Insulation of Dwellings.</u> This analysis is based on obtaining the same environmental health and welfare benefits as lowering the truck noise level from 83 to 80 dB. By comparing the number of people exposed in various $L_{dn}$ level bands, each 3 dB wide (i.e., 55-57, 58-60, etc.), we estimate that the potential improvement due to the 80 dB regulation is equivalent to reducing $L_{dn}$ by 3 dB for 15 percent of those people exposed to traffic noise above

$L_{dn}$ = 55 dB, or about 19 million people.

One can achieve approximately the same benefit (per indoor exposure only) by improving by 3 dB the sound transmission loss of the houses that the people occupy. Assuming 4 people per house, this entails treating approximately 4.8 million houses.

In the absence of hard data, we have made the following simplifying assumptions in order to estimate costs:

(1) a 1500 sq ft house, with 20 percent glazed area.

(2) the front and side exterior walls are acoustically treated.

(3) construction is conventional wood frame and siding for 90 percent of the houses, and 10 percent concrete block or brick with brick veneer.

Data from the National Bureau of Standards shows the following costs of acoustic treatment per square foot per dB for these types of construction:

| | |
|---|---|
| Door | $.46/sq ft/per dB |
| Windows | .80/sq ft/dB |
| Walls - wood frame | .07/sq ft/dB |
| Brick | .25/sq ft/dB |

Using this data results in the following costs for our example which has 1100 sq ft of wall (20 percent glazed).

| | | | | | |
|---|---|---|---|---|---|
| Windows | 220 sq ft | at | $ .80 | = | $176.00 |
| Door | 17 sq ft | at | .46 | = | 7.50 |
| Wood wall | (.9 x 863) sq ft | at | .07 | = | 54.36 |
| Brick wall | (.1 x 863) sq ft | at | .25 | = | 21.58 |
| | | | | | $259.44 per dB |

Thus, for a sound attenuation of 3 dB, the estimated cost for a house is $1012.50. The above estimate is for new construction. Conservatively, retrofit will cost about 50 percent more than new construction, yielding an estimated cost of roughly $1500 per house. This estimate does not take into account probable changes needed to the forced-air system in the house to feed in fresh air since windows must remain closed for the noise insulation to be effective. Studies by an independent laboratory show an estimated cost of $5400 to retrofit a typical 2-story house for a sound reduction of 3 to 5 dB against aircraft noise - averaging over $1000 per dB. Therefore, an estimate of $1500 per house is considered conservative.

Using $1500 per house, the total estimated cost for treating 4.8 million houses would be $7.14 billion. Assuming that this amount is invested uniformly over the period 1980 - 2000 (concurrent with the truck regulation) the present value is $3.235 billion and the corresponding uniform annualized cost is $374 million (1980 dollars).

The average annual reduction in LWP for the 80 dB regulation relative to the 83 dB standard is 2.34 million. The cost-effectiveness may be stated in terms of dollars of uniform annualized cost per unit of annual average reduction in LWP. Since sound insulation of houses yields approximately the same incremental benefit as the 80 dB standard, the cost-effectiveness is therefore $374 million divided by 2.34 million (LWP), or $159.80 per LWP reduced. This is about 2.8 times as costly as the 80 dB truck regulation.

## REFERENCES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