Background Document to PROPOSED INTERSTATE MOTOR CARRIER REGULATIONS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

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Section 1

STATUTORY AUTHORITY

RESPONSIBILITIES OF THE ENVIRONMENTAL PROTECTION AGENCY

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 or welfare." In pursuit of that policy, Congress stated, in Section 2 of that 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 a part of that essential Federal action, Section 18 of that Act (86 Stat. 1249) directed the Administrator of the Environmental Protection Agency (EPA) to publish proposed noise emission regulations for motor carriers engaged in interstate commerce. Motor carriers subject to such regulations include common carriers by motor vehicle, contract carriers by motor vehicle and private carriers of property by motor vehicle as these terms are defined by paragraphs (14), (15), and (17) of the Interstate Commerce Act (49 U.S.C. 303 (a).

The EPA regulations proposed under Section 18 of the Noise Control Act are to include "noise emission standards setting such limits on noise emissions resulting from operation of motor carriers engaged in interstate co mmerce which reflect the degree of noise reduction achievable through the application of the best available technology, taking into account the cost of compliance." Final regulations are to be promulgated only after consultation with the Secretary of Transportation, to assure appropriate consideration for safety and for availability of technology. The regulations are to take effect after such period as the Administrator of EPA finds necessary, after consultation with the Secretary of Transportation, to permit the development and application of the requisite technology. Further, appropriate consideration is to be given to the cost of compliance within such a period. The regulations promulgated under Section 18 may be revised from time to time, in accordance with Subsection 18(a). They shall be in addition to any regulations proposed for new motor vehicles under Section 6.

RESPONSIBILITIES OF THE DEPARTMENT OF TRANSPORTATION

After final interstate motor carrier noise emission standards have been promulgated by EPA, the Secretary of Transportation is responsible for promulgating regulations to ensure compliance with those standards. This will be accomplished through the use of the Secretary's powers and duties of enforcement and inspection as authorized by the Interstate Commerce Act and the Department of Transportation Act. These enforcement regulations are to be promulgated only after consultation with the Administrator of EPA.

ROLE OF STATE AND LOCAL GOVERNMENTS

After the effective date of a regulation on noise emissions from an operation of interstate motor carriers promulgated under Section 18, no state or political subdivision thereof may adopt or enforce a standard on noise emissions from the same operation that differs from the one promulgated under Section 18. State and local governments may, however, adopt a standard identical to such a Federal standard to add their enforcement capabilities to those of the Department of Transportation.

Further, interstate motor carrier operations not covered by Federal regulations will remain subject to state and local noise standards and regulations. Such state and local regulations are limited, of course, by the constitutional prohibition of state or local action that constitutes an undue burden on interstate commerce.

Finally, nothing in Section 18 shall "...diminish or enhance the rights of any State or political subdivision thereof to estabish and enforce standards or controls on levels of environmental noise, or to control, license, regulate, or restrict the use, operation, or movement of any product if the Administrator, after consultation with the Secretary of Transportation, determines that such standard, control, license, regulation, or restriction is necessitated by special local conditions and is not in conflict with regulations promulgated under this section."

Section 2

MOTOR CARRIER INDUSTRY

This discussion briefly summarizes the organization, size, and economics of the motor carrier industry in order to provide a general perspective of the impact of EPA regulations on that industry. There are over 15,000 firms in the motor carrier industry. These firms are engaged in moving both people and property. The majority of their trips are local, with 70 percent in urban areas or between adjacent counties.(1) Those firms involved in interstate commerce will be affected by the proposed EPA regulations.

ORGANIZATION OF THE INDUSTRY

The industry is divided into two general classifications of carriers: 1. private carriers which use their own or leased trucks, to move their own goods, and 2. carriers which provide transportation of others' freight. The latter group of carriers is further divided into two categories: 1. common carriers--available to the general public to transport given types of freight at published rates, between authorized points, 2. contract carriers--operate under contract with one or more shippers to serve their distinct requirements.

The proposed standards are applicable to those motor carriers meeting the definition of common carrier, contract carrier, and carriers of property as set forth in the Interstate Commerce Act.

SIZE OF THE INDUSTRY

The motor carrier industry today is the largest transporter of goods in this country. In 1971, the gross operating revenue of the motor carrier industry (from the transportation of goods) comprised approximately 53 percent of the total among all regulated carriers. Regulated carriers include: railroads, motor carriers, water carriers, oil pipelines, and airways. The industry can be characterized as composed of a large number of small carriers competing with a few very large carriers.

The number of trucks and buses engaged in the transport of goods and people in this country has been steadily increasing. During the period from 1960 to 1970, the total number of trucks and buses increased from 12.2 to 19.3 million, for an average increase of 0.7 million vehicles per year.[52] Total miles traveled per year have also increased. For trucks specifically, total miles traveled have increased from 90.5 billion in 1950 to 206.7 billion in 1969.

ECONOMICS OF THE INDUSTRY

In 1970, the larger intercity common carriers of general freight had average assets of $3,243,000, average operating revenues of $6,837,000 and averaged $89,300 net income after taxes. (1)

The average revenue for large intercity carriers of general freight in 1970 was $1.24 per intercity truck-mile. Expenses for these carriers averaged $1.20 per intercity vehicle-mile, and of this, wages took $ 0.645 . repairs and servicing (maintenance) took $ 0.076 fuel and oil $ 0.03 (not including State and Federal tax), and tires and tubes $ 0.019 cents.(1) The major cost in carrier operation is, therefore, operator wages, and tires and tubes rank fourth. Repairs and servicing are approximately four times tire and tube costs.

The general economic health of the industry is reflected in the 1970 financial ratios for large carriers, which include 4.96 revenue to worth, 0.06 profit (net after taxes) to worth, and 0.013 profit (net after taxes) to revenue. (1)

Section 3

INFORMATION BASE FOR THE PROPOSED REGULATION

DATA ACQUISITION

To develop the noise emission standards that constitute this proposed regulation, it was necessary to establish a well defined data base. In connection with motor carriers engaged in interstate commerce, this data base included the following information:

1. The existing noise levels produced by the various vehicles used by motor carriers under different operating conditions.
2. The degree of noise reduction possible on these vehicles, using available technology, together with the cost associated with this reduction.
3. The percentage of vehicles that would require any particular treatment or modifications to achieve various noise levels.
4. The production supply of hardware necessary to achieve those noise levels.

In order to gather and coordinate the input of the required information, a Task Force was set up consisting of representatives from various Federal and state agencies and consultants to the Environmental Protection Agency. The Task Force reviewed and analyzed the data and developed recommendations for consideration by the Agency in the development of the proposed regulations. In addition, the Agency amassed technology and cost information submitted to the official docket of the regulations as a result of the Advanced Notice of Proposed Rule Making,[3] and information previously developed by the Agency as part of its hearings under Title IV, P.L. 91-604.[4,5]

AVAILABILITY OF DATA

In general, the main sources of existing highway noise data were the Federal and State government agencies and knowledge of EPA consultants. Although a certain amount of retrofit information was available from the vehicle manufacturers, a greater source was the individual component manufacturer.

Data were analyzed from 5838 diesel trucks operating on freeways in California in 1965,[6] 531 trucks in the state of Washington in 1972,[7] and from 1,000 trucks in New Jersey in 1972.[8] These data, collected before the California noise regulations took effect, and from states not having noise regulations, were considered to be representative of existing (1973) noise levels from trucks operating on freeways in states not having noise regulations.

The noise level data for trucks accelerating at low speed (less than 35 mph), were taken from 776 trucks in California in 1971[9] and from

*Since the regulations were proposed on July 27, 1973, additional data have been gathered from eight other States. See Appendix A.

239 trucks in the State of Washington in 1972.[7] For constant speed operation at speeds less than 35 miles per hour, data were obtained from 340 trucks in California in 1971.[9]

An additional part of the data base consisted of noise levels measured from stationary trucks by means of an engine run-up technique. The data were obtained on 877 trucks by the Society of Automotive Engineers Vehicle Sound Committee.[10] There was a paucity of data on the levels of noise emitted by interstate motor carrier vehicles other than large multi-axle trucks, which are primarily powered by diesel engines. It is known, however, that vehicles such as gasoline trucks and buses are inherently quieter than large multi-axle diesel trucks, and should have no difficulty in complying with any noise emission standard which is reasonable for the latter.[(98,99)] The proposed regulation applies to all interstate motor carrier vehicles over 10,000 pounds GVWR or GCWR. Additional data will be obtained in the future so that subcategories of those vehicles, such as gasoline trucks and buses, may be treated separately in future revisions of the regulation.

Data on auxiliary equipment of motor vehicles were also limited. Manufacturers have submitted some information on the noise emissions from typical refrigerator units,[11] but additional data will be developed for possible inclusion in subsequent revisions of the regulation.

The remainder of this Background Document is based upon an analysis of the data described in this section.

MEASUREMENT METHODOLOGY DEFINED

The proposed regulation concerns the noise emitted by motor vehicles engaged in interstate commerce. In order to set a meaningful regulation based upon specific noise level standards, it is necessary to specify an appropriate method for characterizing and measuring the noise emission from an individual vehicle. This entails defining the operation of the vehicle under measurement as well as the method by which the measurement is conducted.

In general, there are two main conditions under which motor vehicles operate, namely

1. Urban driving at low speeds
2. Highway driving at high speeds

In urban areas, the vehicle is seldom allowed to exceed a speed of 35 miles per hour, except in the western area of the nation where speed zones of 45 miles per hour are common. On the open highway, and on urban freeways, vehicle speeds are limited to a range of from about 55 to 70 miles per hour. Subsequent sections of this background document will show that the noise characteristics of motor vehicles are different in the two operational conditions. Therefore, the proposed regulation will include separate noise standards for these two conditions; i.e., the two speed ranges. However, if the actual vehicle speed is specified in the regulation, then subsequent enforcement would require simultaneous measurement of this speed along with the noise level produced. To remove this obstacle to enforcement in the proposed regulation, the speed zone in which the vehicle is operating, rather than the actual speed of the vehicle under measurement, is specified in the proposed regulation.

For the noise standards to be meaningful it is necessary to specify the noise level at a given distance produced by a truck when it is operating under the conditions just discussed. In the proposed regulation, all references to a quantitative method for specifying the magnitude of a noise are in terms of the A-weighted noise level scale, the units being in dB(A). A-weighting corresponds approximately to the way in which a person hears a noise and is effected by means of a simple electrical circuit contained in most sound level meters.[12] Other scales are available, but they require a more complex analysis which is normally not justified by the improved correlation with human assessment.[13]

The standard measurement distance selected is 50 feet. This is consistent with current recommended practice, for the measurement of both the noise from new vehicles[14] and the operational noise levels from vehicles on the highway[15] in various States and cities. The distance of 50 feet is a compromise between 25 feet (the ISO[16] standard distance), at which[5] slight variations in vehicle distance can lead to significant errors in the measured noise level, and greater distances at which background noise and nearby reflecting obstacles can pose a problem in measurement site selection.[17] Furthermore, almost all of the data base consists of noise levels measured at this distance. There may be some occasions when a measurement at 50 feet is not possible or undesirable; for example, urban or suburban areas with nearby acoustically reflecting surfaces which could distort the measurement. Alternative measurement distances together with suitable correction factors to standardize to a measurement distance of 50 feet can be specified[17] in the enforcement procedures established for these proposed regulations. The enforcement procedure should also specify the criteria for selecting suitable highway measurement sites.

SECTION 4

CATEGORIES OF INTERSTATE MOTOR CARRIER VEHICLES

Interstate motor carriers utilize a broad range of vehicles; from small two-axle "straight" trucks and buses up to "combination" (tractor-trailer) trucks with 5 or more axles.(18) All of these vehicles contribute to noise emitted along highways and streets, which sets the ambient noise level in most urban communities.(19) But large motor carrier vehicles cause a noise problem that can be separated from the problem of motor vehicls noise in general. At the present time, diesel trucks emit noise levels that are so much higher than those emitted by other motor vehicles that they stand out very noticeably. Noise peaks of 12 dB above the ambient noise level from other traffic are common.(20) It has been widely acknowledged that such noise peaks are more objectionable to people than is the ambient noise.(21)

Trucks weighing less than 10,000 pounds gross vehicle weight rating (GVWR) typically produce noise levels ranging from 64 to 72 dBA at 35 mph, when measured at 50 feet. This correlates closely to the noise level produced by ordinary passenger automobiles, which generate up to 68 dB(A) at 50 feet at the same speed.(22) Such a result is not surprising since the basic noise-producing components of such small trucks are little different from those of automobiles. They are powered by gasoline engines similar in most respects to automobile engines; they have two-axle chassis, and they usually use rib tires similar to automobile tires.

Trucks of over 10,000 pounds GWWR or Gross Combination Weight Rating (GCWP) for combination vehicles, on the other hand, are different from small trucks and automobiles. They can produce noise levels of 95 dB(A) or more at highways speeds when measured at 50 feet.[23,8] Their higher noise level can be accounted for by their common use of relatively noisy diesel engines instead of gasoline engines, their frequent employment of three, four, and five axle designs using more noise-producing tires, and their occasional use of "pocket retread" tires, which produce more noise than other tire designs[24] (see discussion of tire noise below).

Moreover, trucks of over 10,000 pounds GVWR or GCWR are typically used for long distance intercity and interstate hauling. They are, therefore, operated many more miles per year on the average than small trucks, which are usually used for general service and delivery work within one relatively small area.[25] Indeed, many small trucks are devoted to individual uses not unlike private automobiles. The vastly greater mileage traveled on an average by large trucks than by small trucks and automobiles causes the former to make up a much larger percentage of vehicles actually observed on the road than would be indicated by the percentage they constitute of the total vehicles registered.* As a result, efforts concentrated on reducing the noise of large trucks will have a proportionately greater effect than might be determined from truck registration data.

All of these aspects of large trucks--their relatively high contribution to the noise problem, their design, their typical use, and their high average mileage--which distinguish them from small trucks and

*See Appendix A.

automobiles indicate that they should be the focus of EPA efforts under Section 18 at this time. The problem of noise from small trucks appears to be more appropriately handled in the same way as the noise from the automobiles they resemble in design and use; for example, through such new product standards as those of Section 6 of the Noise Control Act and through vehicle use regulations of State and local governments. If in the future it appears that the operation of smaller vehicles should be regulated under Section 18, the regulations may be revised pursuant to Subsection 18 (a).

The dividing line between large and small trucks has been drawn at 10,000 pounds gross vehicle weight rating or gross combination weight rating* because virtually all trucks designed and used much like passenger cars, are below that weight, while few trucks with significantly different characteristics, such as diesel engines, multiple axles, and significantly higher noise emission levels, are below that weight. Moreover, a break at 10,000 pounds is convenient because most states use that weight as a boundary in their vehicle registration categories. In addition it is a standard weight category distinction used by DOT in their safety regulations. Compatibility with the present DOT weight categories is advantageous since DOT is the Federal enforcing agent.

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*"Gross vehicle weight rating," GVWR, is defined for single vehicles; whereas "gross combination weight rating," GCWR, is defined for combina-vehicles such as tractor-trailer trucks.

The category of interstate motor carrier vehicles over 10,000 pounds includes many vehicles between 10,000 and 33,000 pounds GVWR or GCWR powered by large gasoline engines, as well as virtually all of the interstate motor carrier vehicles powered by diesel engines. As will be discussed in the section on truck noise characteristics, diesel engines are inherently noisier than gasoline engines. In addition, as a rule, diesel engines are used in heavier trucks that have other more noisy components, such as a greater number of tires, than trucks powered by gasoline engines.[27] Buses, whether diesel or gasoline, are also inherently quieter than trucks because of design features such as more fully enclosed engine compartments (see Section 6).

Since large multi-axle diesel trucks pose the most severe motor vehicle noise problem, the vast majority of the work done on motor vehicle noise has been directed at them. Thus, the data discussed in Sections 5 and 6 of this document are in large part derived from, and specifically applicable to, large multi-axle diesel trucks. The noise emission standard based on the analysis of those data is, therefore, one that is most appropriate for trucks with more than three axles. This is borne out by the data presented in Appendix A, which show the highest proportion of vehicles in violation of the proposed standard to be trucks with three axles or more, which are often diesel powered.

It might be argued that since this is the case, the category of large motor carrier vehicles should be further subdivided to reflect different noise standards for gasoline versus diesel trucks, buses, and any other relevant categories. Further distinctions could be made on the basis of the age of trucks, and for new trucks, to reflect the degree of noise reduction that each class of truck can achieve. This approach has considerable merit and is being carefully considered for use in future revisions of the interstate motor carrier noise regulations. At present, however, the available data on vehicles other than large multi-axle diesel trucks are not sufficient to permit the selection of different noise standards for them. Since large multi-axle trucks are the most severe noise problem, and since much of the possible noise abatement technology, such as mufflers and cooling fans, is basically the same for all large vehicles, a standard that is reasonable for multi-axle trucks can be assumed to be feasible for other large motor carrier vehicles. (See references 58 and 59). Applying the same standard to other large motor carrier vehicles on an interim basis, while more specific data is gathered for them, will limit any increase in their noise emissions.

Section 5

SPECIFIC NOISE SOURCES

This section of the document describes the noise characteristics of large motor carrier trucks and the methods available for effecting noise reduction. It specifically discusses trucks because, as indicated in Section 4, they are the most severe noise problem, most of the available data concerns trucks, and any regulation that is reasonable for trucks will be reasonable for other large vehicles. The noise produced by a truck is dependent on the type and the quality of the component parts. Large trucks are not standardized as are automobiles. Specialized user needs result in a greatly varied assembly of truck components, especially with respect to powertrain and related equipment. As a result, the noise produced can vary considerably from vehicle to vehicle. To illustrate the extend of the variation that can exist, the following discussion of noise sources is preceded by a brief description of truck components.

GENERAL CHARACTERISTICS OF LARGE TRUCKS

Virtually all trucks in excess of 10,000 pounds GVWR or GCWR are powered either by gasoline or diesel engines; those in excess of 33,000 pounds GVWR or GCWR are powered almost exclusively by diesel engines.[28] Diesel engines may be naturally aspirated (air introduced at atmospheric pressure), turbocharged,or supercharged by the engine itself. The engine is located at the front of the cab in a conventional style (C) and under the cab in a cab-over-engine (COE) style truck.

The engine exhaust for both engine types may be routed horizontally underneath the body of the vehicle or vertically to the rear of the cab--commonly referred to as a "straight stack." The latter is often preferred so as to direct exhaust fumes away from motorists and pedestrians. Single or double exhaust systems may be installed. The engine intake may be situated on or under the hood in a conventional style truck or to the rear of the cab in either style. In the latter case, it may be on the same or opposite side of the cab as the exhaust system.

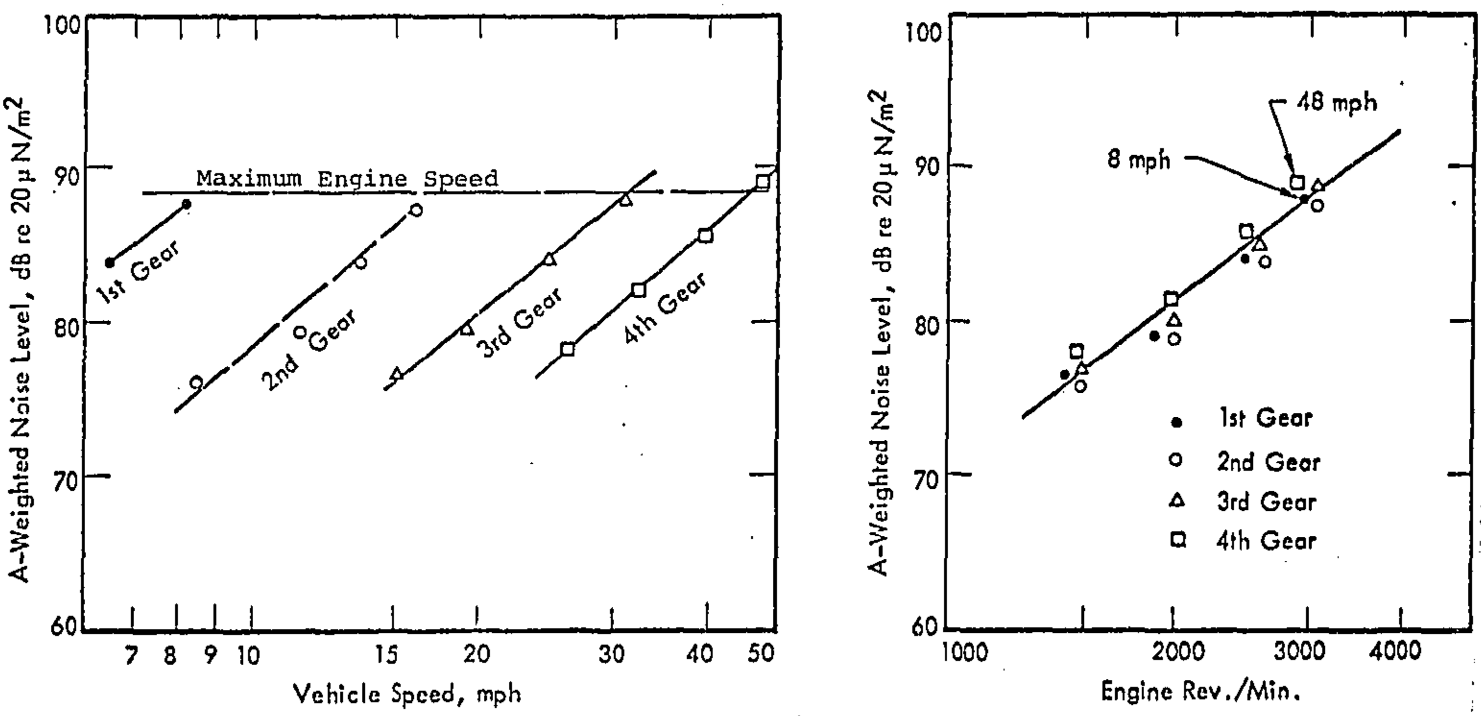
The power-to-weight ratio for a fully laden truck is significantly less than that for an automobile, with the result that the necessary torque must be transmitted through a wide range of gears--up to as many as 15. This torque is usually applied to either one or two drive axles on the vehicle. The number of axles on the entire vehicle, including the trailer, depends upon the load to be hauled, and varies according to State regulations. The result is that the number of tires on a heavy truck-trailer combination can range from 10 to 42.

TRUCK NOISE CHARACTERISTICS

Many combinations of components exist that affect the total noise level of a truck.[29] This is true not only for trucks designed specifically to perform different tasks, but also for trucks designed to perform similar tasks. The reason for the variety is the very marked owner preference in the trucking industry--a preference based on actual performance, imagined performance, or simply a traditional attachment to a given model configuration.

The noise from the propulsion system is not the only contributor to the overall noise level. At speeds greater than about 45 miles per hour, additional noise of significant magnitude compared to the propulsion system noise is produced by the interaction between the tires and the road surface.[31] The relationship between propulsion system noise and tire noise as a function of vehicle speed is shown in Figure 2.[31, 32] In this figure, the noise levels produced by both the propulsion system and the tires are shown as functions of vehicle speed. There are 2 fairly distinct vehicle speed ranges in which the noise level can be characterized. At speeds less than 45 miles per hour, the overall noise level for a truck fitted with a typical combination of tires is determined mainly by the contribution from the propulsion system, which is independent of the vehicle speed. At speeds greater than 45 miles per hour, a major contributor can be tire noise, which increases with vehicle speed. The vehicle speed at which tire noise begins to dominate depends primarily on the type and number of tires on the truck, the degree of tire wear, tire load, type of pavement, and tire inflation pressure.[33]

The effect of vehicle speed on the noise levels produced by one type of truck operating on the highway is shown in Figure 3. This Figure presents the cumulative distribution of the noise levels from tractor-trailor trucks operating at low and high speeds. These data were taken in California, where noise regulations are in existence. The data shown in Figure 3 are therefore not necessarily typical of the nation, since the Califorina noise regulations may have reduced the number of noisy trucks in that State. The basic distinction between low and high speeds, however, is typical. The difference



Microphone 7.5 Meters (25 Feet) From Centerline of Vehicle's Path

Figure 1. Propulsion System Noise Versus Vehicle Speed and Engine Speed

* "Motor Vehicle Noise" Report, by A. Alexandre of the O.E.C.D. Staff, November 1971

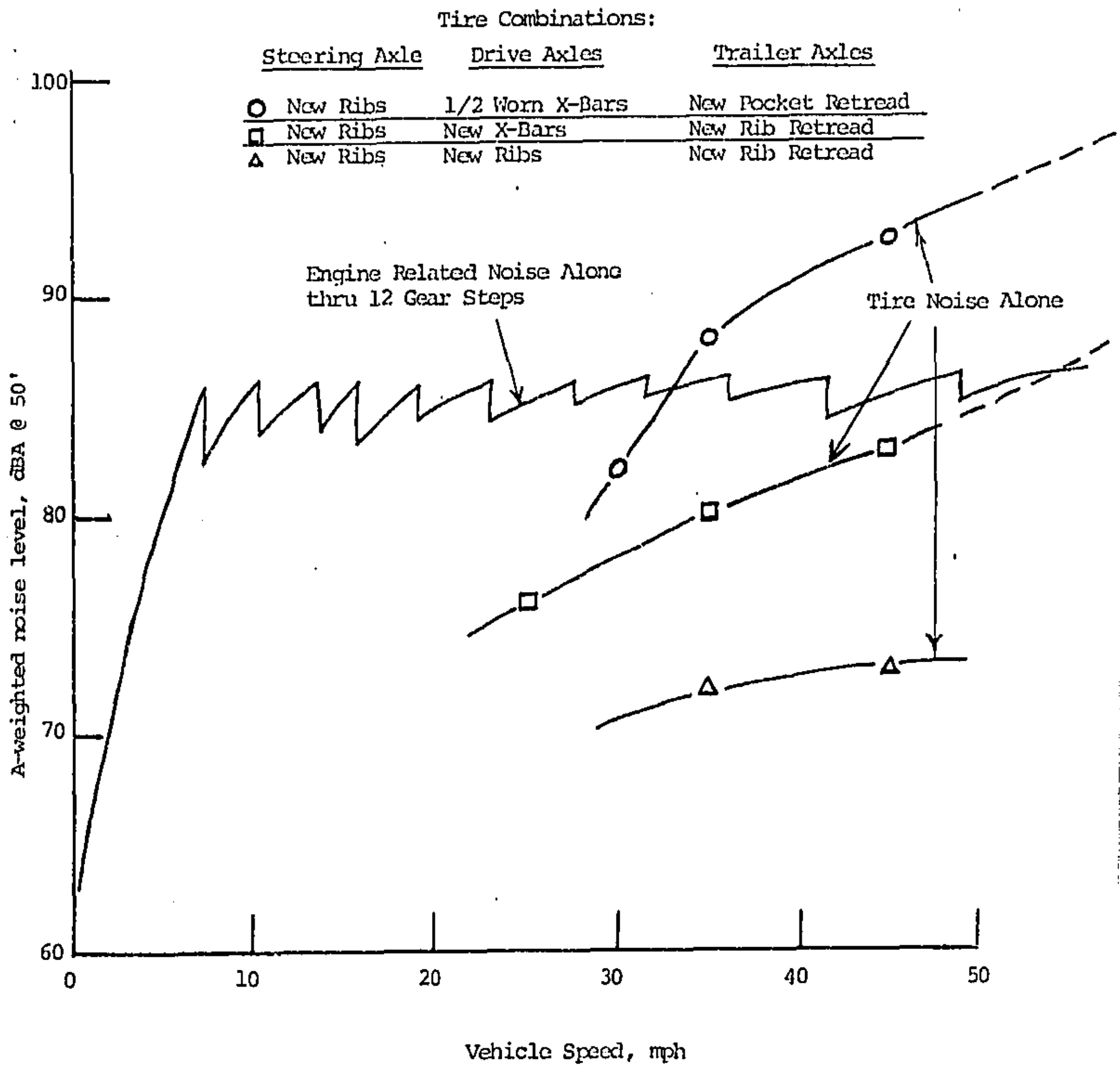


Figure 2 - Propulsion System and Tire Noise for a Typical 5 Axle Tractor Trailer (from reference 31 and 32)

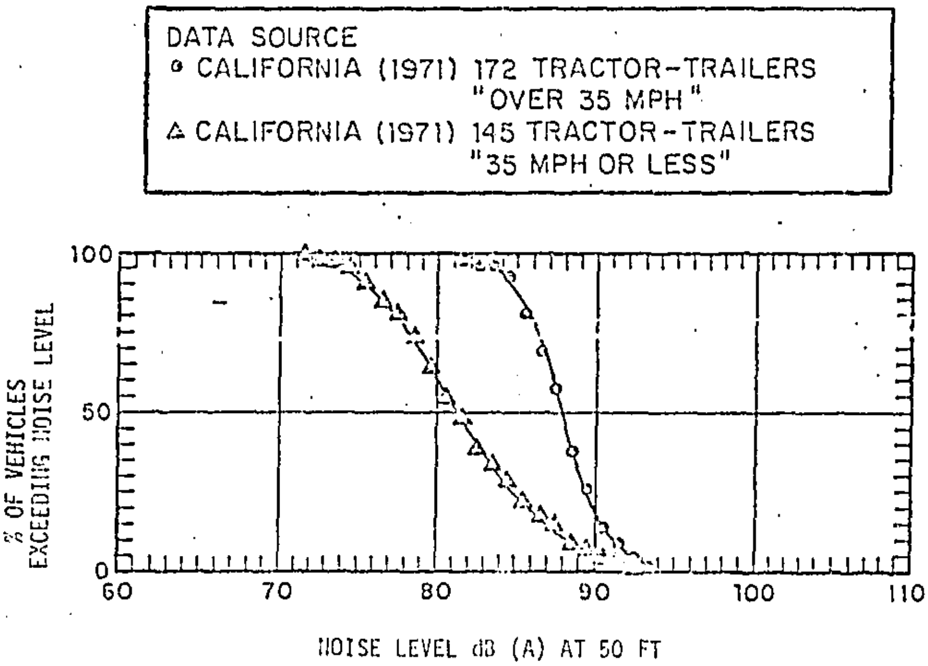


Figure 3. Tractor-Trailer Noise Emission Distributions at 35 mph and over 35 mph

in noise level in the two speed ranges is due mainly to the increased level of the tire noise contribution.

This completes the summary of overall truck noise characteristics as a function of operation. Next, the individual truck components that contribute to the overall noise level are discussed.

TRUCK COMPONENT NOISE SOURCES, ABATEMENT, AND COSTS.

The total noise level produced by a truck is the logarithmic sum of the individual noise levels produced by several different components. These component noise sources are as follows[34] (not necessarily in order of importance)--see Figure 4.

Engine system

Engine cooling fan

Engine (mechanical)

Air intake system

Transmission (gearbox, drive shaft, rear axle(s))

Engine auxiliary equipment

Tire/roadway interaction

Aerodynamic flow

Brakes

Of these, the first four sources are of major importance for trucks of concern here when traveling at low speeds[35] (less than 45 miles per hour). At higher speeds (greater than 45 miles per hour) tire noise assumes a much greater significance. A brief discussion of these major sources is contained in the following sections.

Exhaust System

Exhaust noise is created when engine exhaust gases excite oscillations in the exhaust pipe. These oscillations are radiated to the atmosphere at the tail pipe. The noise is a function of engine type, induction system, exhaust system, and other associated parameters.[35] In addition to the radiation from the end of the tail pipe, noise is also transmitted through the exhaust pipe and muffler walls. Noise is also produced by the application of engine brakes (with trucks so equippped) that, when in use, provide a retarding force on the engine that reduces the speed of the truck. Typical exhaust noise levels range from 77 to 85 db) at 50 feet irrespective of speed[29] and are usually greater in trucks that have been poorly maintained.

Although the exhaust system is a major noise source, the associated noise levels can be reduced fairly easily. A good muffler is mandatory, and for maximum quieting, a double wall or wrapped muffler can be used to reduce radiation through the walls. Besides the muffler, consideration can also be given to wrapping the tail and exhaust pipes with insulation. The system must be free from leaks and should be attached by isolation mounts to the truck frame. The location of the muffler in the overall system, the exhaust pipe length and diameter and the tail pipe length and diameter, should be considered although these factors assume a gradually lessening importance as the insertion loss of the muffler is increased. Muffler specification and suggested exhaust system configurations are currently offered by major muffler manufacturers for almost every engine, since no universal muffler exists that is the best for all types of engines.

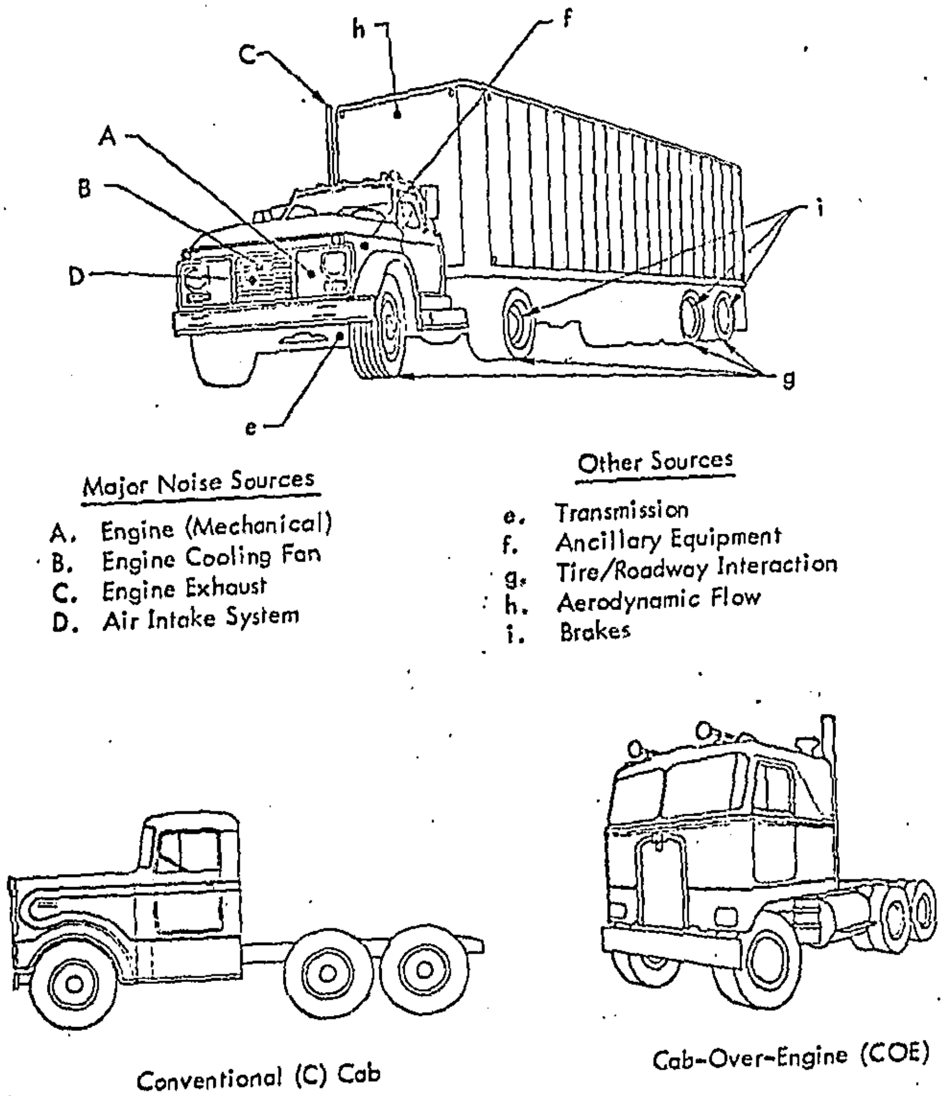


Figure 4. Truck Noise Sources and Cab Types

Exhaust noise, using the best available mufflers, typically ranges from 72.5 to 80 dB(A) at 50 feet for today's most popular diesel engines.[36] These mufflers provide insertion losses of from 9.5 to 27 dB, and are of the type installed on new trucks as standard equipment.[36] A good quality muffler typically costs from $35 to $45; and since the installation is simple, many trucking companies do it themselves. Installation costs for either single or dual systems are about $15.[36, 37] For maximum effect it is necessary to replace existing flexible exhaust pipes with rigid pipe and slip joints at a cost of about $45 per side including labor.

A sudden increase in demand for replacement mufflers would not pose a significant problem to the manufacturers, many of whom are at present expanding their facilities to increase their output by a factor of 1.5 to 2.[38]

Cooling Fan

Trucks generally use axial fans to draw air through a front-mounted radiator to provide water cooling, which in turn provides engine cooling. Fan noise is the result of air flow irregularities and is partially governed by the proximity of shrods, radiators, grills, radiator shutters, etc.[39] The noise produced by the fan is related to fan tip speed. Most diesel engines for heavy trucks are rated for maximum horsepower at about 2,100 rpm. At this speed, engine cooling demand is greatest and the fan can very easily be a major contributor to the overall truck noise level. Typical truck fans usually exhibit noise levels in the range of 78 to 83 dBA at 50 feet at rated engine speed.[29]

Since noise from a cooling fan increases with the rotational speed, it is possible to reduce the noise while maintaining the same air flow (to satisfy the same cooling requirement), by using a larger fan turning at a lower speed. In many cases this may also require the installation of a larger radiator, which could result in an expensive modification to the front of the engine compartment.

It is more feasible to install a fan blade that produces less noise, while at the same time allowing for adequate cooling. Most existing fans are stamped out of sheet metal with equal spacing between the blades, and they are driven at a predetermined fixed ratio of fan to engine speed by a belt-driven pulley. This type of fan was not originally designed to be quiet nor particularly efficient in performing its task. In many cases it can be replaced with a more sophisticated design that affords a noise reduction from the fan alone of from 7 to 12 dB.[40] The cost is in the range of $30 to $35 installed.[41] The overall truck noise can also be reduced by about 1 dB in some cases by incorporating a venturi-type shroud around the fan with a small tip clearance at an installed price of about $45.

Trucks are designed to be able to cope with heat rejection of maximum engine power with little or no ram air. Since ram air increases with truck speed, fans become proportionally of lesser importance at higher speeds and could be slowed or stopped in many instances. The critical condition occurs when — as in pulling a heavy load up a long grade—the truck is moving slowly in a low gear but the engine is developing full horsepower. Trucks, unlike automobiles, usually do not have an overheating problem when the vehicle is stopped and the engine idles at low rpm. As a result of these characteristics, there are only a limited number of conditions under which additional cooling is required. When, the fan is needed only a small percentage of the total engine on-time, there are certain types of fans available that rotate only when this additional engine cooling is required and that idle when the cooling due to ram air flow is sufficient. (42) Typical fans of this type incorporate a thermostatic clutch or a viscous fluid drive. Viscous fluid-clutched fans permit the far to rotate at reduced speeds when not needed. They offer some fan noise reduction (about 3 to 10 dB) but the on-off mechanical clutch would be preferred because of the total elimination of fan noise while the fan is off. (42)

Typical costs for a viscous clutch are about $225 plus about $15 for the suggested fan blade. (43) A thermostatically controlled unit including the necessary fittings costs typically on the order of $285 to $360, plus $40 to $50 for installation. (37, 43)

Engine (Mechanical)

Engine mechanical noise in internal combustion engines is produced by the combustion process, which produces the high gas pressures necessary to force the piston down the cylinder and turn the crankshaft. The rapid rise in cylinder pressure immediately following combustion produces mechanical vibrations in the engine structure that are transmitted through the cylinder walls, oil pan, rocker arm, covers, etc. Some of the vibrational engery is subsequently radiated in the atmosphere as acoustic energy.

Gasoline engines initiate combustion with a flame that smoothly spreads throughout the cylinder until the fuel-air mixture is burned. Diesel engines, however, rely on much higher compression ratios (about 17:1 rather than 9:1) to produce spontaneous combustion. This causes a more rapid change in pressure in the cylinder, which in turn results in increased engine vibration and, hence, higher noise levels than those associated with gasoline engines. (44) As a result, noise levels from diesel engines often are as much as 10 dB greater than those from gasoline engines. (44) The engine noise contribution in typical diesel-powered trucks is on the order of 78-85 dBA. (29) Turbochargers are often used to increase the pressure of the intake air. This reduces the pressure fluctuations in the engine, which in turn lowers the engine noise level. (44) The devices used to increase the pressure may in some cases contribute to the overall noise level; i.e., turbocharger "whine." Retrofit methods of reducing the noise produced by engines generally fall into one of two categories:

1. Reduction of noise radiated by the engine by modifying certain exterior surface covers.
2. Installation of acoustic absorption and barriers in the engine enclosure.

Engine noise reduction kits suitable for retrofit applications to limited engine models are available from a few major engine manufacturers. These kits consist of various acoustically treated panels and covers and provide a reduction of about 3 dB in engine noise only (as opposed to total vehicle noise level) at a cost of between \$50 to \$100 for material (45) and, typically, \$30 for installation. (37) Such kits are in limited production at this time and have not undergone complete durability testing. [52] They will be considered for suitability and availability whenever the proposed regulations are revised.

Air Induction System

Induction system noise is created by the opening and closing of the intake valve, which causes the volume of air in the system to pulsate. The associated noise levels are dependent upon the type of engine, the engine operating conditions, and whether it is turbocharged or naturally aspirated. [39] Typical intake noise levels vary from 70 to 80 dBA.

Intake noise reduction technology is very similar to that for exhaust noise reduction. Major manufacturers are able to provide assistance in proper selection of air intake systems for all popular engine models. [46] Retrofitting the intake systems of trucks in service consists of replacing older air cleaners with modern quality, dry element air cleaners. This would result in a cost of $100 - $130, on the average. [36] Intake cleaners and silencers are manufactured largely by the major muffler manufacturers, so that the production could be increased as described in the above discussion of mufflers.

Tire/Roadway Interaction

Truck tires for highway usage can be classified into two categories - rib tires and crossbar tires (also known as lug or cross rib). Rib tires have the tread principally oriented longitudinally around the tire (similar to automobile tires). This is the most common type of truck tire and can be used in all wheel positions;

however, they are almost exclusively utilized in steering axle positions because of their superior lateral traction and uniform wear characteristics. Crossbar designs have the tread elements principally arranged laterally and are popular for use on drive axles. These designs provide for up to 60 percent more tread depth due to the rigid cross elements. [47]

The physical mechanisms of the production of noise by tires and tire/roadway interaction are not completely understood. It is known that the entrapment and release of air from the tire tread cavities produces noise. [48] Also, it appears that the vibration of the tire contributes to the total noise level. [48] However, the effect of the large lugs on crossbar tires, and the effect of the road surface on the noise levels produced are not well quantified. The result is that basically all the noise information available has been obtained experimentally, and the tire manufacturers do not appear to be close to any major breakthrough that would result in crossbar tire design exhibiting significantly lower noise levels.

There seem to be no conclusive data that indicate any significant difference between the traction properties of rib and crossbar tires under dry, wet, or icy conditions. [49] Any difference is possibly in favor of using rib tires because they normally provide about 5 percent more rubber in contact with the road. However, in snow, sand, gravel, mud, or loose dirt, where the tire does not come into contact with a firm surface, there is an advantage to installing crossbars. [49]

There is no conclusive economic preference to the use of crossbar or rib tires. (50) A rib tire has a tread depth on the order of 17/32 inch and costs about $100. Its life is about 50,000 miles if it is worn down to 2/32 inch on a drive axle. An equal quality crossbar tire costing about $130 may have an initial tread depth of 27/32 inch and last typically 100,000 miles when reduced to 2/32 inch. At this point, some firms sell the carcasses (the rib possibly being worth more in this case) and buy new tires. Under this policy it is more economical (54 percent more mileage per dollar) to use crossbars. However, other firms choose to spend about $30 to recap the rib tire with an additional 17/32 inch tread and use it again, obtaining an overall life of 100,000 miles at a total cost of $140—the same as the original crossbar type. If the crossbar and rib carcasses (of equivalent quality) have been subjected to the same abuse, then they will have essentially the same number of miles left in them. Some trucking companies will use only new tires on drive axles and when they are half worn they will be removed and used on a trailer position until completely worn. They will then be recapped. Rib tires are thought by some to wear more quickly than crossbars in drive axle positions.

Extensive measurements of the noise level produced by tires mounted on the drive axle of a truck-tractor have been conducted by the National Bureau of Standards and the Department of Transportation (31) —see figure 5. (51) Typical values of the noise level measured at

50 feet are 68 dBA and 73 dBA at 35 miles per hour for new ribbed and crossbar tires respectively on a concrete roadway.[51] At 50 miles per hour these levels typically increase to 73 dBA and 80 dBA[51] respectively, although higher values are by no means uncommon. In general, ribbed tires produce lower noise levels than crossbar tires. The noise produced increases with tire wear, reaching a maximum value when the tread is approximately half worn.

Data indicate that some retread tires that exhibit a tread design composed largely of pockets that are not vented either around the tire or to the side produce excessive noise levels by allowing air to be trapped, compressed, and subsequently released as the pockets pass through the footprint area of the tire. These pocket retreads are responsible for noise levels exceeding 90 dBA at highway speeds.[51]

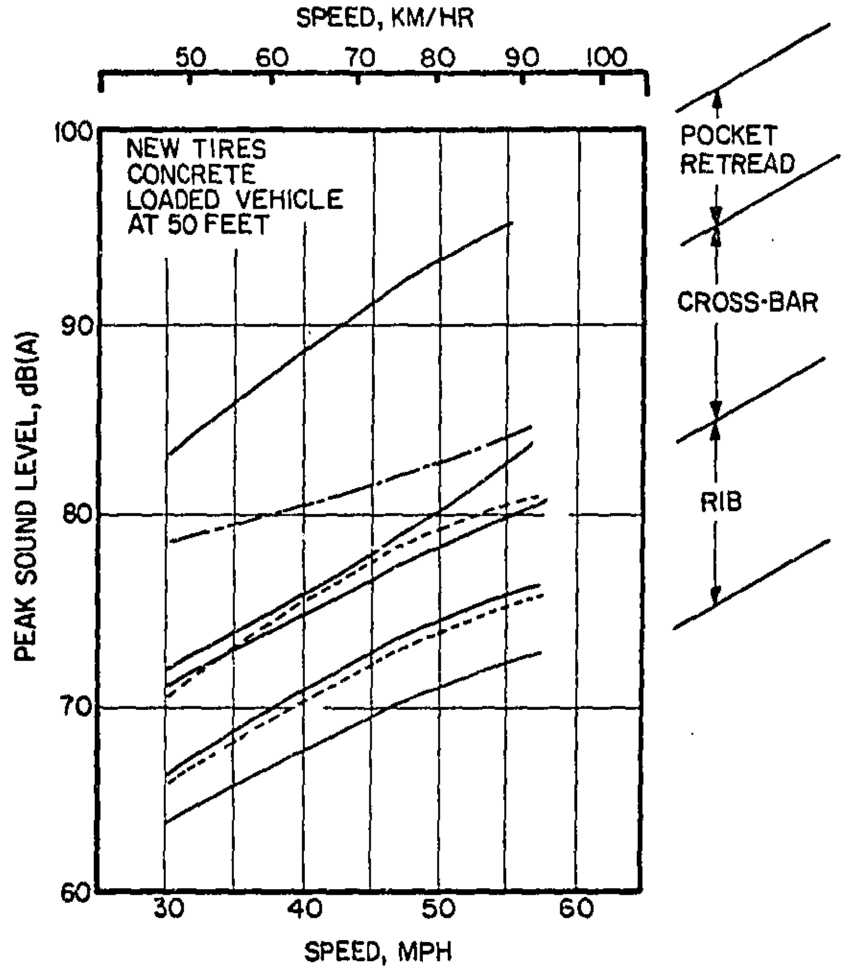


Figure 5. Peak A-weighted sound level, as measured at 50 feet, versus speed for a loaded single-chassis vehicle running on a concrete surface. Various types of new tires are represented on the graph. These were mounted on the drive axle.

Section 6

NOISE EMISSION STANDARDS

NOISE LEVELS FOR LARGE INTERSTATE MOTOR CARRIER VEHICLES

The noise control information given in the preceding section corresponds essentially to the state of available knowledge of retrofit technology for each individual noise source. To reduce the noise level produced by an existing vehicle, it is necessary to apply one or more of the modifications outlined--the number or type of modifications depending upon the vehicle in question and the overall noise reduction required. For example, more components of an old or poorly maintained truck would normally need to be modified than those of one in newer condition. Similarly, more treatment would be required to reduce the noise level of a vehicle to 84 dB(A) than would be required to reach 88 dB(A).

As stated in the discussion of motor carrier vehicle categories, most of the available data concerns large trucks with three or more axles, which are predominately diesel powered. Knowledge of some noise sources, such as tires, is of course applicable to other vehicles such as gasoline powered trucks and buses; and it is probable that knowledge of other noise sources such as cooling fans will prove applicable to all large vehicles. But the specific information available at present does not permit an enumeration of specific treatments, with associated costs, to produce predictable amounts of noise reduction for vehicles other than large multi-axle trucks. The data presented in Tables 1 and 2 and Figures 6, 7, 8, and 9 in this section are based upon studies of large multi-axle trucks that are primarily diesel powered. As discussed in Section 4, it can be assumed that any noise standard that is reasonable for such large trucks is feasible for other motor carrier vehicles, including buses.(58, 59)

Types of treatment that might be required to reduce noise emissions (other than noise emissions from the tire/road interaction) from trucks to various levels, and the associated costs per treatment, are listed in Table 1. The levels indicated correspond to noise emission at maximum engine speed (where noise other than tire noise is highest), measured at 50 feet. Since the noise levels of individual existing trucks vary, not all existing trucks requiring some treatment would require each of the treatments indicated to reach each noise level indicated. The percentage of trucks indicated in Table 1 to require each type of component change is based upon actual experience of a company that has been extensively engaged in retrofitting trucks to reduce noise emissions. The average cost per large multi-axle truck that requires treatment to meet each level is thus the sum of the percentage of trucks that require each treatment times the cost of that treatment, for each type of treatment. The average cost of bringing noise levels of existing multi-axle trucks down to 86 dB(A) is thus $114.

For comparison with the estimated retrofit costs, Figure 6 shows the typical costs actually incurred in the retrofit of over 7,600 large multi-axle trucks by that company. The agreement is good with the

TABLE 1 - ESTIMATED COSTS TO RETROFIT TRUCKS TO VARIOUS NOISE LEVELS (According to SAE J366a)

Noise Level dBA @ 50'	Required Treatment	Estimated Cost Per Item $	% Trucks exceeding specified noise level Requiring Component Change	Avg. Cost Per Truck Requiring Retrofitti
90	Exhaust[1]	50-100	100%	$50 - $100
				Total $50 - $100
88	Exhaust[1] Fan[2]	50-100 35	100% 5%	50 - 100 2 - 2
				Total $52 -$102
86	Exhaust[3] Fan[4] Intake[5]	100 80 115	100% 10% 5%	100 8 6
				Total $114
84	Exhaust[6] Fan[7] Intake[5] Engine[8]	100-200 285-400 115 80-130	100% 50% 25% 25%	$100 - $200 $143 - $200 $ 29 - $ 29 $ 20 - $ 33
				Total $292 - $462

1. Muffler and labor--single or dual system
2. Replaced fan blade
3. Mean cost for muffler and labor, plus additional cost for some trucks requiring replacement of flexible tubing, etc.
4. Replaced fan blade and added shroud
5. Average cost of dry element air cleaner with built-in silencer.
6. Muffler and replacement of feasible pipes--single or dual system
7. Viscous fan clutch and new fan blade in conjunction with shroud. Thermostatically controlled clutch.
8. Partial engine kit plus installation.

PERCENTAGE OF TRUCKS EXCEEDING A GIVEN NOISE LEVEL DURING TYPICAL HIGHWAY OPERATION — CALIFORNIA DATA

Noise Level dBA	% trucks exceeding noise level	
	Speeds 35 mph and less	Speeds greater than 35 mph
94	0	0
92	5	10
90	6	19
88	12	50
86	19	78
84	30	93
82	46	97

exception of the costs to achieve a noise level of 84 dB(A). At this level, the incurred costs are for a very small number of vehicles and the estimated costs are approximate. Experience in retrofitting trucks indicates that the noise level of almost all trucks on the road today can be reduced to an 86 dB(A) level; however, the noise level of only about 50 percent of existing multi-axle trucks could be brought down to 84 dB(A) using available hardware. To achieve this level on those trucks on which it can be achieved, engine enclosures would often be required. This type of hardware is not currently available in the large quantities that would be required by an 84 dB(A) standard, nor has it been fully tested on in-service trucks. The completion of tests on such hardware and the establishment of production distribution systems for large quantities of enclosures for specific application will require an inestimable lead time. The company estimates that from their very limited experience with engine enclosures in achieving noise levels of 84 dB(A) that it would cost about $950 per truck to bring large multi-axle diesel trucks down to that level, if adequate hardware for that purpose were available and if the safety and maintenance aspects of the enclosure configuration were established. For application to significant numbers of trucks, additional lead time would be required to establish a production base and supply system to retrofitters.

"BEST AVAILABLE TECHNOLOGY, TAKING INTO ACCOUNT THE COST OF COMPLIANCE"

These terms have been defined for purposes of this proposed regulation as follows:

"Best available technology" is that noise abatement technology available for retrofit application to motor carriers that produce meaningful reduction in the noise produced by interstate motor carriers. "Available" is further defined to include:

1. Technology applications that have been demonstrated and can be retrofitted on existing trucks.

2. Technology for which there will be a production capacity to produce the estimated number of parts required in reasonable time to allow for distribution and installation prior to the effective date of the regulation.

3. Technology that is compatible with all safety regulations and takes into account operational considerations, including maintenance, and other pollution control equipment.

The cost of compliance means the cost of identifying what action must be taken to meet the specified noise emission level, and the additional cost of operation and maintenance. The cost for future replacement parts was also considered.

Summarizing the discussion of truck noise other than the tire noise leads to the following major conclusions:

1. Nearly all existing large trucks can be retrofitted to achieve a noise level of 86 dB(A) under 35 mph.

2. A large proportion of the trucks that presently exceed 84 dB(A) under 35 mph could not be brought to this level using current available hardware or technology without extreme modifications, e.g., total encapsulation or replacement of the engine.

3. The costs associated with retrofitting large multi-axle diesel trucks increase greatly between the levels of 86 dB(A) and 84 dB(A).

4. Large multi-axle diesel trucks constitute the most severe interstate motor carrier noise problem. Any noise standard that is reasonable for them to meet can be assumed to be reasible for other interstate motor carrier vehicles to meet. It is therefore possible to hold all interstate motor carrier vehicles over 10,000 pounds GVWR or GCWR to the standard set on the basis of the noisiest trucks for an interim period. When more information is available on feasible noise standards for various subcategories of interstate motor carrier vehicles, the proposed regulation can be revised to incorporate such information.

Accordingly, the conclusion can be reached that the noise emission level that existing trucks can be expected to achieve, exclusive of tire noise, after the application of the best available technology, taking into account the cost of compliance, is 86 dB(A), for speeds less than 35 miles per hour. Based on the truck survey data from California in 1965 discussed earlier in this section (see Table 2), 19 percent of the large multi-axle diesel trucks in operation today will not initially comply with the noise standard. Non-diesel trucks and other vehicles will generally require much less treatment to meet the standard than diesel trucks and, consequently, will incur much smaller average costs. Most of them meet the proposed standard now, and those that do not will rarely require more than a new muffler to meet the proposed low speed standard.

Since the noise characteristics of large vehicles differ at low and high speeds--the propulsion system noise dominating the former and the tire noise the latter--it is necessary to set different noise standards for low and high speed operation so that both major noise sources will be covered. At speeds greater than 35 miles per hour, the noise levels produced by trucks complying with the 86 dB(A) low speed standard will normally exceed 86 dB(A) because of the increase in the tire noise contribution. Examination of the noise distribution of trucks operating on the highway--see Figure 3--shows that the same number of trucks that exceed 86 dB(A) at speeds less than 35 miles per hour exceed 90 dB(A) at speeds greater than 35 miles per hour. In most cases, trucks that can comply with the low speed noise standard can also comply with a 90 dB(A) noise level at high speeds. Some trucks equipped with the noisier types of cross-bar tires will exhibit higher noise levels and would be required to install alternative cross-bar or rib tires, particularly on the drive axles. Trucks equipped with pocket retread tires will normally exceed the proposed regulation of 90 dB(A) at speeds in excess of 35 miles per hour--see Figure 2. The 90 dB(A) high speed standard will therefore effectively remove this type of tire from highway use. It is therefore appropriate to incorporate into the regulation a visual inspection clause to restrict the use of pocket retread tires.

In many cases, trucks will exceed the proposed noise standards because of poorly maintained exhaust systems. Accordingly, it is considered that the proposed regulation should contain a clause allowing for a visual inspection of the exhaust system.

When heavy trucks are operated at speeds of 35 miles per hour or less, they are often in urban or suburban areas. It is during this phase of their operation that truck noise emissions can have a major impact on the public due to the large population densities in these areas. Under certain conditions of highway grade and constant speed less than 35 miles per hour, trucks can be operated in a manner that will minimize exterior noise emissions. The principal variable in attaining these lower levels is operator technique.

Trucks designed or retrofitted to the recommended 35 miles per hour all-conditions pass-by test level of 86 dB(A), if operated in a quiet manner, would emit exterior sound levels of 80 dB(A) or less. As shown in Figure 9, the percentage of vehicles that could not comply with a level of 80 dB(A) on level roadways is approximately the same as the percentage of vehicles not complying with the two recommended noise emission standards at 86 and 90 dB(A) discussed earlier.

An 80 dB(A) level does not impose an additional cost to the industry above that which is required to meet the other recommended noise control levels, but it does require quiet operation in areas where population densities are generally high.

STATIONARY RUN-UP TEST

The Federal enforcement of the proposed noise regulation will be undertaken by inspectors from the Bureau of Motor Carrier Safety (BMCS) of the Department of Transportation (DOT). Four possible enforcement strategies were considered. These are:

1. Enforcement at the time the owner first receives the vehicle
2. Enforcement at random times at the vehicle depot
3. Enforcement during normal operation on the highway
4. Enforcement at specific roadside locations, such as weigh stations.

Enforcing the noise regulation at the time of initial (or subsequent) sale would not take into consideration that the noise level produced by a motor vehicle may increase with age as a result of poor maintenance or improper selection or replacement of parts. Enforcement at the vehicle depots would lead to significant logistic problems due to the wide dispersion of depots. The noise regulation could be enforced by setting up measurement locations alongside major highways and monitoring the noise produced by each vehicle as it passes through the site. This is the method adopted by the California Highway Patrol and other enforcement agencies who have "curbing" power, or , the ability to pursue and apprehend offending operators. The DOT inspectors do not have this power, but they do have the power to inspect vehicles at roadside weighing stations. This form of enforcement requires a method of measuring the noise produced by the vehicle while in the weighing station such that the noise levels correlate well with those measured for typical operation on the highway. Lack of space at the weighing station indicates that this should be a test conducted with a stationary vehicle. Such a stationary test procedure has been developed by the motor vehicle manufacturers through the Society of Automotive Engineers. Though the test procedure has only been documented on 877 trucks, the results indicate a close relationship with the SAE J366a test, and it is considered acceptable by DOT. It consists of running the engine from idle to stabilized governed engine speed with rapid application of the throttle. The noise level measured is the maximum value observed during the test.

No such stationary test is recommended for vehicles that use engines without engine speed governors (ungoverned engines) for the following reasons:

1. The operator variability (including tachometer error) in achieving horsepower rated rpm.
2. The variability of manufacturer specified horsepower rated rpm.
3. The likelihood of catastrophic engine failure when an ungoverned engine is rapidly accelerated to such high speeds.

None of these drawbacks exists for governed truck engines. Since it is the diesels and big gasoline engines that normally produce the highest noise levels (exclusive of purposefully modified exhaust systems) and since these engines are normally equipped with engine speed governors, the fact that this test procedure is limited to such vehicles will not reduce the effectiveness of the overall regulation.

The noise level of a truck measured according to the above stationary procedure is about 2 dB greater than the noise level produced in the course of typical acceleration at low speeds (less than 35 miles per hour). Therefore, a noise level of 88 dB(A) measured according to the stationary test procedure is considered approximately equivalent to a level of 86 dB(A) measured on the highway during acceleration at speeds less than 35 miles per hour.

TIME FOR COMPLIANCE

In determining the amount of time required for trucks to apply some retrofit solution--if they exceed the proposed noise emission standards--the following factors must be taken into account:

1. The availability of replacement hardware--mainly mufflers and quiet tires
2. The replacement cycle for items that need to be replaced.

In many cases, the action required to bring a noisy truck into compliance with a proposed noise emission regulation would be the replacement or installation of a suitable muffler. Replacement mufflers are provided by the original equipment manufacturers as well as by the replacement equipment manufacturers. In general, the industry is capable of increasing its output of mufflers, probably by a factor of two, because it has the additional facilities and material necessary.[38]

The life of a muffler depends greatly on the actual truck operation, but is on the order of one to two years. Therefore, to a first approximation, one-half of the trucks will install new mufflers every year.

In contrast, the tire industry is at present striving just to maintain a sufficient supply for the demands of the trucking companies. The life of a cross-bar tire as installed on a "line-haul" truck is not usually greater than 100,000 miles, which corresponds to a tire tread life of approximately one year.

Considering all of the information given leads to the conclusion that the majority of trucks can be modified to comply with the proposed noise emission standards within one year from promulgation of the regulation. It should be noted that the estimated costs for compliance do not take into account the normal replacement cycle for mufflers, since such repalcements are not related to these costs.

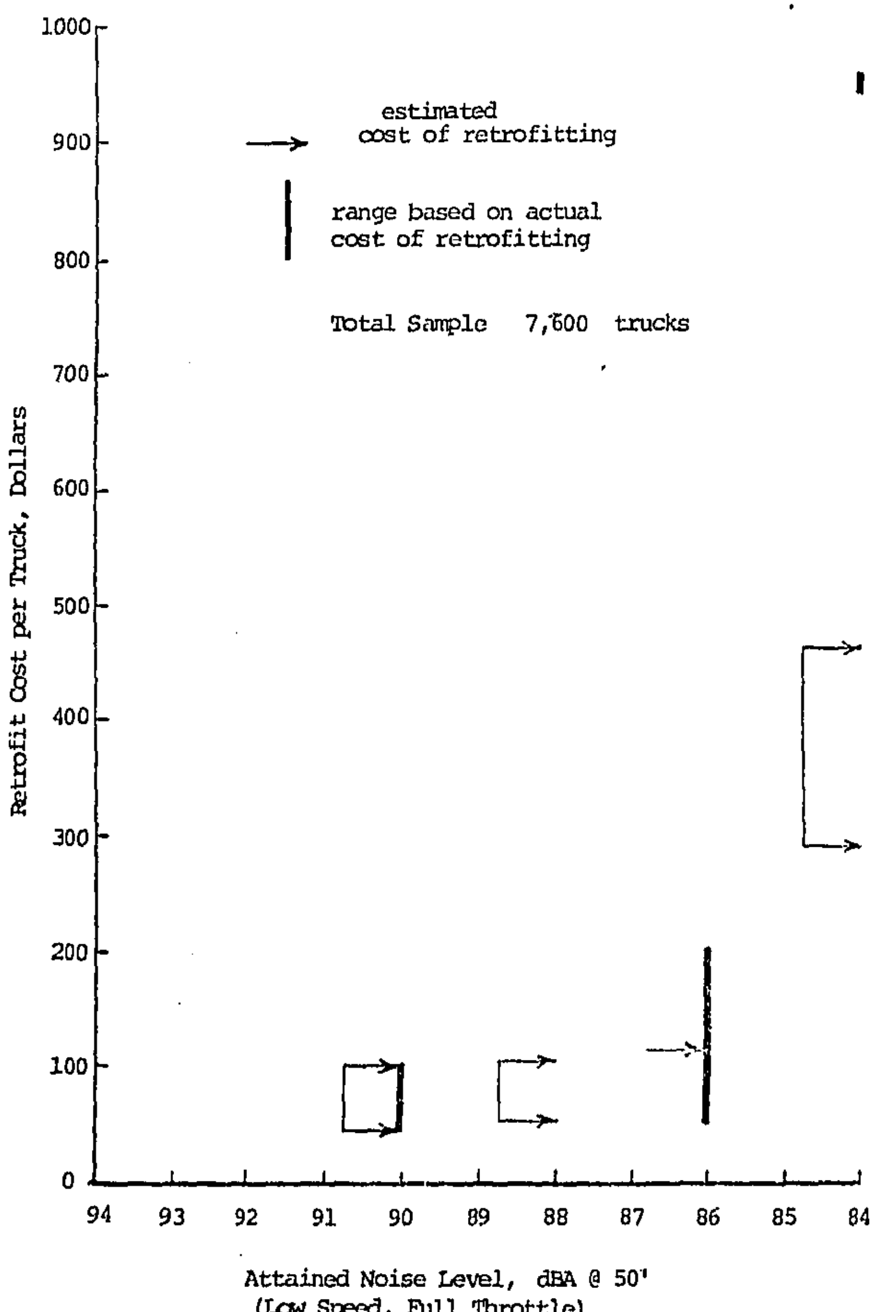


Figure 6. Estimated and Actual Cost Incurred in Retrofitting Trucks to Various Noise Levels

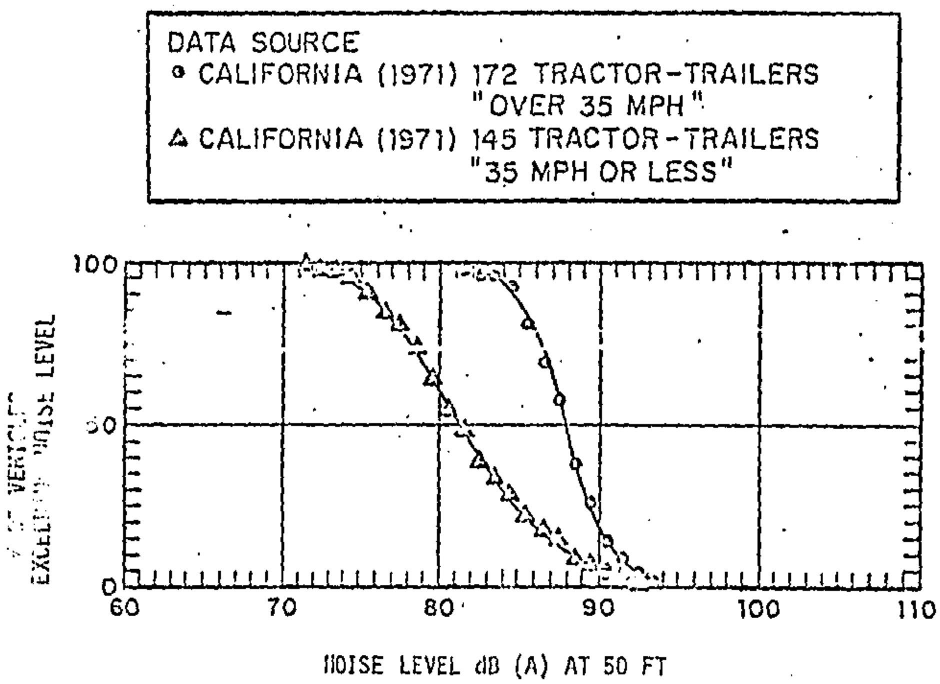


Figure 7. Tractor-Trailer Noise Emission Distributions at 35 mph and over 35 mph

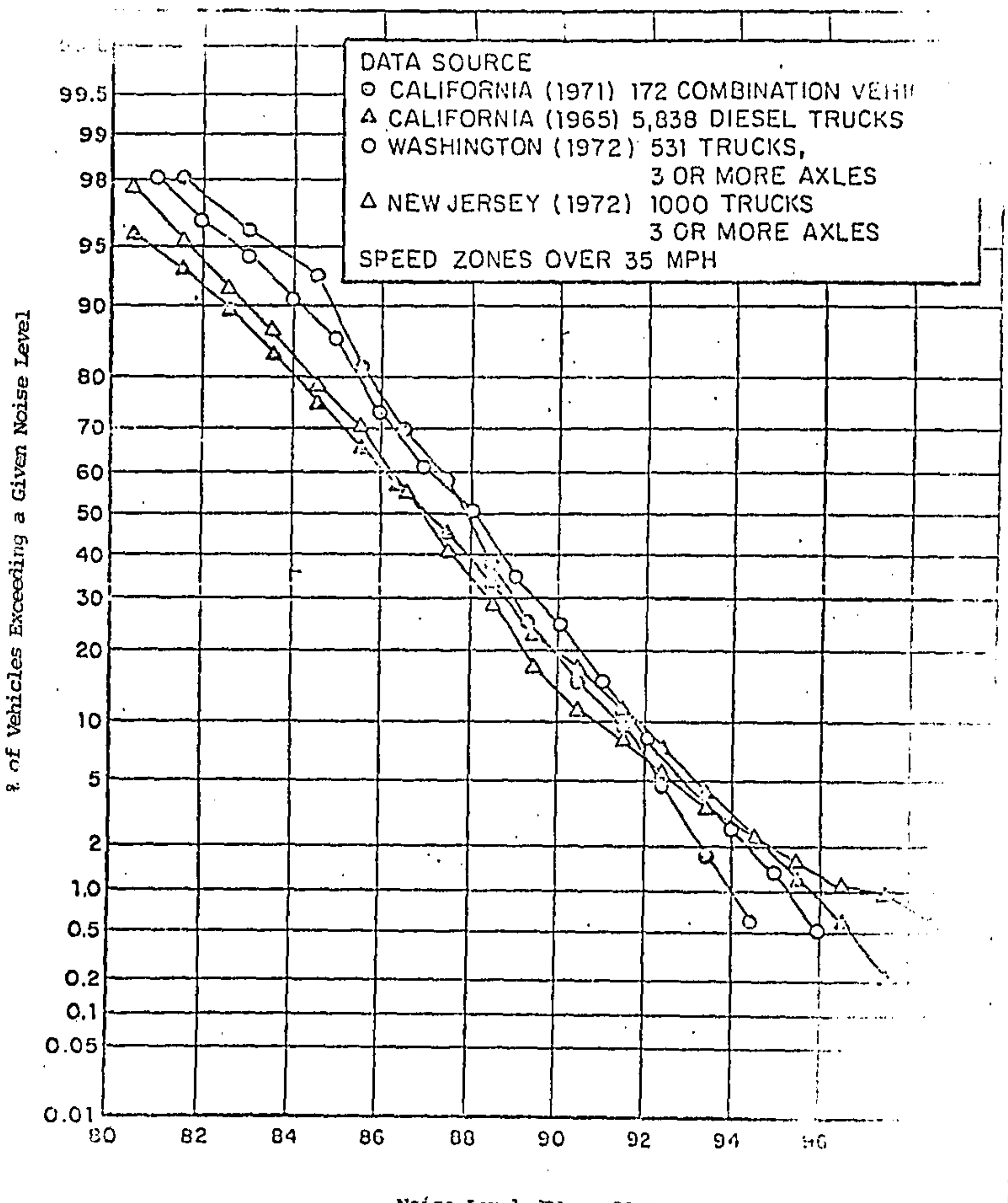


Figure 8. Truck Noise Emission Road Side Survey Da... 35 mph.

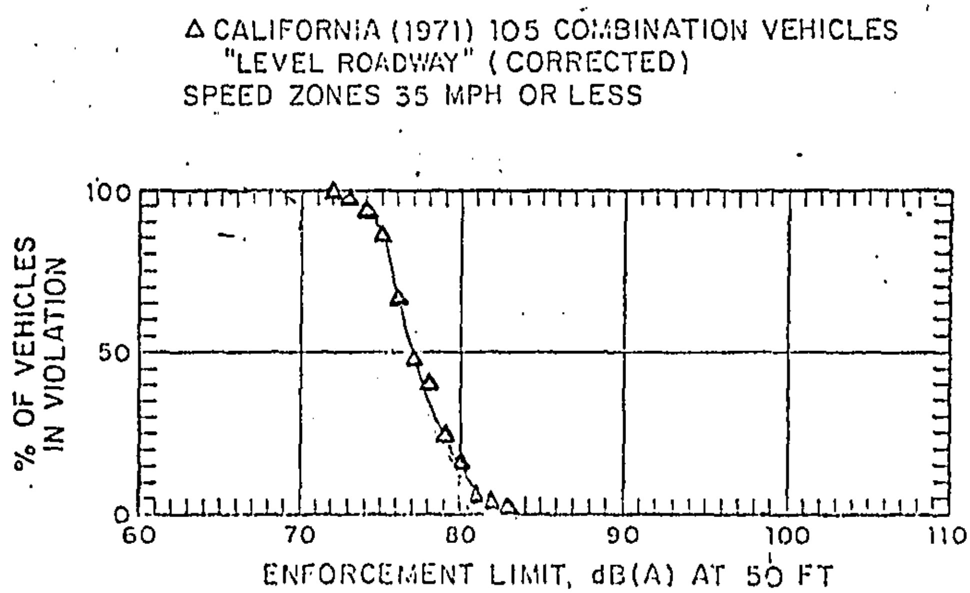


FIGURE 9. Tractor-Trailer Noise Emission Distribution at 35 mph or Less on Level Roadways.

Section 7

ECONOMIC IMPACT OF THE PROPOSED REGULATIONS

DIRECT RETROFIT COST

In order to relate individual truck retrofit costs to the total impact on the industry, the number of trucks engaged in interstate commerce over 10,000 pounds GVWR must be determined. There is no direct method for making this determination. A reasoned judgement was made based on truck population statistics, industry information, and inputs to the Advance Notice of Proposed Rule Making Docket that approximately 1 million trucks over 10,000 lb GVWR or GCWR were engaged in interstate commerce.[55, 54, 1,2]

As discussed in Section 6, the primary impact of the proposed regulation will be on large multiaxle trucks, which are primarily powered by diesel engines. Section 6 shows an estimated average cost of $114 (with a range of $50 to $200) to bring into compliance those trucks with 3 or more axles that are not presently in compliance with the proposed regulation. Figure 8, a survey of diesel trucks in California in 1965 (before that state had any noise regulation that might influence the data), shows that 19% of those trucks would be in violation of the proposed standard. Data from New Jersey and Washington (figure 8), support this figure of about 19% of multi-axle diesel trucks that would be in violation of the proposed standard. (See Appendix A for data on the percentage of vehicles that might initially be in violation of the proposed standards that have been accumulated for EPA since the date of publication of the proposed regulation).

The $114 average cost per truck shown in Section 6 is for those approximately 19% of the trucks (3 axles and over) that are expected initially to be in violation of the proposed standard. The mean direct retrofit cost to the industry is therefore $22 million dollars, with a range of $10 to $38 million dollars.

For a truck running 50,000 revenue miles per year, a $114 retrofit cost represents an increased expense of $0.002 per revenue mile when amortezed over a single year. When this increase is compared with current average expenses of $1.20 per revenue mile (see Section 2), it can be seen that cost is not an obstacle to lower noise emission standards.

OTHER COST CONSIDERATIONS

Additional costs include loss of revenue resulting from trucks being out of service during retrofit. The installation of a suitable muffler may increase the back pressure on the engine and in turn increase the fuel consumption. Considering the wide variety of mufflers available for different types of engines, a significant increase in back pressure is avoidable.[46]

There are also some factors that reduce the total cost. First, the muffler on a line-haul truck is normally replaced at 1-1/2 to 2 year intervals. Thus, of those trucks that require a replacement muffler about one-half will be installing a new muffler even in the absence of the regulations. In these cases, the cost incurred will be the difference between that for the required muffler and that for the one that would have been installed, the difference in cost being in the range of a few dollars.

Secondly, for those trucks requiring installations of a more efficient fan, the amount of engine power wasted in driving the fan will be reduced. Standard diesel fans typically consume 15-25 horsepower.[56] In particular, the addition of a thermostatically controlled fan clutch can decrease the fuel consumption by 1 to 1.5% and can reduce operating cost for the life of the truck. With these considerations, the long term cost of compliance with the noise regulations may be less than that given above.

Section 8

ENVIRONMENTAL IMPACT OF PROPOSED REGULATION

POSITIVE EFFECTS

The proposed regulation impacts directly on those trucks that presently make the most noise and requires that they be quieted to levels that are feasible from a cost and technology standpoint within one year of final promulgation. The principal noise reduction will be of the intrusive "noise peaks", which have been widely acknowledged as more objectionable to people than much lower levels of continous noise.[21] These peaks can be 12 dB or more above ambient highway noise level.[20] The benefit of noise reduction is to be realized in 1 year or less.

A significant increase in truck fuel economy will also be realized for those trucks that require installation of more efficient fans to meet the proposed noise emission standard. As described in Section 7, thermostatically controlled fan clutches that engage the fan only on engine cooling demand can decrease fuel consumption throughout the life of the truck.

NEGATIVE EFFECTS

There may be a slight increase in the number of older trucks retired from service; and that would therefore suddenly increase the solid waste disposal problem by the number of trucks scrapped. Following this, the scrappage rate would decrease as a result of the younger population of trucks. However, a small net increase on total trucks scrapped would be obtained - an increase related to the number of truck years lost from service. Because the net increase in scrappage would be small, and because of the ready market for steel, adverse environmental effects would be minimal.

There will be no anticipated increase in scrap tires resulting from these regulations. The pocket tread design tire that the regulation excludes from highway use is not in wide use, and those currently installed and in stock would wear out prior to the effective date of the regulation. In some installations of a quieter muffler, there may be an increase in back pressure on the engine and a resulting decrease in fuel economy. As discussed in Section 6, a significant increase in back pressure is avoidable in almost all cases by a muffler matched to a particular engine.

APPENDIX A

TRUCK NOISE EMISSION DATA AND ANALYSIS

Subsequent to the issuance of the proposed regulation, a substantial additional body of recent vehicle noise survey data has now been analyzed. This body of data was obtained in 10 states, in which approximately 39 percent of all U.S. trucks and buses are registered. For 9* of these 10 states, the data permitted an assessment of the percentages of various types of trucks that would exceed the proposed standards. From the analysis, it was concluded that:

1. An average of 23 percent of all observed trucks above 10,000 pounds GVWR or GCWR exceeded the proposed standards (Table A-1).

2. The mean percentage of observed trucks exceeding the proposed standards varied significantly by type of truck: 1.9 percent for two-axle straight trucks, 10.8 percent for three-axle combination trucks, 15.0 percent for four-axle combination trucks and 36.1% for 5-axle combination trucks (Table A-2).

3. The range of percentages of trucks observed in the nine states that exceeded the proposed limits was substantial: 0.6 to 3.5 percent for two-axle straight trucks above 10,000 pounds GVWR, 1.2 to 26.0 percent for three-axle straight trucks,

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*California, Colorado, Illinois, Kentucky, Maryland, New Jersey, New York, Pennsylvania, Texas

**The average of 23.1 percent calculated in Table A-1 is an arithmetic mean of percentages exceeding the proposed standards in various states, unweighted by sample size.

1.0 to 26.0 percent for three-axle combination trucks,

3.0 to 26.0 percent for four-axle combination trucks,

and 7.0 to 74.0 percent for five-axle combination trucks (Table A-2).

4. According to the 1972 Census of Transportation - Truck Inventory and Use Survey (Department of Commerce, Bureau of the Census), the total population of registered trucks above 10,000 lbs. GVWR or GCWR is distributed approximately as follows:

   72.1 percent two-axle straight trucks,

   10.3 percent three-axle straight trucks,

   2.4 percent three-axle combination trucks,

   5.5 percent four-axle combination trucks,

   8.0 percent five-axle combination trucks, and

   1.7 percent other or unspecified types.

5. Multiplying these percentages by the mean percentage of each type exceeding the proposed standards reveals that approximately 7 percent of all registered trucks above 10,000 lbs. GVWR or GCWR exceed the proposed standards (Table A-3).

6. The apparent discrepancy between the 23 percent of trucks observed on the road and the 7 percent of all registered trucks above 10,000 lbs. GVWR or GCWR that exceed the proposed standards results from the fact that combination trucks travel many more road miles per vehicle per year than straight

trucks do. For example, five-axle combination trucks constitute approximately 50 percent * of the trucks observed on a typical interstate highway, even though they represent only 8 percent of all registered trucks in the weight class under consideration.

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[3]For the nine of ten States represented in the new data base where the data allow for a breakdown by axle category, of the 6,875 total trucks over 10,000 pounds GWVR/GCWR, 4,098 or 59.5 percent were 5-axle trucks.

Table A-1

SUMMARY OATH FOR ALL TRUCKS ABOVE 10,000 LBS GVWR OR GCWR

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	91.0 dB(A)	92.0 dB(A)
CA	W.L.	85.4dB(A)(a)	-	5.0%	3.0%	1.5%
CO	BBN	84.6	51.7mph	10.0	4.5	2.0
IL	BBN	89.1	57.2	42.0	21.0	15.0
KY	BBN	88.8	61.3	40.0	30.0	21.0
MD	Md.DOT	88.1	-	30.0	21.0	14.5
NJ	BBN	87.2	56.5	20.0	12.0	7.0
NY	BBN	88.8	60.0	43.0	30.0	18.0
PA	W.L.	86.2(a)	-	13.0	8.0	5.0
TX	BBN	83.7	56.1	12.5	7.5	4.0
WA	WA-72	86.6(a)	-	16.0	9.0	6.0

mean percentage exceeding given noise level:

				23.1%	14.6%	9.4%

(a) median

Table A-2

SUMMARY OF TRUCK NOISE EMISSIONS BY TYPE OF TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	% Above 91.0 dB(A)	% Above 92.0 dB(A)
CA	W.L.	81.0dB(A)(a)	-	1.2%	0.6%	0.3%
CO	BBN	80.4	50.9mph	1.9	1.0	0.5
IL	BBN	83.1	55.7	1.0	0.3	0.1
KY	BBN	82.9	57.7	1.0	0.3	0.1
MD	Md.DOT	83.9	-	3.5	1.6	0.8
NJ	BBN	82.3	55.7	0.6	0.2	0.1
NY	BBN	85.1	59.4	6.0	3.3	1.9
PA	W.L.	81.2(a)	-	0.9	0.4	0.2
TX	BBN	78.6	54.6	0.6	0.3	0.1
mean percentage exceeding given noise level:				1.9%	0.9%	0.5%

3 AXLE STRAIGHT TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	% Above 91.0 dB(A)	% Above 92.0 dB(A)
CA	W.L.	85.2(a)(b)	-	8.0	4.0	2.0
CO	BBN	84.1	47.7	1.2	0.4	0.1
IL	BBN	85.8	54.5	9.0	4.5	2.0
KY	BBN	87.7	59.9	*	*	*
MD	Md.DOT	87.5	-	*	*	*
NJ	BBN	84.7	57.4	*	*	*
NY	W.L.	88.0(a)(b)	-	26.0	17.0	11.0
PA	W.L.	84.5(a)(b)	-	2.0	0.9	0.3
TX	BBN	84.8	50.6	*	*	*
mean percentage exceeding given noise level:				9.3%	5.4%	2.7%

3 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	% Above 91.0 dB(A)	% Above 92.0 dB(A)
CA	W.L.	85.2(a)(b)	-	8.0	4.0	2.0
CO	BBN	83.8	51.9	*	*	*
IL	BBN	86.0	55.7	*	*	*
KY	BBN	87.8	59.0	*	*	*
MD	Md.DOT	86.6	-	17.0	11.0	7.0
NJ	BBN	85.7	57.2	1.0	0.3	0.1
NY	W.L.	88.0(a)(b)	-	26.0	17.0	11.0
PA	W.L.	84.5(a)(b)	-	2.0	0.9	0.3
TX	BBN	83.0	56.5	*	*	*
mean percentage exceeding given noise level:				10.8%	6.6%	4.1%

(a) median
(b) all 3 axle trucks
* insufficient data

Table A-2 (Continued)

4 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	% Above 91.0 dB(A)	% Above 92.0 dB(A)
CA	W.L.	84.2(a)	-	3.0%	2.0%	1.2%
CO	BBN	84.8	49.0	9.0	4.0	1.4
IL	BBN	87.1	55.4	22.0	15.0	9.0
KY	BBN	88.0	61.0	24.0	13.0	6.0
MD	Md.DOT	87.9	-	26.0	19.0	12.5
NJ	BBN	86.7	57.7	11.0	6.0	2.5
NY	BBN	88.8	58.8	26.0	13.0	7.0
PA	W.L.	85.7(a)	-	9.0	3.5	2.0
TX	BBN	83.9	56.4	4.5	2.0	1.0
mean percentage exceeding given noise level:				15.0%	8.6%	4.7%

5 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)	% Above 91.0 dB(A)	% Above 92.0 dB(A)
CA	W.L.	85.9(a)	-	7.0	3.5	1.6
CO	BBN	87.0	53.7	18.0	8.0	3.0
IL	BBN	90.2	57.7	51.0	38.0	26.0
KY	BBN	90.6	62.6	56.0	42.0	30.0
MD	Md.DOT	89.7	-	42.0	31.0	21.0
NJ	BBN	88.3	58.7	32.0	20.0	12.0
NY	BBN	91.2	61.6	74.0	56.0	34.0
PA	W.L.	87.6(a)	-	22.0	14.0	9.0
TX	BBN	87.5	57.9	23.0	14.0	8.0
mean percentage exceeding given noise level:				36.1%	24.9%	16.0%

(a) median

Table A-3
ESTIMATED NUMBER OF TRUCKS AFFECTED

	% of all trucks above 10,000 lbs	% of type exceeding 90.0 dB(A)	% of all trucks above 10,000 lbs affected
2 axle straight truck	72.1%	1.9%	1.37%
3 axle straight truck	10.3	9.3	0.96
3 axle combination	2.4	10.8	0.26
4 axle combination	5.5	15.0	0.83
5 axle combination	8.0	36.1	2.90
All other (a)	1.7	36.1(b)	0.61
			6.93%

	% of all trucks above 10,000 lbs	% of type exceeding 91.0 dB(A)	% of all trucks above 10,000 lbs affected
2 axle straight truck	72.1%	0.9%	0.65%
3 axle straight truck	10.3	5.4	0.56
3 axle combination	2.4	6.6	0.16
4 axle combination	5.5	8.6	0.47
5 axle combination	8.0	24.9	1.99
All other (a)	1.7	24.9(b)	0.42
			4.25%

	% of all trucks above 10,000 lbs	% of type exceeding 92.0 dB(A)	% of all trucks above 10,000 lbs affected
2 axle straight truck	72.1%	0.5%	0.36%
3 axle straight truck	10.3	2.7	0.28
3 axle combination	2.4	4.1	0.10
4 axle combination	5.5	4.7	0.26
5 axle combination	8.0	16.0	1.28
All other (a)	1.7	16.0(b)	0.27
			2.55%

(a) "All other" includes straight truck with trailer, combinations with 6 or more axles, and unspecified combinations.

(b) No data available. Percentages exceeding various noise levels assumed to be the same as for 5 axle combinations.

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