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BACKGROUND DOCUMENT
FOR
INTERSTATE MOTOR CARRIER NOISE EMISSION REGULATIONS

OCTOBER 1974

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

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PREPARED BY

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Section 1

EPA STRATEGY FOR CONTROL OF MEDIUM AND HEAVY DUTY MOTOR VEHICLE NOISE

In March, 1974, in accordance with Section 5(a)(2) of the Noise Control Act of 1972, EPA published a document in which levels of environmental noise requisite to protect public health and welfare were identified[1]. Since EPA studies have shown that actual environmental noise levels in many parts of the country exceed the levels identified as desirable, a Federal strategy is being developed to control environmental noise.

NOISE LEVELS PROTECTIVE OF PUBLIC HEALTH AND WELFARE

As part of the identification of noise levels protective of public health and welfare, EPA has selected the noise measures it believes are most useful for describing environmental noise and its effects on people.

Environmental noise is defined in the Noise Control Act as "the intensity, duration and the character of sounds from all sources." The measures for characterizing environment noise must, therefore, evaluate these factors. However, the measures must also predict human response and be simple to monitor if they are to be useful. EPA has chosen two cumulative equivalent sound level measures as its basic indicators of noise that constitutes a long-term hazard to public health and welfare. The first measure is the equivalent sound level (L_{eq}), which is the constant sound level (dBA) that in a given situation and time period would convey the same sound energy as does the actual time-varying sound; L_{eq} is used as an indicator of long-term hazard to hearing. A variation of L_{eq}, the day-night sound level (L_{dn}) is the equivalent sound level during a 24 hour period with a 10 dB(A) penalty added to events occurring between the hours of 10 p.m. and 7 a.m. to account for the increased annoyance caused by noise at night; L_{dn} is used as an indicator of long-term annoyance.

The relationships between environmental noise and human response have been quantified using the simple measures described above. The human response examined was a combination of such factors as hearing interference, sleep interference, speech interference, desire for a tranquil environment and the ability to use telephones, radios, and TV satisfactorily.

The levels identified by EPA as desirable from a public health and welfare viewpoint are predicated on minimizing the average number of people who may experience an adverse reaction to noise as a result of extended exposure. However, different individuals do not have the same susceptibility to noise. Even groups of people may vary in response depending on previous exposure, age, socio-economic status, political cohesiveness and other social variables. In the aggregate, however, the average response of groups of people is predictable and related to cumulative noise exposure as expressed by L_{dn} or L_{eq}.

Detailed discussions of the relationships between environmental noise and human response is provided in the EPA document Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. Desirable outdoor noise levels are summarized in Table 1 in terms of yearly equivalent levels which, if not exceeded, would be safe from a health and welfare viewpoint. Public health and welfare for the purpose of this analysis was defined so as to include personal comfort, well-being, and the absence of clinical symptoms.

TABLE 1

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY.[2]

Effect	Level in dB	Area
Hearing Loss	$L_{eq(24)} \leq 70$	All Areas
Activity Interference Outdoors	$L_{dn} \leq 55$	Residential Areas

ACTUAL NOISE LEVELS IN RESIDENTIAL AREAS

Studies have been performed to measure the noise levels in residential areas and to estimate the number of people subjected to noise in those areas. Table 2 contains estimates of the number of people residing in urban areas which are exposed to noise principally caused by urban traffic, freeway traffic, and aircraft operations.

TABLE 2

ESTIMATED CUMULATIVE NUMBER OF PEOPLE IN MILLIONS IN THE UNITED STATES RESIDING IN URBAN AREAS WHICH ARE EXPOSED TO VARIOUS LEVELS OF OUTDOOR DAY/NIGHT AVERAGE SOUND LEVEL[3]

Outdoor L_{dn} Exceeds	Urban Traffic	Freeway Traffic	Aircraft Operations	Total
60	59.0	3.1	16.0	78.1
65	24.3	2.5	7.5	34.3
70	6.9	1.9	3.4	12.2
75	1.3	0.9	1.5	3.7
80	0.1	0.3	0.2	0.6

The data in the table clearly indicate that motor vehicles are the principal source of environmental noise in urban areas.

EPA REGULATORY STRATEGY FOR MOTOR VEHICLES

Accordingly, EPA has developed a regulatory strategy that places high priority on the control of motor vehicle noise. As part of the development of the strategy, studies were performed for EPA that provide information on the relative noise contribution of different kinds of motor vehicles to traffic noise levels in urban areas. Table 3 gives information on the typical sound level at 50 feet of seven types of motor vehicles and also indicates the estimated total daily sound energy emitted into the environment by all in-service vehicles of each type. For the purpose of the analysis, trucks and automobiles were divided into groups having different noise emission and technology characteristics. Light trucks were separated from medium and heavy duty trucks because they have a higher power-to-weight ratio and are quieter in normal operation. Large passenger cars were separated from compact and sports cars for the same reason.

TABLE 3

Motor Vehicles	Typical Sound Level dB (A) at 50 feet	Estimated Total Sound Energy KW-Hrs/Day
1. Trucks (medium & heavy)	84	5800
2. Automobiles (sports, compacts)	75	1150
3. Automobiles (passenger)	69	800
4. Trucks (light, pickup)	72	570
5. Motorcycles (highway)	82	325
6. Buses (city and school)	73	20
7. Buses (highway)	82	12

The sound level (dB(A)) at 50 feet is a measure that suggests which motor vehicles will be perceived as noisy by the community when they are operated alone. The daily total sound energy emission is useful because it is an aggregate measure that takes into account the sound energy emission rate of the vehicle, the number of vehicles operating, and the amount of time they are operated each day. Neither measure directly relates human exposure or response to the vehicle's noise emission; but when several kinds of vehicles are operated in similar situations, these two measures serve to indicate which are the major sources of noise.

The data in Table 3 clearly indicates that medium and heavy duty trucks contribute more sound energy to the environment than any other type of highway vehicle and that an individual truck will typically be perceived to be louder than some other type of motor vehicle. These values are a composite of noise emitted in both urban traffic conditions and on freeways, and there can be little doubt that medium and heavy duty trucks are the major contributor to traffic noise in many situations.

The Noise Control Act contains two sections of primary importance for the control of motor vehicle noise. Section 6 contains authority by which EPA may promulgate product noise emission standards for new motor vehicles that are applicable at the time of sale of such vehicles.

Section 18 of the Act requires EPA to promulgate noise emission regulations that include "noise emission standards setting such limits on noise emissions resulting from operation of motor carriers engaged in interstate commerce which reflect the degree of noise reduction achievable through the application of the best available technology, taking into account the cost of compliance."

Accordingly, EPA has developed and is now implementing a motor vehicle noise control strategy based on sections 6 and 18 of the Act that should prove to be effective in reducing environmental noise in many areas to the levels identified as protective of public health and welfare. The strategy calls first, for the reduction, within one year of the promulgation of these regulations under section 18, of the noise from vehicles over 10,000 pounds GVWR/GCWR operated by motor carriers engaged in interstate commerce, to the lowest noise level consistent with the noise abatement technology available for retrofit application during the one year period, taking into account the cost of compliance.

Subsequently, under section 6, new product noise emission standards will be proposed for medium and heavy duty trucks, and it is contemplated that the new product standards will be maintained for new trucks beyond the initial point of sale through subsequent modification of these initial Interstate Motor Carrier Regulations pursuant to section 18 to require that vehicles manufactured to comply with new product performance standards and used in interstate commerce shall maintain the lower noise emission levels during operation.

Additionally, it is anticipated that the performance standards in the interstate motor carrier regulations relating to older vehicles will be made more stringent as more advanced retrofit technology becomes available and the cost of compliance permits.

The effect of the initial Interstate Motor Carrier Regulations will be noticeable principally around highways. The principle noise reduction will be of the intrusive "noise peaks," which have been widely acknowledged as more objectionable to people than much lower levels of continuous noise[4]. However, the reduction of traffic noise to levels protective of public health and welfare is not feasible through retrofit programs alone and must await the replacement of the current vehicle population by new quiet vehicles in conformance with noise standards promulgated under Section 6.

RATIONALE FOR THE COVERAGE OF VEHICLES OVER 10,000 POUNDS GVWR/GCWR

Prior to proposing regulations applicable only to vehicles over 10,000 pounds GVWR/GCWR, the Agency analyzed both the relative noise contribution to traffic noise levels and the typical use patterns of different kinds of motor vehicles. Light trucks and automobiles were separated from medium and heavy duty trucks for the analysis because they have a higher power-to-weight ratio, they are quieter in normal operation, and they have different uses than larger vehicles.

In addition to their higher noise emissions, medium and heavy duty motor vehicles are distinguished from lighter vehicles by their typical use for long distance intercity and interstate hauling. They are, therefore, operated many more miles per year on the average than light duty vehicles, which are normally used for general service and delivery work within a relatively small area.

Medium as well as heavy duty motor vehicles operated by interstate motor carriers are in significant numbers constantly in transit between different jurisdictions, and it would be impractical for them to comply with a different noise emission standard in different jurisdictions. Thus, "medium duty" as well as "heavy duty" motor vehicles operated by interstate motor carriers are construed by the Agency to be "major noise sources in commerce control of which require uniform national treatment" under section 18 of the Noise Control Act.

Conversely, since light duty vehicles are typically used for general service and delivery work within relatively small areas and are not usually subject to the noise emission regulations of many different jurisdictions, national uniformity of treatment of the noise emission resulting from their operation does not appear essential at this time.

The specification of a precise delineation between "light duty" or "small" vehicles and "medium and heavy duty" vehicles for purposes of regulation is largely an exercise of technical judgment. EPA has chosen to make that delineation at 10,000 pounds GVWR/or GCWR in these regulations.

A break at 10,000 pounds GVWR/GCWR is also convenient because most states use that weight rating as a distinction in their vehicle registration categories. The Department of Commerce and the Motor Vehicle Manufacturers Association divide light duty and medium duty vehicles at that weight rating. In addition, it is a standard weight category distinction used by the Department of Transportation in their safety regulations, and compatibility of the Interstate Motor Carrier Regulations with the present DOT weight categories is advantageous because DOT is the Federal enforcement agent.

Section 2

TECHNOLOGY AND COST OF QUIETING IN-SERVICE MOTOR VEHICLES

Section 18(a)(1) of the Noise Control Act requires that noise emission standards pursuant to that part set limits on noise emissions resulting from the operation of motor carriers which ". . . reflect the degree of noise reduction achievable through the application of best available technology, taking into account the cost of compliance."

In order to implement this section of the Act, "best available technology" and "cost of compliance" have been defined as follows:

> "Best available technology" is that noise abatement technology available for retrofit application to motor vehicles that produces meaningful reduction in the noise produced by vehicles used by motor carriers engaged in interstate commerce. "Available" is further defined to include:
>
> 1. Technology applications that have been demonstrated and can be retrofitted on existing motor vehicles.
> 2. Technology for which there will be a production capacity available to produce the estimated number of parts required soon enough 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.
>
> "Cost of compliance" means the cost of identifying and carrying out the action that must be taken to meet the specified noise emission level, including the additional cost of operation and maintenance.

Discussion of the technology and cost required to achieve specified noise emission levels must be based on an understanding of the sources of motor vehicle noise. This section describes the noise characteristics of large motor vehicles, the technology available, and the cost of achieving noise reduction. It specifically discusses multiaxle diesel trucks because (1) they make the most noise, (2) most of the available data relate to these trucks, and (3) any regulation which is feasible for such trucks will also be feasible for other large vehicles.

The noise produced by a truck depends on the type and the quality of its component parts. Large trucks are not standardized as are automobiles. Specialized user needs result in a greatly varied assembly of components, especially with respect to power train and related equipment. As a result, truck noise can vary considerably from vehicle to vehicle. To illustrate the extent of this variation, the discussion of noise sources below is preceded by a brief description of truck components.

GENERAL CHARACTERISTICS OF LARGE TRUCKS

Diesel engines may be naturally aspirated (air introduced at atmospheric pressure), turbocharged, or supercharged by the engine itself. The engine can be located either at the front of the cab (in "conventional" trucks) or under the cab (in "cab-over-engine" trucks).

Exhaust pipes 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". A straight stack is usually preferred, because it directs exhaust fumes away from motorists and pedestrians. Either single or dual 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 the conventional or the cab-over-engine (COE) style. If it is behind the cab, 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. The torque is usually applied to either one or two drive axles. The number of axles on the entire vehicle, including the trailer, can range from 2 to 11, the limit varying according to state regulations. In general, the greater the number of axles, the greater the load-carrying capacity of the truck. Corresponding in part to the number of axles, the number of tires on a heavy truck trailer combination can range from 10 to 42.

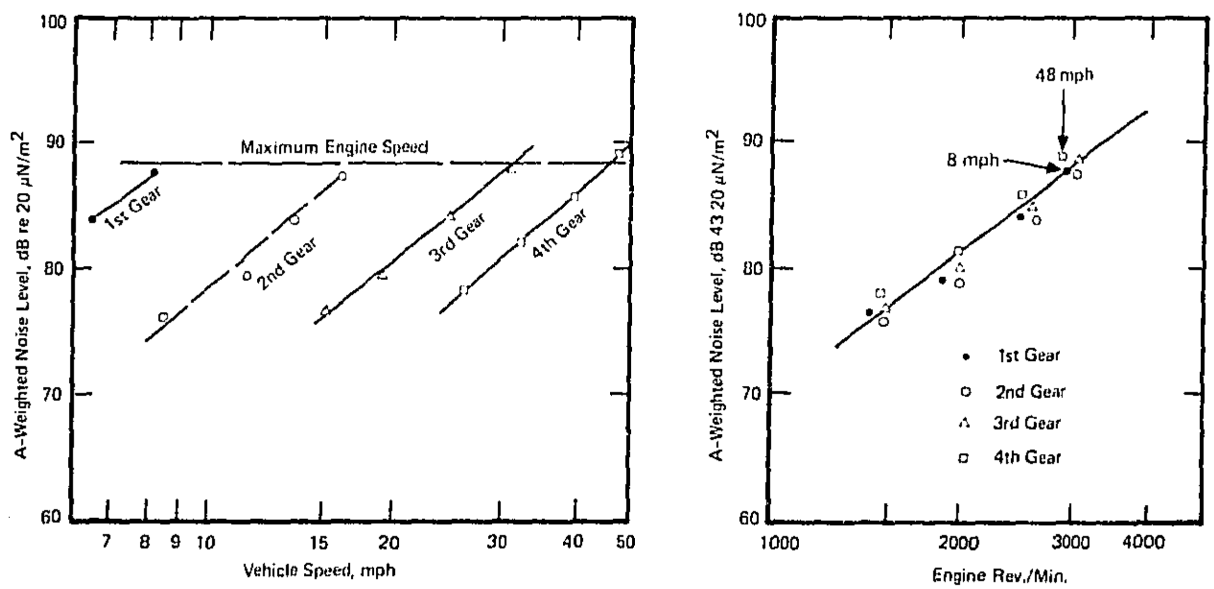
Figure 1 shows the effect of vehicle speed and engine rpm on engine noise at 25 ft. However, noise from the propulsion system is not the only contributor to the overall noise level. At speeds greater than about 45 mph, additional noise of significant magnitude is produced by the interaction between the tires and the road surface[5]. The relationship between propulsion system noise and tire noise as a function of vehicle speed is shown in Figure 2[6,7]. The 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[8].

COMPONENT NOISE SOURCES AND QUIETING TECHNIQUES

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, shown in Figure 3, are as follows (not necessarily in order of importance)[9]:

- Exhaust system
- Engine cooling fan
- Engine (mechanical)
- Air intake system
- Transmission (gearbox, drive shaft, rear axles(s))
- Auxiliary engine equipment
- Tire/roadway interaction
- Aerodynamic flow
- Brakes

The first four sources are of major importance for the trucks of concern here when they are traveling at low speeds (less than 45 mph)[10]. As Figure 2 shows, at higher speeds (greater than 45 mph), tire noise assumes a much greater significance. A brief discussion of these major sources is contained in the following sections.



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

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

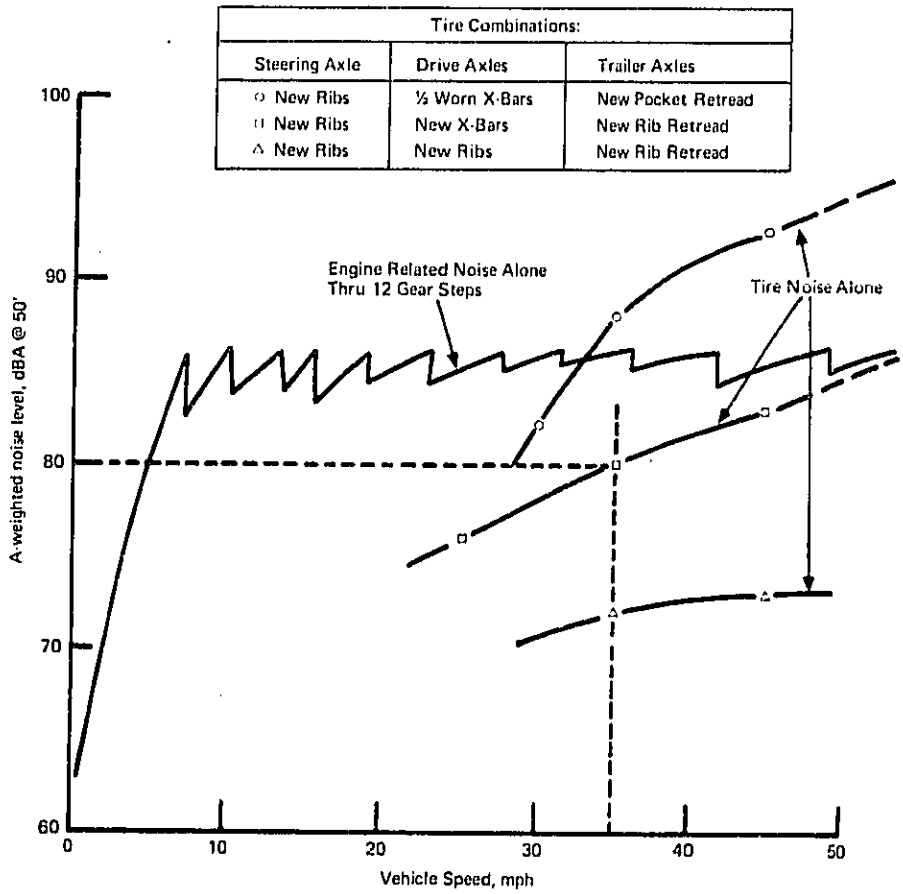
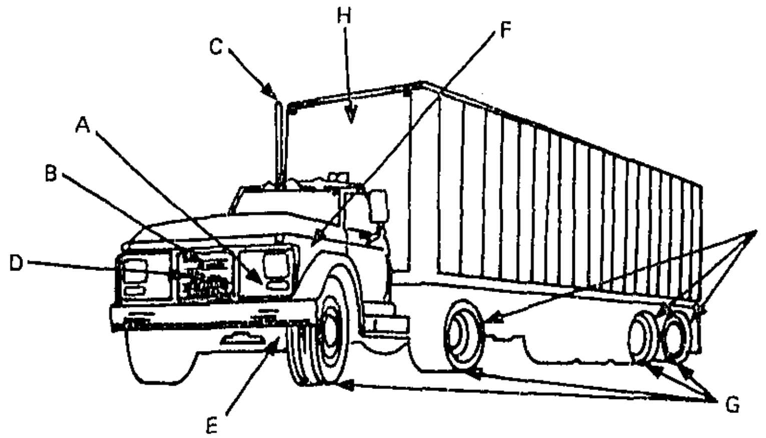


Figure 2. Propulsion System and Tire Noise for a Typical 5 Axle Tractor Trailer (from reference 6 and 7)

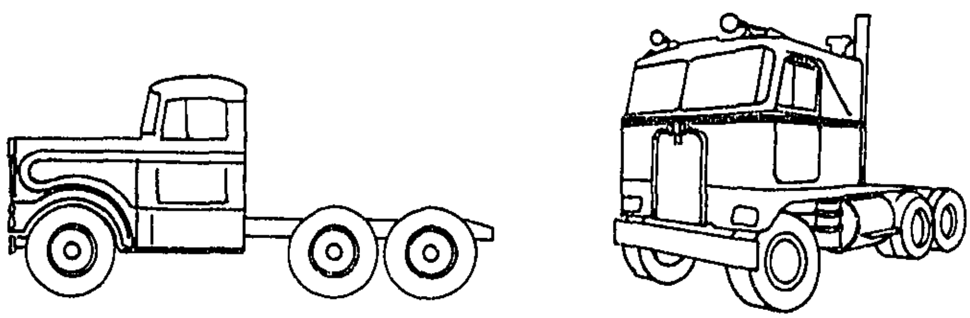


Major Noise Sources

A. Engine (Mechanical)
B. Engine Cooling Fan
C. Engine Exhaust
D. Air Intake System

Other Sources

E. Transmission
F. Ancillary Equipment
G. Tire/Roadway Interaction
H. Aerodynamic Flow
I. Brakes



Conventional (C) Cab

Cab-Over-Engine (COE)

Figure 3. Truck Noise Sources and Cab Types

EXHAUST SYSTEM

Exhaust noise is created when engine exhaust gases cause oscillations within 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[10]. In addition to being radiated from the end of the tail pipe, exhaust noise is transmitted through the exhaust pipe and muffler walls. Noise is also produced by the application of engine brakes (on trucks so equipped), which assist the wheel brakes by producing a retarding force on the engine. Typical exhaust noise levels range from 77 to 85 dB(A) at 50 ft, independent of vehicle speed[11], and can be much higher in trucks which have been poorly maintained.

Although the exhaust system is a major noise source, significant noise level reductions can be achieved 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. 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 attenuation capability of the muffler increases. Muffler specifications and suggested exhaust system configurations are currently offered by major muffler manufacturers for almost every engine, although no universal muffler exists which is the best for all types of engines.

Exhaust noise alone from trucks equipped with the best available mufflers typically ranges from 72.5 to 80 dB(A) at 50 ft. These mufflers provide attenuation of from 9.5 to 27 dB and are installed on some new trucks as standard equipment[12]. 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[13, 14]. 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.

COOLING FAN

Trucks generally use axial fans to draw air through a front-mounted radiator. The air cools water which in turn cools the engine. Fan noise is the result of air flow irregularities and is partially governed by the proximity of shrouds, radiators, grills, and radiator shutters [15]. The noise produced by the fan is related to fan tip speed. Most diesel engines on heavy trucks reach maximum rated horsepower at about 2100 rpm. At this speed, the fan can be a major contributor to the overall truck noise level. Typical truck fans alone exhibit noise levels in the range of 78 to 83 dB(A) at 50 ft at rated engine speed[16].

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 slower speed. In many cases this may require the installation of a larger radiator, which could result in an expensive modification to the front of the engine compartment.

It is often possible to install a fan blade that produces less noise while at the same time providing adequate cooling. Most existing fans are stamped out of 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 is it particularly efficient in performing its task. In many cases, it can be replaced with a more sophisticated design that affords a fan noise (not total truck noise) reduction of from 7 to 12 dB[17]. The cost is in the range of $40 to $35 including installation[18]. Overall truck noise can also be reduced by about 1 dB in some cases by incorporating a venturi-type shroud with a small tip clearance, at a cost of about $45 including installation.

Trucks are designed to be able to cope with heat rejection at maximum engine power with little or no ram air. Since ram air increases with vehicle speed, fans become less important at higher vehicle speeds and could be slowed or stopped in many instances. The critical cooling requirement occurs when the truck is moving slowly in a low gear but the engine is developing full horsepower (e.g. when pulling a heavy load up a long grade). Trucks, unlike automobiles, usually do not have an overheating problem when the vehicle is stopped and the engine idles at low rpm. Given these characteristics, it is possible for a truck to have a fan which does not operate continuously.

Fans are now available which operate only when additional engine cooling is required and which idle when the cooling due to ram air flow is sufficient. A typical fan of this type has either a thermostatically controlled mechanical clutch or a viscous fluid clutch. The viscous fluid clutch permits the fan to rotate at reduced speeds and the thermostatically controlled mechanical clutch permits the fan to stop completely when not needed. Fans utilizing these clutches are about 3 to 10 dB quieter than conventional fans[19].

A viscous clutch costs about $240 including about $15 for the suggested fan blade. A thermostatically controlled mechanical clutch including the necessary fittings costs from about $285 to $360, plus $40 to $50 for installation[20, 21].

ENGINE (MECHANICAL)

Mechanical noise in internal combustion engines is caused 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 creates mechanical vibrations in the engine structure which are transmitted through the cylinder walls, oil pan, rocker arm, and covers. Some of this vibration is subsequently radiated into the atmosphere as acoustic energy.

Gasoline engines initiate combustion with a flame which spreads smoothly 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. As a result, the mechanical noise levels of diesel engines often are as much as 10 dB higher than those of gasoline engines [22]. The engine mechanical noise contribution in typical diesel-powered trucks is on the order of 78 to 85 dB(A)[23].

Turbochargers are often used to increase the pressure of the intake air. This reduces the pressure fluctuations in the engine and, in turn, lowers the engine noise level[24]. However, turbochargers may in some cases whine, contributing to the overall noise level.

Retrofit methods of reducing engine noise are generally one of two kinds:

1. Modification of certain exterior surface covers.
2. Installation of acoustic absorption material and acoustic barriers in the engine enclosure.

Engine noise reduction kits suitable for a limited number of 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 mechanical noise (as opposed to total vehicle noise level) at a cost of $50 to $100 for materials[25] and, typically, $30 for installation[26]. Such kits are in limited production at this time and have not undergone complete durability testing[27].

AIR INDUCTION SYSTEM

Induction system noise is created by the opening and closing of the intake valves; this action causes the volume of air in the system to pulsate. The associated noise levels depend upon the type of engine, the engine operating conditions, and whether it is turbocharged or naturally aspirated. Typical intake noise levels alone vary from 70 to 80 dB(A)[28].

The state of intake noise reduction technology is very similar to that of exhaust noise reduction. Major manufacturers are able to provide assistance in proper selection of air intake systems for all popular engine models[29]. Retrofitting the intake systems of trucks in service consists of replacing older air cleaners with modern quality, dry element air cleaners at an average cost of from $100 to $130[30]. Intake cleaners and silencers are manufactured largely by the major muffler manufacturers.

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 tires). Rib tires look like automobile tires, with the tread elements oriented circumferentially around the tire. This is the most common type of truck tire and can be used in all wheel positions. Rib tires are used almost exclusively on steering axles because of their superior lateral traction and uniform wear characteristics. Crossbar designs have the tread elements oriented transversely to the plane of the tire. Many trucking companies prefer to use crossbar tires on drive axles, since they provide up to 60% greater initial tread depth[31], and hence greater mileage before recapping.

The noise-generating mechanisms of tire/roadway interaction are not completely understood. It is known that the entrapment and release of air from the tire tread cavities produces noise. Also, it appears that the vibration of the tire contributes to the total noise level[32]. However, the effect on noise levels of the large lugs on crossbar tires and of the road surface are not well quantified. The result is that basically all the noise information available has been obtained experimentally, and tire manufacturers do not appear to be close to any major breakthrough that would result in crossbar tire designs exhibiting significantly lower noise levels.

There seem to be no conclusive data which indicate any significant difference in traction properties between rib and crossbar tires under dry, wet, or icy conditions Any advantage in traction is probably in favor of rib tires, because they normally provide about 5% 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, some crossbars will give better traction than rib tires[33].

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[34] (see Figure 4). Typical values of the noise level measured at 50 ft are 68 and 73 dB(A) at 35 mph for new rib and crossbar tires, respectively, on a concrete roadway. At 55 mph these levels typically increase to 75 and 83 dB(A)[35], respectively, although higher values are by no means uncommon. In general, rib 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. An increase in noise level of 5 dB(A) over the levels of new tires is not uncommon[36].

Data indicate that some retread tires having a tread composed largely of pockets which 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 around 95 dB(A) at highway speeds [37].

COST OF RETROFITTING INDIVIDUAL TRUCKS

The noise control information given in the preceding section reflects the state of available retrofit technology for each noise source. To reduce the noise level produced by an existing vehicle, it is necessary to apply one or more of the modifications outlined, depending upon the vehicle in question and the overall noise reduction required. For example, more components of an old, poorly maintained truck will normally need to be modified than those of one in new condition. Also, more treatment will be required for trucks originally built with very noisy diesel engines.

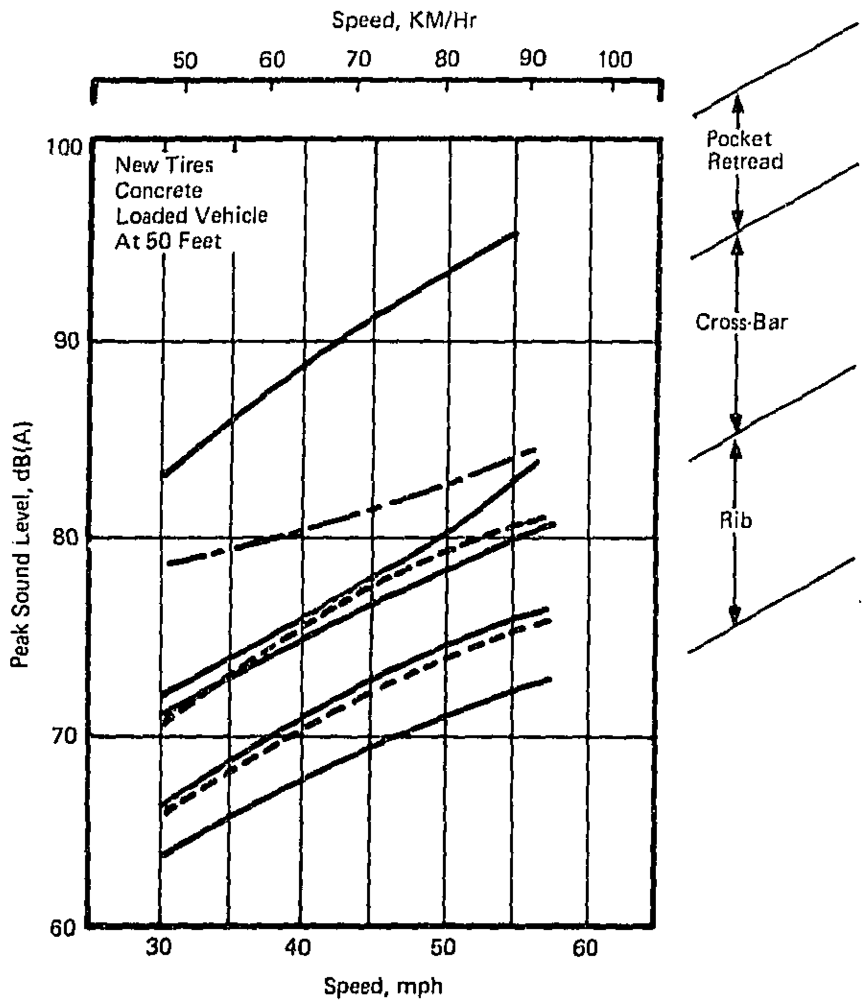


Figure 4. Peak A-Weighted Sound Level, as Measured at 50 Feet, Versus Speed for a Loaded Single-Chassis Vehicle Running on a Concrete Surface. Various Types of New Tires are Represented on the Graph. These Were Mounted on the Drive Axle(35)

TECHNOLOGY AND COST REQUIRED TO COMPLY WITH A LOW-SPEED STANDARD

Treatments indicative of what might be required to lower truck noise (other than from tire/road interaction) to various levels and the associated costs per treatment are listed in Table 4. The noise levels are for low-speed full-throttle acceleration measured according to SAE J366a on an open site over a hard surface. Since the noise levels of individual trucks vary, not all trucks requiring treatment would require the treatments indicated to meet each noise level. The percentage of trucks in Table 4 that need each type of component change were estimated by an EPA contractor from data gathered by a company located in a regulated region of the country which has been extensively engaged in retrofitting trucks to reduce their noise.

The estimated costs to achieve 90, 88 and 86 dB(A) are comparable to the actual costs incurred by that company in retrofitting 7600 large multi-axle trucks, which are shown in Table 5[38]. The 7600 trucks include both gasoline and diesel-powered units, representing the proportion of each type that required retrofit or repair to meet the noise limits.

Very few trucks have actually been retrofitted to achieve a noise level of 84 dB(A), since few State and local jurisdictions have low speed noise standards at levels below 86 dB(A). The EPA contractor estimated a range of costs of $292–462 to quiet the average multiaxle truck to 84 dB(A), while the retrofit service company estimated that it might cost $950 to quiet a diesel multiaxle truck to that level. Costs should be somewhat lower for smaller medium and heavy duty trucks, some of which could be quieted to 84 dB(A).

There is a practical limit as to what noise levels can be achieved on all trucks through the use of retrofit technology. EPA studies have indicated that it is not cost-effective and often not feasible to quiet in-service motor vehicles much below the noise levels that characterized them when new. There are trucks in the existing fleet that contain diesel engines that are

TABLE 4

ESTIMATED COSTS TO RETROFIT TRUCKS TO VARIOUS NOISE LEVELS (According to SAE J366a) IN 1973 DOLLARS

Noise Level dB(A) @ 50'	Typical Treatment	Estimated Cost Per Item $	% Trucks Exceeding Specified Noise Level Requiring Component Change	Avg. Cost Per Truck Retrofitted
90	Exhaust[1]	50-100	100%	$50-$100
				Total $50-$100
88	Exhaust[1]	50-100	100%	50-100
	Fan[2]	35	5%	2- 2
				Total $52-$102
86	Exhaust[3]	100	100%	100
	Fan[4]	80	10%	8
	Intake[5]	115	5%	6
				Total $114
84	Exhaust[6]	100-200	100%	$100-$200
	Fan[7]	285-400	50%	$143-$200
	Intake[5]	115	25%	$ 29-$ 29
	Engine[8]	80-130	25%	$ 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 in some cases
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.

TABLE 5

ACTUAL COSTS OF RETROFITTING 7600 TRUCKS TO ACHIEVE SPECIFIED NOISE LEVELS ACCORDING TO SAE J366a[38]

Level	90 dB(A)	88 dB(A)	86 dB(A)	84 dB(A)
Actual Cost (1973 $) Per Truck	$45-100	$50-110	$50-205	—

too noisy to be sold in jurisdictions that enforce an 86 dB(A) noise emission standard at 50 feet. These engines are being phased out of new trucks, but they represent an obstacle to limits lower than 86 dB(A) for Interstate Motor Carrier Regulations that must take best available technology and cost of compliance into account.

Many heavy trucks are custom-built, and it is technologically possible to replace engines or rebuild in-service trucks to achieve large reductions in noise emissions. However, this is not considered to be within the definition of "best available technology," and would involve very high costs. Even achieving 84 dB(A) for all trucks would require the extensive use of engine enclosures that are not currently available and that have not been adequately tested for safety and compatibility with engine maintenance needs.

EPA believes that a noise level of 86 dB(A), measured according to SAE J366a, is achievable through the use of best available technology by almost all medium and heavy duty trucks in the existing fleet. It is also achievable by buses, since they use the same engines and tires as trucks. Trucks are already being retrofitted to reach 86 dB(A) in a number of states and actual experience indicates that the associated costs were $50-205 per truck in 1973 for those in-service trucks that had to be retrofitted.

Additionally, at least one major truck manufacturer has indicated its intention to work with suppliers to develop a retrofit noise control package to bring older trucks into compliance with noise levels already proposed. This should help provide the retrofit service capability that will be needed to enable vehicles to comply with the Interstate Motor Carrier Regulations.

Table 4 indicates that most trucks currently exceeding 86 dB(A) require only a muffler to be in compliance, and muffler manufacturers have testified in public hearings that adequate mufflers can be available in sufficient numbers to permit compliance of all trucks within one year of promulgation of the Interstate Motor Carrier Regulations.

TECHNOLOGY AND COST REQUIRED TO COMPLY WITH A HIGH-SPEED STANDARD

Since engine-related noise does not increase at high speed above the levels associated with low speed maximum acceleration, the high speed standard should exceed the low speed standard only by the noise differential associated with the increase in tire noise at higher speeds. Figure 4 indicated that tire noise continues to increase as truck speed increases.

Considerable high speed noise reductions can be obtained through the replacement of "pocket retread" tires by crossbar tires at no increase in cost or loss of performance. However, crossbar tires begin to dominate overall truck noise levels at speeds in excess of 45 mph and a high speed standard of 86 dB(A) might require the elimination of virtually all crossbar tires.

It appears that per-mile cost differentials between tires having different types of tread may depend on tire composition and terrain as well as on motor carrier recapping policies. A comprehensive study of cost-differentials associated with the use of truck tires of different types is being carried out by EPA as preparation for possible future tire regulations and/or revisions of the Interstate Motor Carrier Regulations.

However, due to performance and safety requirements it does not appear feasible or desirable to require the elimination of all crossbar tires at this time. It may be desirable to further restrict the use of noisy crossbar tires in the future, but such an action requires more data on cost, performance, and safety differentials between tires of different treads than currently is available.

Accordingly, a four decibel margin has been added to the 86 dB(A) low speed standard to take tire noise into account. Actual experience indicates that this will require the elimination of some crossbar tires on heavy trucks that have a very large number of axles. However, it should still be possible for these trucks to operate with crossbar tires on the drive axles.

A comparison of the results of surveys of actual truck noise levels (data from the surveys is presented in section 4), indicates that essentially the same percentages of trucks exceeded 86 dB(A) under low speed acceleration as exceeded 90 dB(A) under high speed conditions, and also that the percentages are very nearly the same for each MVMA class of trucks considered separately by number of axles. This strongly suggests that the two standards are comparable.

For those trucks that must change from crossbar tires to rib tires in order to comply with the standards, a small cost penalty may result. Under a strategy of recapping each tire only once, the cost difference between crossbar and rib tires is approximately $.23 per thousand miles. For a single drive axle truck, this represents a cost difference of less than $.001 per mile.

A high-speed noise level of 88 dB(A) would be achievable by two-axle trucks because they have fewer tires than multiaxle trucks. A separate standard was considered for this category, but an analysis of highway noise levels performed using a DOT Highway Noise Prediction Model indicated that reducing the noise emissions of a portion of the truck fleet over 10,000 pounds by two decibels would have no measurable effect on highway noise levels. Accordingly, one high-speed noise limit seemed reasonable for all motor vehicles over 10,000 pounds GVWR operated by motor carriers engaged in interstate commerce.

Section 3

INTERSTATE MOTOR CARRIER REGULATIONS

This section contains a summary of the regulations, a short explanation of the changes made in the regulations since the notice of proposed rule-making, and an analysis of the relationship between the various test measurement procedures used to ascertain compliance of motor vehicles with noise emission standards.

SUMMARY OF THE REGULATIONS

The Interstate Motor Carrier Noise Emission Standards are applicable to all motor vehicles above 10,000 lb GVWR/GCWR operated by motor carriers engaged in interstate commerce. There are two interrelated standards directed to the way in which the motor vehicles are operated while in use. The first is a requirement that motor vehicles generate no more than 86 dB(A) at 50 feet in speed zones at or under 35 mph under all conditions. The second is that the vehicles generate no more than 90 dB(A) at 50 feet in speed zones over 35 mph under all conditions. The intent of these two standards is to limit maximum propulsion system noise to the same level in both speed zones, but to provide an additional margin for tire noise in the high speed zones.

If the actual vehicle speed (rather than the posted speed limit) were used in the regulation, then enforcement would require the simultaneous measurement of each vehicle's speed and noise level. This would be quite difficult in the case of a truck operating in a stream of faster-moving passenger car traffic. To remove this obstacle to enforcement, the standards are keyed to the speed zone in which the vehicle is operating rather than its actual speed. This is the rationale for setting the low-speed, high-speed break at 35 mph rather than 45 mph, where tire noise could begin to be important.

A stationary engine run-up test standard of 88 dB(A) has been included in order to permit enforcement at roadside weighing stations. This test will typically be performed over a hard site and is applicable only to vehicles with engine speed governors. The test is inappropriate for vehicles without governors because of the following:

a. Wide variability is introduced by operator technique and tachometer errors in accelerating to maximum rated rpm in tests of ungoverned engines.

b. Wide variability exists in the maximum rated rpm for ungoverned engines, and maximum rpm in a stationary run-up test may be far above maximum rpm of the engine when in operation.

c. The possibility of catastrophic failure exists when an ungoverned engine is accelerated rapidly to maximum speed when not under load.

Most vehicles will violate the regulations only when their exhaust systems are faulty, and a visual exhaust system inspection standard has been included to cover this possibility.

A visual tire inspection standard has also been included to provide an effective means of eliminating the noisiest type of tire treat pattern, except in cases where it can be shown that the vehicle can meet the 90 dB(A) standard even when using tires whose tread appears to be noisy.

The effective date of the regulations is one year from the date of promulgation. EPA has determined that the required retrofit components will be available within this period and that a one year effective date will not impose an undue hardship on the trucking industry.

REVISION OF THE PROPOSED REGULATIONS PRIOR TO PROMULGATION

The Interstate Motor Carrier Noise Emission Regulations which are now being promulgated incorporate several changes from the proposed regulations which were published on July 27, 1973. These changes are based upon the public comments received and upon the continuing study of motor carrier noise by the Agency. In all but one instance such changes are not substantial; they are only intended to further clarify the intent of the proposed regulations.

The sole substantive change is the deletion of proposed Section 202.12, "Standards for Level Street Operations 35 MPH or Under." This section was originally proposed as it was felt that vehicles which could comply with a standard of 86 dB(A) under any conditions on highways with speed limits of 35 mph or less could be driven so as to comply with a standard of 80 dB(A) when operated at constant speed on level streets with speed limits of 35 mph or less. It was the intent of the Agency through this section to thereby regulate the manner of operation of the vehicle, by the driver, without imposing any additional noise reduction requirement to the vehicle proper beyond that needed to meet the 86 dB(A) standard. Substantial questions were raised regarding the validity of the data upon which the standard was based. The Agency, upon review of the relevant data, agrees with the comments and accordingly, the Standards for Level Street Operations section has been deleted.

Those changes made to clarify the intent of the regulations, and the reasons therefore, are as follows:

Section 202.10 - Definitions

"Common carrier by motor vehicle," "contract carrier by motor vehicle," and "private carrier of property by motor vehicle" were deleted. In their place, the definition of "motor carrier" was expanded to incorporate, by reference, the definition of those terms in paragraphs 14, 15, and 17, of Section 203(a) of the Interstate Commerce Act (49 USC 303 A). This treatment more closely follows Section 18(d) of the Noise Control Act and thereby insures that any question as to the definition of those terms will be resolved by reference to the body of law which Congress intended to apply to Section 18.

The definitions of "dB(A)," "sound pressure level," and "sound level," were changed slighty to be consistent with the definitions of those terms used in the document "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," issued by the Environmental Protection Agency in March 1974. "Fast meter response" has been expanded for clarity.

"Gross combination weight rating" (GCWR) has been added to avoid any possible confusion over whether the regulation is applicable to combination trucks (i.e., tractor-trailer rigs) over 10,000 pounds weight rating. The provisions of Subpart B of the regulation are applicable to all single and combination vehicles over 10,000 pounds GVWR or GCWR operated by interstate motor carriers.

"Interstate commerce" has been modified to insure that any questions as to its scope would be resolved by reference to Section 203(a) of the Interstate Commerce Act, consistent with the reference to that Act in Section 18(d) of the Noise Control Act.

"Person" has been deleted, since (as discussed below) that word is no longer used in Subpart B of the regulations.

"Street," and "official traffic device," have been deleted, since proposed Section 202.12 in which they were used has been deleted.

"Muffler" has been added to simplify the language of proposed Section 202.14, "Visual Exhaust System Inspection."

"Open site" has been added to further clarify the standards.

Section 202.11 - Effective Date

An effective date of October 1, 1974 was originally proposed for the regulations. The intent of the Agency in the Notice of Proposed Rulemaking was that the proposed regulations would become effective one year from the date of promulgation. This intent is retained in this new section.

Section 202.12 - Applicability

"Applicability" was moved to Subpart A of the final regulations as it is appropriately considered a "general provision" of the regulations. It has been modified to clarify the intent of the Agency that the standards do not apply to noise emission from warning devices or auxiliary equipment mounted on motor vehicles; and that compliance with any provision of Subpart B does not excuse any motor vehicle from compliance with the other provisions of Subpart B.

Subpart B - Interstate Motor Carrier Operations

The language used in Subpart B has been changed from, "no person shall operate," to "no motor carrier subject to these regulations shall operate... ;" and the language in section 202.20 was modified slightly to conform to this change. This change is intended to reflect more accurately the intent of Congress and these regulations, that they are to establish uniform national noise emission regulations for those operations of interstate motor carriers which require such treatment. The revised language clearly imposes sole responsibility for meeting the requirements upon the motor carriers which own and operate the subject motor vehicles. The proposed language, using the broad term "person," would have imposed that responsibility upon the drivers of subject motor vehicles as well as the companies which operate them. "Motor carrier," as defined in these regulations, includes independent truckers who both own and drive their own vehicles. The phrase "on an open site over any surface," was added to the standards of Subpart B to further clarify the standards.

Section 202.21 - Standard for Operation Under Stationary Test

The language of this section has been modified to further clarify that it applies only to vehicles which have an engine speed governor. Application of a stationary run-up test to vehicles which are not equipped with engine speed limiting devices could result in engine damage.

Section 202.22 - Visual Exhaust System Inspection

The intent of the Agency in requiring motor vehicles subject to this regulation to be equipped with exhaust system noise dissipative devices has been further clarified through modification of the language of proposed Section 202.14. In addition, the exception to the proposed requirement relating to vehicles with gas driven turbochargers and equipped with engine brakes, which were demonstrated to meet the other standards of Subpart B, has been deleted. Such equipment is included in the term "other noise dissipative device," and therefore need not be treated separately.

Section 202.23 - Visual Tire Inspection

The intent of the Agency was to specifically preclude the use of "pocket retread" tires which when new are demonstrably noisier without having any accompanying benefit in safety or cost over other types of tires. The proposed Section 202.15 has been modified in response to comments by tire manufacturers that the regulation as proposed could have covered some types of tires which are not in fact exceptionally noisy.

Proposed Section 202.16 - Enforcement Procedures

This proposed section has been deleted. As the Noise Control Act places enforcement responsibilities for these regulations with the Department of Transportation, the section as proposed added nothing not specified in the Act.

Proposed Subpart C - Special Local Conditions Determinations

The procedures for applying for determinations as called for in Section 18(c)(2) of the Act, will be published by EPA as "procedures" and not as part of this regulation. Accordingly, Subpart C has been deleted.

Preemption

Under Subsection 18(c)(1) of the Noise Control Act, after the effective date of these regulations no State or political subdivision thereof may adopt or enforce any standard applicable to noise emissions resulting from the operation of motor vehicles over 10,000 pounds GVWR or GCWR by motor carriers engaged in interstate commerce unless such standard is identical to the standard prescribed by these regulations. Subsection 18(c)(2), however, provides that this section does not diminish or enhance the rights of any State or political subdivision thereof to establish 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 Section 18.

Conversely, Subsection 18(c)(1) does not in any way preempt State or local standards applicable to noise emissions resulting from any operation of interstate motor carriers which is not covered by Federal regulations. Thus, under the proposed regulations States and localities will remain free to enact and enforce noise regulations on motor carrier operations other than their operation of motor vehicles over 10,000 pounds GVWR or GCWR, without any special determination by the Administrator. Only after a Federal regulation on noise emissions resulting from a particular interstate motor carrier operation has become effective must the States and localities obtain a special determination by the Administrator under Subsection 18(c)(2), in order to adopt or enforce their own use restrictions or environmental noise limits on that operation.

Some interstate motor carrier operations on which no Federal noise standards or regulations have become effective, and which may, therefore, be subjected to State and local noise standards without any special determination by the Administrator, may indirectly include motor vehicles which are covered by preemptive Federal regulations. Motor carrier maintenance shops, for example, may from time to time emit the noise of trucks undergoing tests along with noises common to many industrial operations such as forging and grinding; and motor carrier terminals and parking areas include trucks among their many types of noise sources.

In most instances, compliance with State or local standards on non-Federally regulated operations of motor carriers is achievable without affecting the Federally regulated motor vehicles within them. Standards on noise emissions from repair shops, for example, can be met by such measures as improved sound insulation in the walls of the shop, buffer zones of land between the shop and noise-impacted areas, and scheduling the operation of the shop to reduce noise at those times of the day when its impact is most severe. Standards on motor carrier terminals and parking areas can be met by a variety of steps, including reducing the volume of loudspeaker systems by using a distributed sound system or replacing speakers with two-way radios, reducing noise emissions from equipment which is not covered by Federal regulations, installing noise barriers around noisy equipment, acquiring additional land to act as a noise buffer, and locating noisy equipment such as parked trucks with operating refrigeration equipment as far as possible from adjacent noise-sensitive property. State or local regulations on noise emissions from motor carrier operations which the motor carrier can reasonably meet by initiating measures such as these are not standards applicable to noise emissions resulting from the operation of motor vehicles over 10,000 pounds GVWR or GCWR, and thus would not be preempted by the proposed regulations. No special determination by the Administrator under Subsection 18(c)(2) would be necessary. State or local noise standards on operations involved in interstate commerce such as motor carrier terminals are, of course, subject to Constitutional prohibition if they are so stringent as to place an undue burden on interstate commerce.

In some cases, however, a State or local noise regulation which is not stated as a regulation applicable to a Federally regulated operation may be such a regulation in effect, if the only way the regulation could be met would be to modify the equipment which meets the Federal regulation applicable to it. This would be the case, for example, if after the proposed regulations become effective, a State or locality attempted to adopt or enforce a limit on noise emissions from motor carrier terminals in urban areas which could not reasonably be met by measures such as noise barriers or relocating the motor vehicles to which this regulation is applicable. Such regulation would, in effect, require modifications to motor vehicles even though they met the Federal regulations and would thus be a regulation applicable to them which would be preempted under Subsection 18(c)(1). It could not stand if it differed from the Federal regulations, unless the Administrator made the determinations specified in Subsection 18(c)(2). The same would be true of any State or local standard on motor carrier operations which could not reasonably be met except by modifying motor vehicles which comply with the proposed Federal standards.

State and local regulations on motor carrier operations which are not directed at the control of noise, or which include noise control as only one of many purposes such as safety, traffic control, and the like, are not preempted by Subsection 18(c)(1) of the Noise Control Act and require no special determination under Subsection 18(c)(2) to be adopted or enforced. Thus, the designation of some streets as truck routes, and prohibition of trucks from other streets, by State or local governments, are valid without any special determination under Subsection 18(c)(2).

Auxiliary Equipment Considerations

Some types of auxiliary equipment used in vehicles operated by interstate motor carriers are necessary for the comfort or safety of passengers, or for the preservation of cargo. Principal examples of such auxiliary equipment are refrigeration or air conditioning units and concrete mixer bodies and drives. The auxiliary equipment noise emissions for these two types of vehicles, in particular, are at a level far enough below other significant components of vehicle noise, as EPA's data indicate, to be masked by other noise sources during normal vehicle highway operations.

Other auxiliary equipment, however, normally operates only when the transporting vehicle is stationary or moving at a very slow speed, normally less than 5 mph. Examples of such equipment include cranes, asphalt spreaders, ditch diggers, liquid or slurry pumps, air compressors, welders, and trash compactors. The operation of such equipment is not intended to be covered by these regulations.

Emergency Equipment and Vehicles

Because of the emergency or safety aspects of their operation the regulations are not applicable to vehicles such as fire engines, ambulances, police vans, and rescue vans when responding to emergency calls. Similarly, these regulations are not intended to apply to snow plow operations.

Enforcement Procedures, Violations, and Penalties

Enforcement procedures are to be developed and promulgated under separate rule making by the Department of Transportation. Such enforcement procedures will specify minimum requirements for instrumentation, test sites, and other conditions necessary to insure uniformity in testing and a minimum level of precision.

Enforcement of the standards is contemplated to be more efficient under some conditions if measurements are permitted to be made at distances other than 50 feet under procedures that provide for equivalency to the standards measured at 50 feet.

Section 10 of the Act specifies that any violation of these and any future regulations established under the authority of section 18 of the Act constitutes a prohibited act. Any person who willfully or knowingly violates the regulation shall be punished by a fine of not more than $25,000.00 per day of violation or imprisonment for not more than one year, or by both, or a fine not exceeding $50,000.00 per day of violation, or imprisonment for not more than two years or by both, following a conviction for a previous violation of the Noise Control Act.

RELATIONSHIP BETWEEN LOW-SPEED MEASUREMENT PROCEDURES

During the Public Hearings on Noise Abatement and Control held in San Francisco in September 1971, testimony was offered to show the variations in noise level of a truck as measured under maximum acceleration low-speed conditions at nine different sites. Compared to a hard surface open site, grass-covered sites produced noise levels that were 1.5 to 2.0 dB(A) lower, while the presence of near-by buildings produced noise levels 1.5 to 2.0 dB(A) higher. This implies that a truck in compliance with a standard as measured over a soft surface could be out of compliance as measured over a hard surface unless suitable correction factors are applied.

In actual practice, highway measurement and enforcement of the noise emission standards contained in these regulations will occur on sites having surfaces that range from hard to soft. Motor vehicles covered by the regulations should have no trouble being retrofitted to comply with an 86 dBA standard as measured at a typical roadsite site.

This same rationale has been used to set the level of 88 dB(A) for the Stationary Run-up Test Standard. The stationary run-up test (SRUT) is a means of determining maximum propulsion system noise. A vehicle propulsion system which emits a given sound power by this test will typically emit that same value in use when power requirements are maximum due to conditions of load, acceleration, and grade when measurement site parameters are comparable.

The stationary standard at 88 dB(A) is approximately equivalent to the low speed standard at 86 dB(A) because of the different measurement sites used. Both levels would be the same if both were to be implemented on pavement, or both on grassy sites. This level would also be the same if the J366 maximum noise test were included in the standards. In a tabular form the relationship between the three test methods is as follows:

	Stationary Runup	Max-Noise Low Speed Passby	J366
Hard Site	88	88	88
Soft Site	86	86	86

SRUT was developed because the Society of Automotive Engineers J366a test, which is almost universally performed by vehicle manufacturers, their customers, and their suppliers, is wholly unsuitable for use in roadside enforcement of a motor carrier regulation because of its technical requirements.

In order to obtain information on the feasibility of using SRUT as an enforcement test procedure, tests were performed at the International Harvester Company Truck Engineering Center at the request of EPA. Although the data collected do not represent a sample large enough to have statistical significance, the experiment is indicative of what relationship can be expected between SAE J366a, SRUT, and Maximum Acceleration Passby results as measured over a hard surface. The data are presented in Figures 5, 6, and 7 and Table 5.

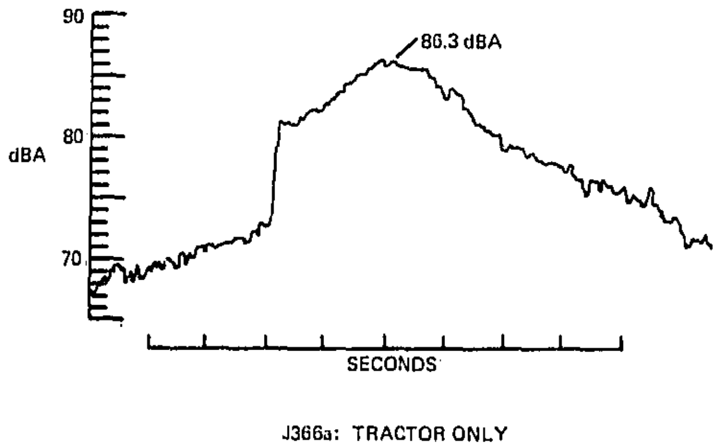


Figure 5. Noise Level of a Large Diesel Truck as it Approaches and Passes a Microphone in the J366a Test.

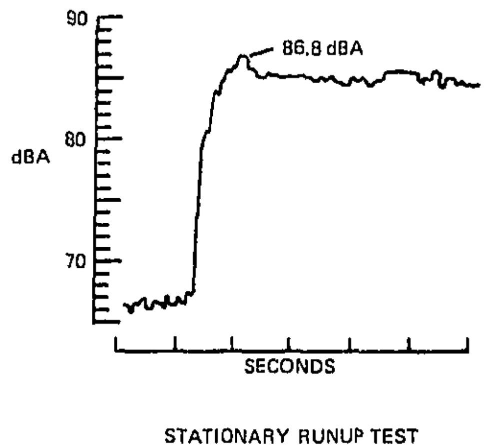


Figure 6. Noise Level of the Same Truck as it Idles, Followed by Engine Acceleration to Maximum Governed rpm in the Stationary Run-up Test.

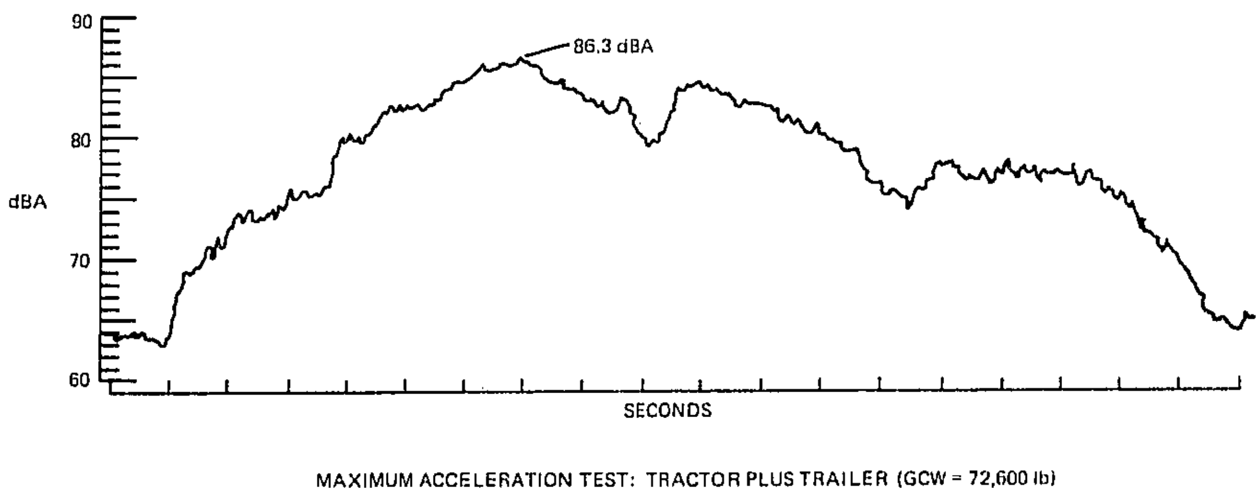


Figure 7. Noise Level from the Same Tractor while Pulling a Load as it Accelerates Past a Microphone in a Pass-by Test.

Table 5

MEASURED VALUES OF NOISE LEVEL IN dB(A) OF SEVERAL TESTS ON TWO DIFFERENT TYPES OF TRUCKS. PASSBY MICROPHONE LOCATIONS ARE ALL 50 FT FROM THE LINE OF TRAVEL, EACH 50 FT SUCCESSIVELY FARTHER FROM THE START POSITION.

TEST	72,600 LB DIESEL CAB-OVER-ENGINE		56,000 LB DIESEL CONVENTIONAL CAB	
	LEFTSIDE	RIGHTSIDE	LEFTSIDE	RIGHTSIDE
J366a (Tractor only)	86.4 dB(A)	86.3 dB(A)	87.3 dB(A)	87.0 dB(A)
SRUT	86.4	86.8	87.0	89.2
Acceleration Passby				
Location #1	87.0	86.3	87.5	88.0
Location #2	86.3	87.0	85.9	87.5
Location #3	85.4	85.8	86.3	88.0
Location #4	86.0	86.8	85.5	87.2

Two large diesel trucks were used for the tests, and in performing these tests all measurement conditions were identical: paved surface, microphone located 4 ft high, 50 ft from the source. The same series of tests, if performed at a different site, would be expected to produce results differing in proportion to the acoustic reflectivity of the surface between microphone and test vehicle and due to normal variations in the tests themselves which render them less than exactly repeatable.

This example shows essentially the same maximum noise level for all tests. However, identical results are not always achievable under such comparisons; the statistical correlation between J366a and SRUT is discussed below. Maximum noise measured during acceleration will vary to some extent as a result of the chance location of the microphone in relation to the maximum noise point in the vehicle gearshift cycle.

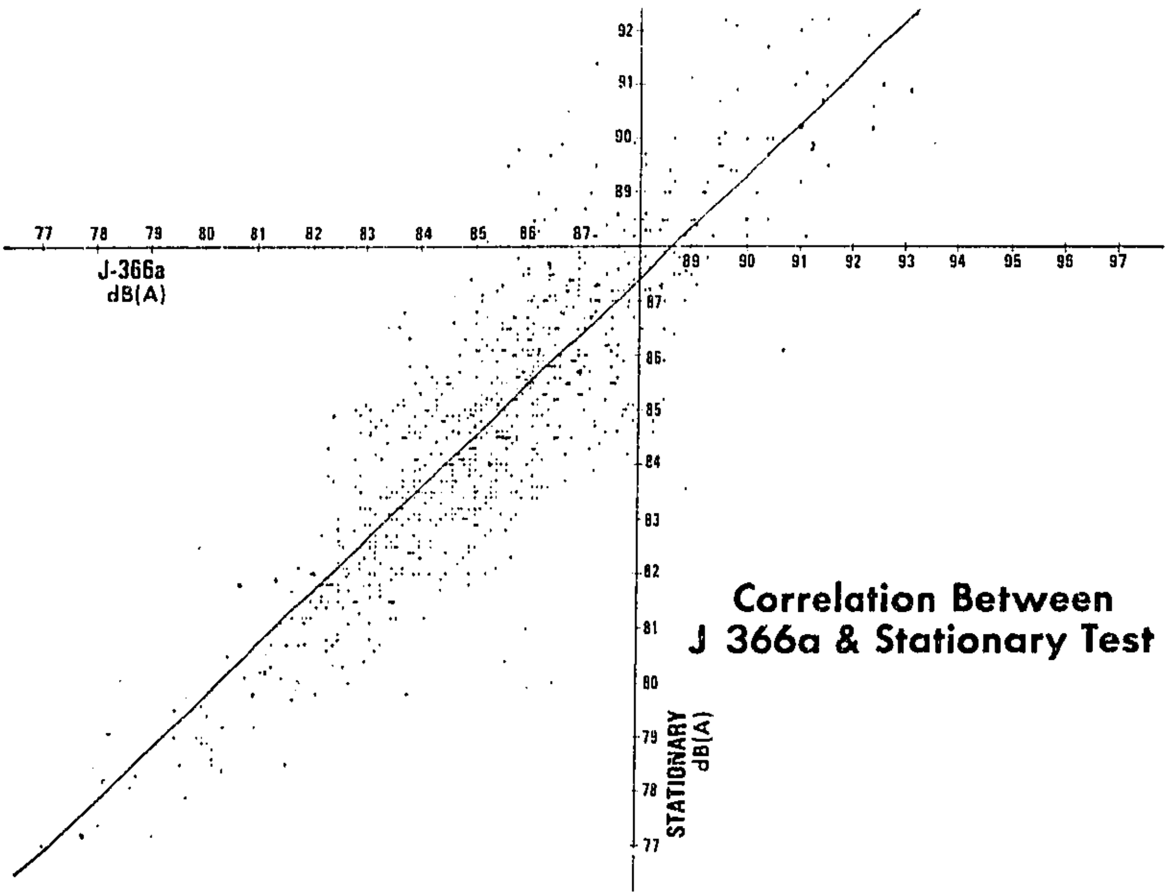


Figure 8. Plot of Test Results According to SRUT and SAE J366a for 877 Trucks.

STATIONARY RUN-UP TEST CORRELATION WITH SAE J366a

A very substantial data base has recently become available that relates the measurements of truck noise taken using the SAE J366a maximum acceleration pass-by test and the stationary Runup Test (SRUT). The data has been collected and compiled by the Society of Automotive Engineers from several industrial sources.

The stationary run-up test consists of measuring the maximum A-weighted sound level at a distance of 50 feet from the vehicle engine exhaust during maximum acceleration of the engine from low idle to high idle. The test is conducted with the transmission in neutral and the clutch engaged. The inertial load of the engine during rapid engine speed acceleration makes an external load on the engine unnecessary. SRUT site and sound measurement instrumentation requirements are similar to the SAE - J366a requirements. Most truck weigh stations can meet these site requirements.

The stationary run-up test will be quite useful for enforcement at State inspection stations and weigh stations. A fleet owner may also use the test to check his vehicle for compliance. The correlation of the stationary run-up test with SAE-J366a is very good. Over 800 different trucks with governed engines have been tested per SAE-J366a and per the stationary run-up test procedure. The results of these tests are plotted in Figure 8. To better understand the meaning of the data points in Figure 8, a statistical analysis of this information is presented in Figure 9.

The analysis shows that given comparable site conditions the SAE J366a test yields noise level measurements that are about 0.5 decibels higher on the average for a given truck than the stationary run-up test measurements. The standard deviation of the difference between the two measurements was 1.4 dB(A) for the trucks in the sample. This means that for 95% of the 877 trucks tested, the stationary run-up test measurement did not exceed the SAE J366a measurement by more than 2 dB(A).

The correlation coefficient for the two sets of test results was computed for a sub-sample of 210 of these trucks, and was found to be 0.71 (where 1.0 represents perfect correlation). The fact that the correlation was so high indicates that a stationary run-up test can be used as a good approximation to a low speed acceleration test.

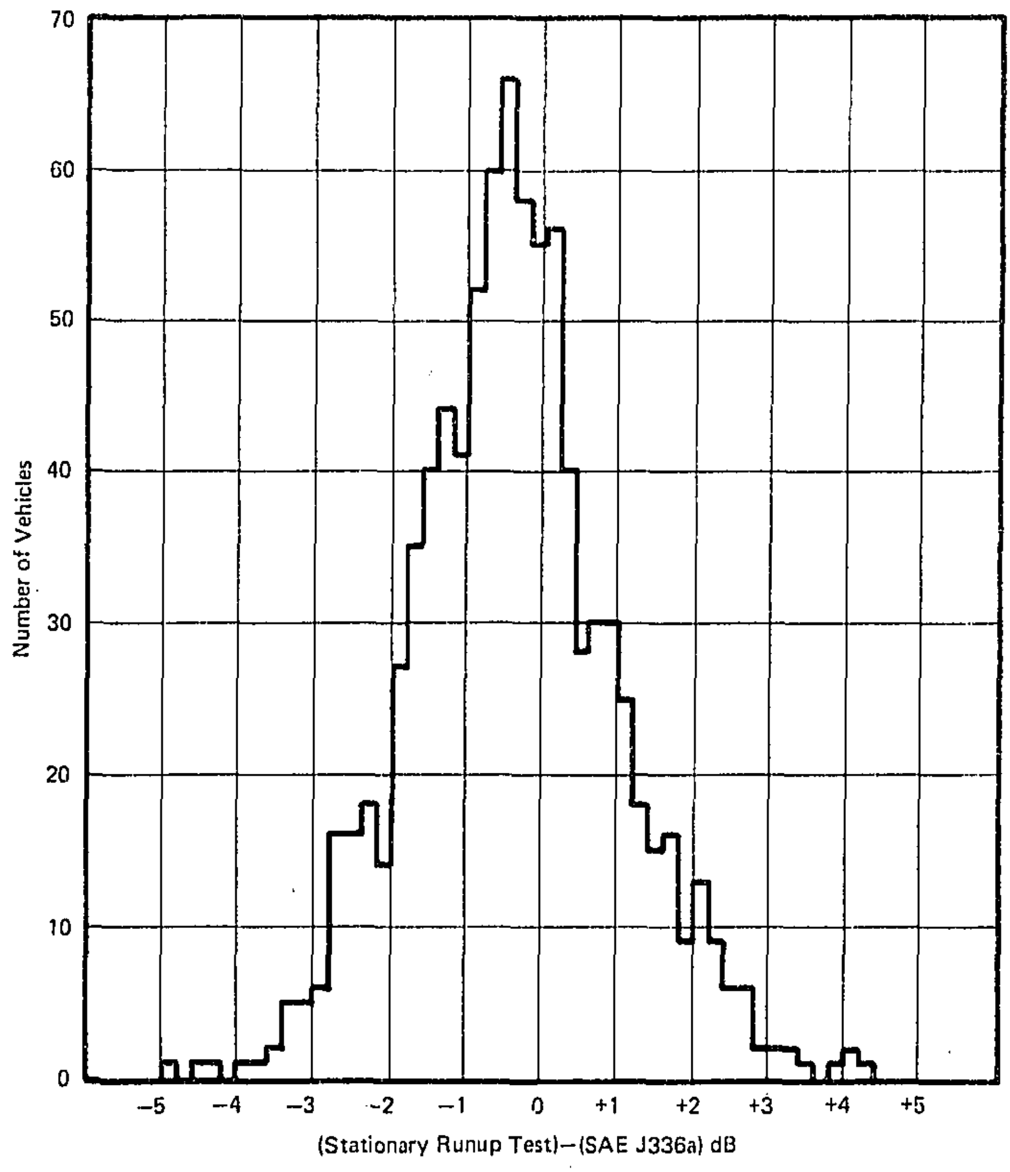


Figure 9. (Stationary Run-up Test) - (SAE J366a), dB

Section 4

NOISE MEASUREMENT OF IN-SERVICE VEHICLES

This section presents the results and implications of a number of surveys of the noise produced by motor vehicles of different kinds, measured at different speeds and conditions according to several standard test procedures.

Light trucks - those with a gross vehicle weight rating (GVWR) of 10,000 lb. or less - typically produce peak passby noise levels of 64 to 72 dB(A) at 35 mph when measured at 50 ft. These noise levels are about the same as those produced by passenger cars at the same speed (40). This result is not surprising, since the major noise-producing components of light trucks are very similar to those of automobiles: both are powered by similar gasoline engines, both have two-axle chassis, and both usually use similar rib-type tires.

Heavy and Medium Duty Vehicles (those with a GVWR or gross combination weight rating (GCWR) of more than 10,000 lb.) can produce peak passby noise levels of 95 dB(A) or more at 50 ft. (41).

Although all vehicles contribute to the noise emitted along streets and highways (which determines the ambient noise level in most urban communities (42)), Heavy and Medium Duty trucks cause a noise problem that can be separated from the problem of motor vehicle noise in general. Heavy trucks emit noise levels that are so much higher than those of other motor vehicles that they stand out very noticeably. Noise peaks of 12 dB above the ambient noise level from other traffic are commonly observed when a heavy truck passes by (43).

MEASUREMENT METHODOLOGY

Noise is measured by determining (by means of a sound level meter) the magnitude of pressure variations of various frequencies in the air. Since a person's subjective estimate of the magnitude of a sound is dependent upon the relative magnitude of its component frequencies, a weighting network is usually employed to match the response of the sound level meter to that of the human ear (44). The most commonly used network is the A-weighting network, which is contained in all sound level meters. Noise levels measured on the A-weighted noise scale are recorded using the notation dB(A). Noise scales other than A, B, and C are available, but they require a more complex analysis procedure, which is normally not justified by improved correlation with human assessment (45). Because noise levels can peak rapidly as a truck passes by, the sound level meter is usually set to "fast" response.

It has been argued that the A-weighted sound level discriminates against low frequencies and, consequently, should be replaced by the C-weighted sound level in motor carrier noise standards. However, the ear also discriminates against low frequencies so that at low frequencies the sound pressure level must be comparatively high before it can even be heard. This may explain why the correlations between A-weighted sound level and human response are consistently better than that obtained with the C-weighted sound level.

A-weighting has been shown to be a fairly good and consistent indicator of loudness for a variety of common noises (46, 47). On the other hand, the C-weighted level is consistently and significantly poorer than the A-weighted level (48). Insofar as a predictor for speech interference for a variety of noises, the C-weighted level is very poor as compared to A-weighted level (49). It may be concluded from the literature that of all standardized weightings, the A-weighted sound level has been the most successful of these measures as an indicator of human response. Some improvements could probably be gained by the new weighting characteristics that have been suggested recently (N, D, D1, and D2); however, these have not been nationally or internationally agreed upon; thus, no standardized procedures or equipment exist for them at the present time.

Noise levels decrease with distance from the noise source, so it is important to specify the distance at which measurements are to be made. For measuring truck noise, the most usual measurement distance selected is 50 ft. At closer distances, slight variations in measurement distance can produce significant errors in the measured noise level (50); at greater distances, background noise levels and the presence of noise-reflecting surfaces can pose problems in site selection (51).

In the surveys presented in this section, an effort was made to maintain standard conditions at almost all sites. Suitable instrumentation was used; sound level meters met the requirements of ANSI SI.4-1971, American National Standard Specification for Sound Level Meters. Microphone calibration was performed by an appropriate procedure and at prescribed intervals. An anemometer was used to determine wind velocity, and microphones were equipped with suitable wind screens.

Restrictions were made to prevent measurements during unfavorable weather conditions (e.g., wind and precipitation). The standard site for pass-by measurements was an open space free of sound reflecting objects such as barriers, walls, hills, parked vehicles, and signs. The nearest reflector to the microphone or vehicle was more than 80 feet away. The road surface was paved, and the ground between the roadside and the microphone was covered by short grass in most cases.

The standard site for the stationary runup test included space requirements that were the same as for pass-by measurements, and the surface between the microphone and vehicle was paved. Microphones for stationary and pass-by measurements were located 50 feet from the centerline of the vehicle or lane of travel, 4 feet off the ground, and oriented as per manufacturer's instructions. Variations from the standard measurement sites and microphone locations were allowed if the measurements were suitably adjusted to be equivalent to measurements made via the standard methods. Exact procedures for the tests are included in the appendix.

SURVEYS OF TRUCK NOISE

Truck noise surveys have been conducted in California in 1965 (52), and 1971 (53), in the State of Washington in 1972 (54), and in New Jersey in 1972 (55). In 1973, EPA contractors conducted additional truck noise surveys of 6,875 trucks operating at speeds over 35 MPH in the states of California, Colorado, Illinois, Kentucky, Maryland, New Jersey, New York, Pennsylvania, and Texas, and of 2,583 trucks operating under acceleration conditions at speeds under 35 MPH in the states of California, Colorado, Florida, Maryland, Missouri, Texas, and Virginia.

In almost all cases, measurements were made at a distance of 50 ft from the center of the first (outer) lane of travel, using A-weighting and fast response on the sound level meter. In the 1973 surveys, the type of truck and number of axles were recorded in order to permit detailed analyses of the noise level distributions for various types of trucks.

In addition, a study of noise levels of 60 trucks produced during a stationary run-up test was carried out by EPA in Virginia in February, 1974.

ANALYSES OF HIGH SPEED (OVER 35 MPH) SURVEY DATA

Figure 10 shows cumulative probability distributions for the peak passby noise levels measured at 50 ft under high-speed freeway conditions in the surveys conducted prior to 1973. The data shown are for heavy trucks: 5,838 diesel trucks in California in 1965 (56), 172 combination trucks in California in 1971 (57), 531 trucks with 3 or more axles in Washington in 1972 (58), and 1,000 trucks with 3 or more axles in New Jersey in 1972 (59). The data are in close agreement: typically, 50% of the trucks were observed to exceed 87 to 88 dB(A) and 20% were observed to exceed 90 dB(A).

Figure 11 shows that under high-speed freeway conditions, buses are about 2 dB quieter than heavy trucks. Approximately 50% exceed 85 dB(A), and 6% exceed 90 dB(A). These data were obtained in New Jersey in 1973.

Table 6 shows the mean noise levels and percentages of all trucks with six or more wheels that were observed to exceed 90.0 dB(A) under high-speed freeway conditions in ten states. These data were all obtained in 1973, except for the Washington state data, which were obtained in 1972. The arithmetic mean of the percentage of trucks exceeding 90.0 dB(A) is 23.1%. When the data is weighted by the sample size obtained in each state, this percentage drops to 22.6%. When the data are weighted by the number of registered trucks above 10,000 lb GVWR/GCWR, the percentage drops to 21.0%.

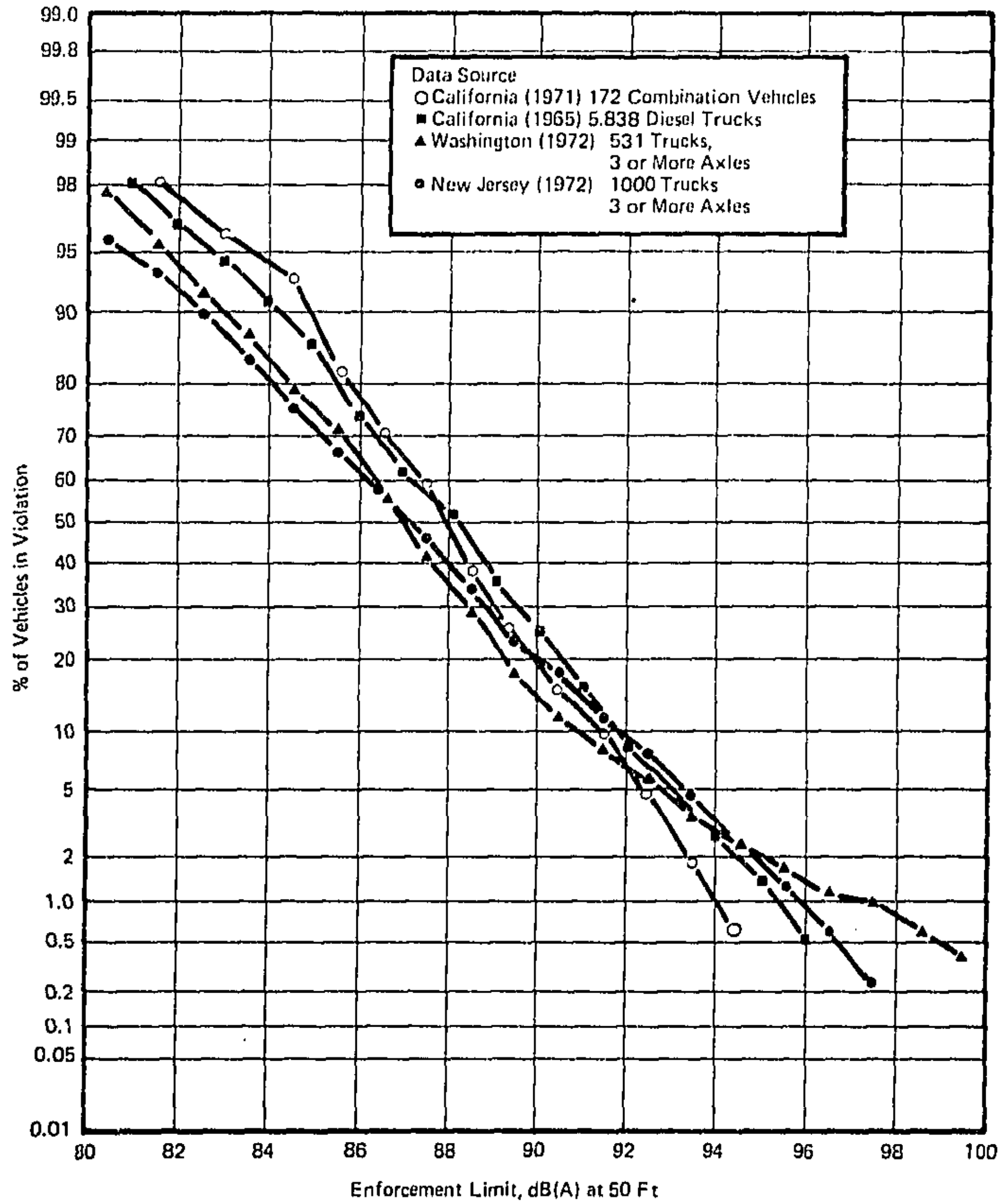


Figure 10. Enforcement Limit, dB(A) At 50 Ft

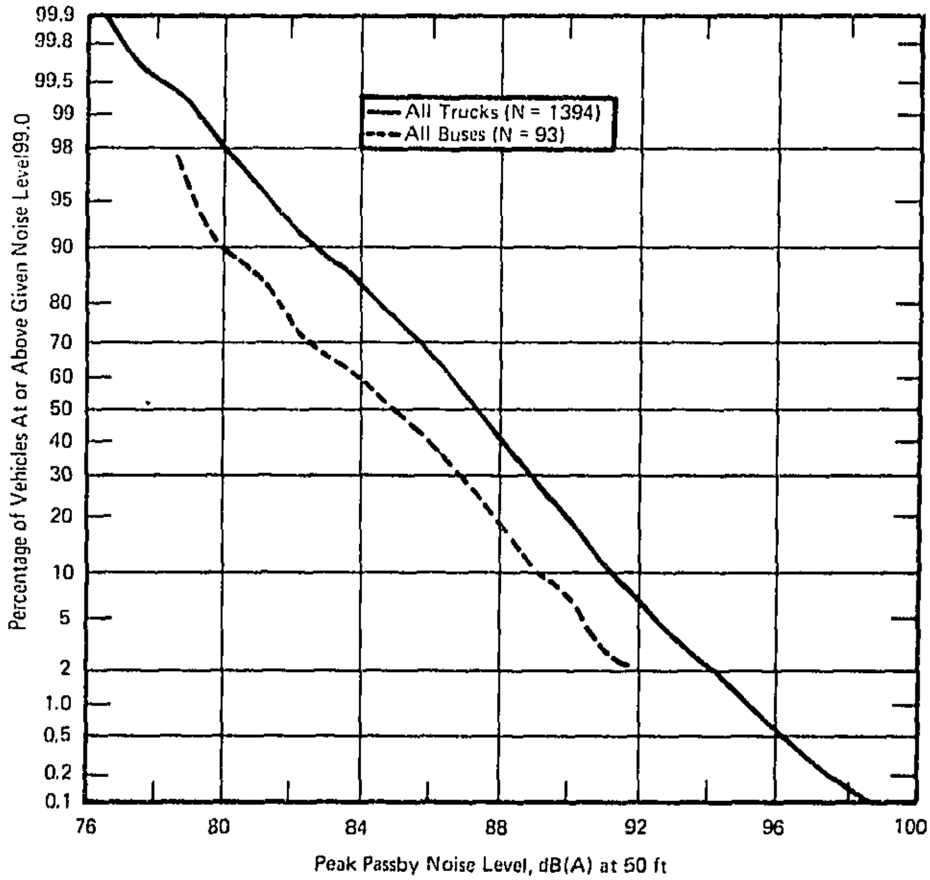


Figure 11. Cumulative Distribution Of Peak Passby Noise Levels For All Trucks And All Buses At Speeds Over 35 MPH

Table 6

ALL TRUCKS ABOVE 10,000 LBS GVWR OR GCWR

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)
CA	W.L.	85.4dB(A) (a)	-	5.0%
CO	BBN	84.6	51.7mph	10.0
IL	BBN	89.1	57.2	42.0
KY	BBN	88.8	61.3	40.0
MD	Md. DOT	88.1	-	30.0
NJ	BBN	87.2	56.5	20.0
NY	BBN	88.8	60.0	43.0
PA	W.L.	86.2 (a)	-	13.0
TX	BBN	83.7	56.1	12.5
WA	WA-72	86.6 (a)	-	16.0

mean percentage exceeding given noise level: 23.1%

(a) median

Table 7 shows the same results by type of truck for the nine states in which data were obtained in 1973. The mean percentages of trucks exceeding 90.0 dB(A) ranges from 1.9% of 2-axle trucks to 36.1% of 5-axle trucks.

A crucial distinction must now be made. The fact that approximately 23% of all trucks observed in these surveys exceeded 90.0 dB(A) does not mean that 23% of all registered trucks above 10,000 lb GVWR/GCWR will exceed this level. This is because larger trucks operate many more miles per vehicle per year than smaller trucks do and accordingly show up more frequently in surveys than their actual numbers would indicate. For example, 2-axle trucks average 10,600 vehicle miles per year, while 5-axle trucks average 63,000 vehicle miles per year (60).

Using data from the 1972 Census of Transportation - Truck Inventory and Use Survey (61), the following breakdown was obtained for the population of registered trucks above 10,000 lb GVWR/GCWR.

TRUCK POPULATION OVER 10,000 POUNDS GVWR/GCWR

2-axle straight truck	71.7%
3-axle straight truck	10.6%
3-axle combination truck	2.4%
4-axle combination truck	5.3%
5-axle combination truck	8.1%
Not reported or other	1.9%
	100.0%

Table 8 shows that when these percentages are multiplied by the mean percentages of each type exceeding 90.0 dB(A) from Table 7, a total of about 7% of all registered trucks above 10,000 lb GVWR/GCWR exceed 90.0 dB(A) at freeway speeds.

Table 7

2 AXLE STRAIGHT TRUCK ABOVE 10,000 LBS GVWR

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

3 AXLE STRAIGHT TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)
CA	W.L.	85.2 (a) (b)	-	8.0
CO	BBN	84.1	47.7	1.2
IL	BBN	85.8	54.5	9.0
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
PA	W.L.	84.5 (a) (b)	-	2.0
TX	BBN	84.8	50.6	*
mean percentage exceeding given noise level:				9.3%

(a) median

(b) all 3 axle trucks

* insufficient data

Table 7 (Continued)

3 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)
CA	W.L.	85.2 (a) (b)	-	8.0%
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
NJ	BBN	85.7	57.2	1.0
NY	W.L.	88.0 (a) (b)	-	26.0
PA	W.L.	84.5 (a) (b)	-	2.0
TX	BBN	83.0	56.5	*
mean percentage exceeding given noise level:				10.8%

4 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)
CA	W.L.	84.2 (a)	-	3.0
CO	BBN	84.8	49.0	9.0
IL	BBN	87.1	55.4	22.0
KY	BBN	88.0	61.0	24.0
MD	Md. DOT	87.9	-	26.0
NJ	BBN	86.7	57.7	11.0
NY	BBN	88.8	58.8	26.0
PA	W.L.	85.7 (a)	-	9.0
TX	BBN	83.9	56.4	4.5
mean percentage exceeding given noise level:				15.0%

(a) median

(b) all 3 axle trucks

* insufficient data

Table 7 (Continued)

5 AXLE COMBINATION TRUCK

State	Source	Mean Noise Level	Mean Speed	% Above 90.0 dB(A)
CA	W.L.	85.9 (a)	-	7.0%
CO	BBN	87.0	53.7	18.0
IL	BBN	90.2	57.7	51.0
KY	BBN	90.6	62.6	56.0
MD	Md.DOT	89.7	-	42.0
NJ	BBN	88.3	58.7	32.0
NY	BBN	91.2	61.6	74.0
PA	W.L.	87.6 (a)	-	22.0
TX	BBN	87.5	57.9	23.0
mean percentage exceeding given noise level:				36.1%

(a) median

Table 8

TRUCKS EXCEEDING 90.0 dBA AT SPEEDS OVER 35 MPH

	% of all trucks above 10,000 lbs (a)	% of type exceeding 90.0 dB(A)	% of all trucks above 10,000 lbs affected (a)
2 axle straight truck	71.7%	1.9%	1.4%
3 axle straight truck	10.6	9.3	1.0
3 axle combination	2.4	10.8	0.3
4 axle combination	5.3	15.0	0.8
5 axle combination	8.1	36.1	2.9
All other (b)	1.9	36.1 (c)	0.7
	100.7%		7.1%

(a) Estimates are for all trucks over 10,000 pounds GVWR or GCWR, including trucks not involved in interstate commerce.

(b) "All other" includes straight truck with trailer, combinations with 6 or more axles, and combinations not specified in the 1972 Census of Transportation survey.

(c) No data available. Percentage exceeding noise level is assumed to be the same as for 5 axle combinations.

ANALYSIS OF LOW SPEED (UNDER 35 MPH) SURVEY DATA

Table 9 shows the percentages of trucks above 10,000 lbs GVWR/GCWR that exceeded 86 dB(A) under low speed acceleration conditions in various states. These data were collected at roadside sites in seven states with acoustic characteristics similar to those of the sites used for the collection of high speed data, except in Maryland and Virginia. At these two sites, the paved surface covered the entire distance between the roadway and the microphone, and there was no grassy shoulder area. A site correction factor of -1.5 dB has been assumed for the data obtained at these sites in order to permit direct comparison with the other data, most of which was taken at open sites over a "soft" surface.

A comparison of the results shown in Table 9 with those of Tables 6 and 7 demonstrates not only that similar total percentages of trucks were observed to exceed 86 dB(A) under low speed acceleration as exceeded 90 dB(A) under high speed conditions, but also that these percentages are very nearly the same for each class of trucks considered separately. For example, 2% of all 2-axle trucks exceeded 86 dB(A) under low speed acceleration, while 1.9% exceeded 90 dB(A) under high speed freeway conditions. For 4-axle trucks, the results are 21% and 15%, respectively. In this sense, an 86 dB(A) limit under low speed conditions can be considered to be about as stringent as a 90 dB(A) high speed limit.

The calculations in Table 10 yield an estimate that at the present time about 8% of the nationwide truck fleet over 10,000 pounds exceeds 86 dBA during low-speed acceleration measured at an open site over a soft surface.

ANALYSIS OF STATIONARY RUNUP TEST DATA

EPA conducted a small-scale investigation to determine that the Stationary Runup Test (SRUT) is suitable with respect to practical enforcement, particularly in terms of repeatability, and to check that predicted violation rates as enforced would be consistent with those of the low-speed passby test. A state-weighing station in Virginia cooperated by allowing a survey team to request the participation of drivers as they appeared for weighing their trucks. Sixty trucks were measured by the method outlined in the appendix.

Table 9

PERCENTAGE OF TRUCKS AT OR ABOVE 86 dB(A)
DURING ACCELERATION BELOW 35 MPH

State	2-Axle	3-Axle	4-Axle	5-Axle	All Trucks
California	2%	12%	*	20%	10%
Colorado	3	6	27	24	17
Florida	1	7	13	36	10
Maryland (a)	*	11	20	40	35
Missouri	0	28	27	49	39
Texas	2	13	*	26	17
Virginia (a)	*	11	20	42	40
Mean Excluding California	2%	13%	21%	36%	24%

* insufficient data

(a). -1.5 dB site correction factor assumed (see text)

Table 10

PERCENT OF TRUCKS OVER 10,000 POUNDS
EXCEEDING 86 dB(A) UNDER 35 MPH

No. of Axles	% of Trucks Above 10,000 pounds (a)	% of Type Exceeding 86 dB(A)	% of Trucks Above 10,000 pounds Affected (a)
2 axle	72%	2%	1.4%
3 axle	13	13	1.7
4 axle	5	21	1.1
5 axle	8	36	2.9
All other (b)	2	36 (c)	0.7
	100%		7.8%

a) Estimates are for all trucks over 10,000 pounds GVWR or GCWR, including trucks not involved in interstate commerce.

b) "All other" includes straight truck with trailer, combinations with 6 or more axles, and combinations not specified in the 1972 Census of Transportation survey.

c) No data available. Percentage exceeding noise level is assumed to be the same as for 5 axle trucks.

A representative from the Bureau of Motor Carrier Safety explained to each driver the technique required to achieve a maximum engine runup. Four runups were performed for each truck and the noise level measurements were recorded. In many cases, the first attempt by the driver did not produce the rapid engine acceleration necessary for the test. However, in most cases the test was performed properly in subsequent attempts.

The average of the three highest noise levels obtained from the four tests was used to characterize the SRUT level for comparison with the EPA standard level of 88 dB(A). The consistency of the three highest levels was such that for 93% of the trucks tested, the range of noise levels was 1.5 dB(A) or less. Of the small population tested 35% exceeded the noise level standard of 88 dB(A).

CLASSIFICATION OF TRUCKS INTO CATEGORIES

The studies performed indicate that truck mean noise levels increase with vehicle size (or number of axles) and speed. Accordingly, regulations have been promulgated for high and low speed truck operations in order to quiet both engine-related noise and tire noise. An effort was also made to develop a suitable classification for trucks based on weight or number of axles in order to require the use of best available technology in trucks of all sizes.

Figure 12 presents cumulative distributions of peak pass-by noise levels over 35 MPH at 50 feet for trucks by number of axles. These data were obtained in New Jersey in 1973, but the differences observed between different vehicle classes are typical of other states as well. Mean noise levels for 2-axle, 3-axle, 4-axle, and 5-axle trucks are 82, 86, 87, and 89 dB(A), respectively. The greatest difference in means occurs between 2 and 3-axle trucks. Since this is also the break point between medium and heavy duty trucks, the Agency examined the feasibility of classifying trucks over 10,000 pounds into two categories in order to promulgate stricter regulations for smaller vehicles.

Although there is a significant difference between the mean noise levels of medium and heavy duty trucks, there is considerable overlap in the distributions of noise levels of trucks of different sizes currently on the road. The basic problem is that noisy propulsion systems are not confined to heavy duty trucks. Many truck manufacturers offer and have traditionally sold the same engines in trucks having 2 or 3 axles. For example,

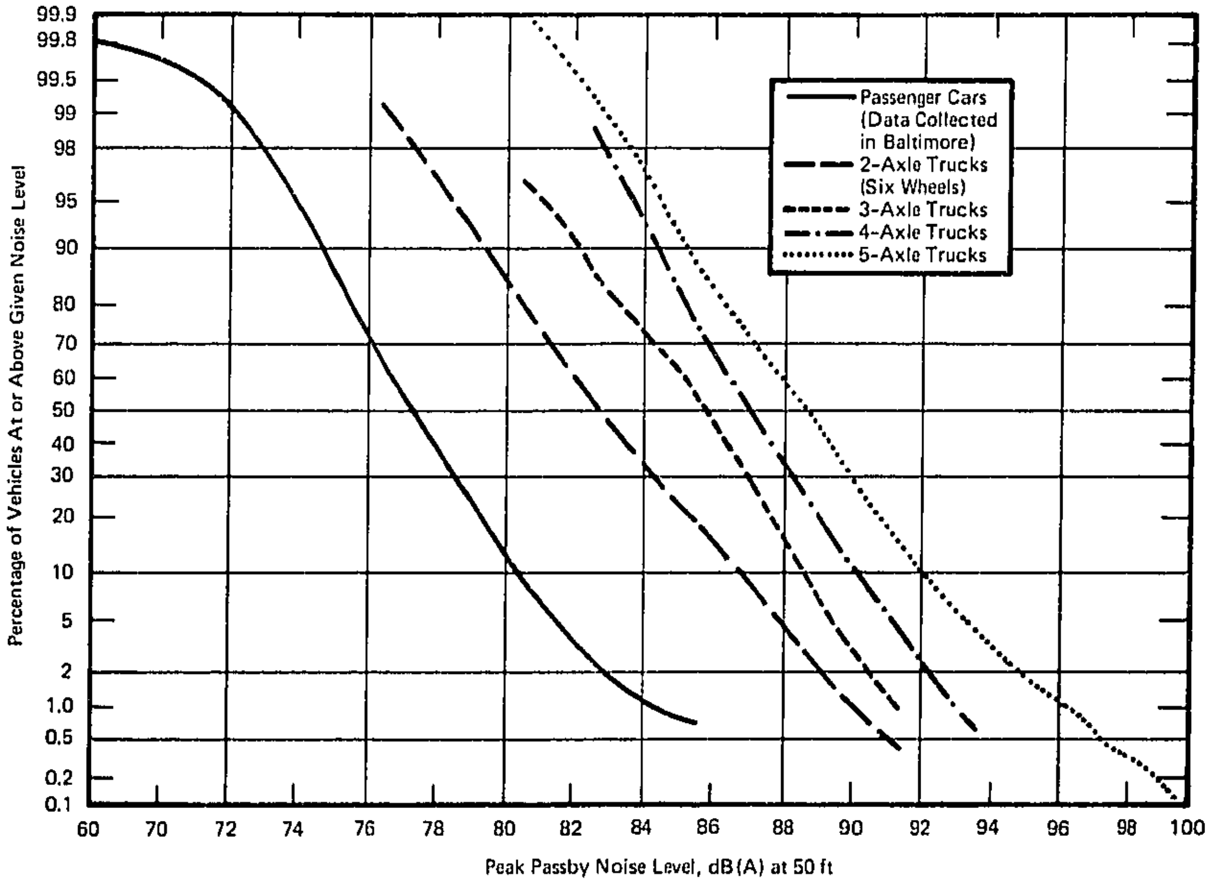


Figure 12. Cumulative Distribution of Peak Passby Noise Levels for Various Classes of Trucks at Speeds Over 35 MPH.

according to MVMA data, 3.5% of all new medium duty trucks sold in 1972 were powered by diesel engines similar or identical to those engines used on heavy duty trucks. The same situation has characterized the use of noisy gasoline engines. For this reason, further classification of motor vehicles into categories over 10,000 pounds GVWR is not feasible for the low speed standard.

An analysis of the feasibility of classifying trucks at speeds over 35 MPH indicated that 88 dBA could probably be achieved by 2-axle vehicles, since they use fewer tires than multi-axle combination vehicles. However, the analysis of the environmental impact of the high speed standard indicated that highway noise levels are determined almost entirely by the noise levels of the heaviest trucks (those with 4 and 5 axles). The additional assumption of an 88 dB(A) limit on 2-axle trucks above 10,000 lbs GVWR and an 82 dB(A) limit on all passenger cars and light trucks in addition to the proposed standards in the analysis produced essentially no further decrease in highway noise levels.

The Agency considered limiting the coverage of the Interstate Motor Carrier Regulations to trucks over 26,000 pounds GVWR/GCWR or to trucks having 3 or more axles because several states had requested that coverage be limited so that more stringent state regulations could be applied to the medium duty trucks. However, limiting coverage to trucks over 26,000 pounds would exclude 56% of all trucks over 10,000 pounds GVWR/GCWR from Federal regulation. Limiting coverage to trucks over 3 axles would exclude 72% of all trucks over 10,000 pounds GVWR/GCWR from Federal regulation.

Even though only a small percentage (2%) of all medium duty trucks exceed 86 dB(A) at speeds under 35 MPH and 90 dB(A) at speeds over 35 MPH, the actual number of trucks exceeding the standard is not small. Since the intent of Section 18 is clearly to provide uniform nationwide noise regulation for all vehicles involved in interstate commerce, and since limitation of coverage would allow medium duty trucks to go unregulated in many states, the Agency has determined that at this time medium and heavy duty trucks over 10,000 pounds operated in interstate commerce shall be subject to identical Federal regulations.

POTENTIAL DEGRADATION OF VEHICLES

Since a large proportion of medium duty vehicles at the present time have noise levels that are considerably below 90 dB(A) at speeds above 35 MPH, it has been suggested that degradation of these vehicles could occur until their noise levels reach 90 dB(A) due to the promulgation of Federal regulations. At the present time a few states enforce noise regulations equal to the proposed Federal regulations, while in other states vehicle noise is currently unregulated. Therefore, there is no a priori reason to believe that the change from this situation to one of Federal regulation should cause any vehicle to become noisier than it would be otherwise.

Nevertheless, some data are available that can be used to investigate the likelihood of degradation at speeds in excess of 35 MPH. In Figure 10 surveys of noise level distributions were presented for certain vehicle populations in Washington State (1972), New Jersey (1972), and California before and after state noise regulations were promulgated (1965 and 1971). Unfortunately, the vehicle populations and other conditions (e.g. speed, grades, and measurement sites) were not uniform in all states. The New Jersey and Washington studies examined vehicles of 3 or more axles, while the 1971 California study examined only combination vehicles. Since combination vehicles are the heavier portion of the heavy trucks having 3 or more axles, the California noise levels measured in the 1971 study would be expected to be above the noise levels measured in the other states.

An analysis of Figure 10 indicates that the 1971 California noise distribution is about one decibel above the other distributions at noise levels below 84 dB(A). The distributions are virtually identical between 84 and 92 dB(A) for all states in all years and for all vehicle populations. Above 92 dB(A), the effect of the California noise regulation is noticeable, since a smaller proportion of of vehicles are currently above 92 dB(A) in California than in other states.

As expected, no evidence exists to indicate that vehicles degrade more when regulated than when unregulated. In fact, since the California noise level distribution for very heavy combination vehicles (tractor trailers) is only one decibel above the distribution of medium and heavy trucks in other states, the state regulation may well have resulted in a reduction of the noise emissions of trucks that were already below 90 dB(A) prior to regulation.

Testimony from muffler manufacturers during EPA public hearings indicated that an increased demand for their better mufflers has been noted in noise-regulated areas. These manufacturers and the American Trucking Association (ATA) indicated they had no reason to believe that degradation had occurred in any states with noise regulations.

However, it is possible that when motor carriers replace the mufflers on their vehicles in order to comply with the Federal regulation requiring an exhaust system "free from defects which affect sound reduction," they will occasionally choose a muffler that is not as good as the original equipment. This is unlikely to occur with heavy duty trucks because it would lead to violation of the performance standards. However, it could happen with some medium duty trucks that originally had noise levels below the standard. The agency investigated the possibility of requiring a muffler "comparable to original equipment," but this requirement was determined to be undesirable because in many cases the original muffler supplied on old trucks did not sufficiently attentuate noise to meet the Federal emission standards.

In the event that future studies of the noise levels of in-serve medium duty trucks indicate that motor carriers are using replacement mufflers that are inferior to effective original equipment, regulations can be developed to label mufflers, and the Interstate Motor Carrier Regulations can be revised to require the use of mufflers comparable or superior to original equipment. Muffler manufacturers already provide information about the effectiveness of their mufflers on specific engine models, although measurement methods vary to some degree. Consequently, if degradation is found to occur, a remedy can be developed relatively easily.

Section 5

IMPACT OF THE FEDERAL NOISE REGULATIONS

Three kinds of potential impacts are associated with the promulgation of the Interstate Motor Carrier Regulations. An economic impact will occur because motor carriers will be required to retrofit those motor vehicles that are not in compliance with the regulations. An impact on highway and urban noise levels will occur because many vehicles will be made quieter. Finally, some States and local jurisdictions may be required to alter their existing regulations because the Federal regulations are preemptive.

ECONOMIC IMPACT OF THE REGULATIONS

According to the analysis presented in Section 5, approximately 7-8% of all registered trucks above 10,000 lb GVWR/GCWR will initially fail to comply with the standards as measured at typical roadside sites. Until such time as state and local jurisdictions adopt these standards as their own, the standards will apply only to motor carriers engaged in interstate commerce.

There is no direct method for determining precisely how many trucks above 10,000 lb GVWR/GCWR are engaged in interstate commerce. Based on truck population statistics, industry information, and inputs to the Advanced Notice of Proposed Rulemaking Docket, it appears that at least 1,000,000 of the 5,147,000 trucks above 10,000 lb GVWR/GCWR will be affected [62, 63, 64, 65].

As discussed in Section 3, the heaviest impact of the standards will fall on multiaxle trucks, and available statistics indicate that an average of $114 was required in 1973 to bring these trucks into compliance with local standards that were identical to the Federal Standards.

Since prices of most commodities and services have risen significantly over the past year and appear likely to continue to rise in the next year, the average retrofit cost can be expected to rise also. A reasonable average retrofit cost estimate for 1975 is therefore $135 per vehicle in violation of the standards.

If, as a worst case, it is assumed that all 5.2 million motor vehicles above 10,000 pounds GVWR/GCWR would be required to meet the standards, and that 8% of them would require retrofit at a cost of $135 per vehicle, then the total direct retrofit cost could be as high as $56 million.

Although the number and composition of trucks operating in interstate commerce is not known, most of the 5-axle trucks are thought to be used for hauling intercity freight, and most of them are involved in interstate commerce. Table 10 indicated that this group of trucks included half of all the trucks over 10,000 pounds GVWR expected to exceed the standards. Accordingly, the total retrofit cost is likely to be at least $28 million.

In 1970, the average revenue per intercity vehicle mile for Class I intercity carriers of all types was 91 cents. For Class I intercity carriers of general freight, average revenue was $1.24 per intercity vehicle mile. Total expenses for the latter group of carriers averaged $1.20 per intercity vehicle mile. Of these expenses, wages represented 46 cents; repairs and servicing, 8 cents; fuel and oil, 3 cents; tires and tubes, 2 cents; and depreciation and amortization, 5 cents. Direct wages represent 38% of expenses per intercity vehicle mile and 52 cents of every truck revenue dollar. Social security taxes, workmen's compensation payments, and welfare benefits bring total wages to 60 cents per truck revenue dollar[66].

A retrofit cost of $135 per vehicle is not a major burden for the interstate motor carrier industry. For a truck running 50,000 revenue miles per year, a $135 retrofit cost represents an increased expense of $.003 per revenue mile when amortized over a single year. When this increase is compared with 1970 average expenses of $1.20 per revenue mile, it can be seen that retrofit cost is not an obstacle to lower noise emission standards.

Additional costs include loss of revenue resulting from trucks being out of service during retrofit. Also, the installation of a suitable muffler may in some cases increase the back pressure on the engine and in turn increase the fuel consumption. Considering the wide variety of mufflers available[67], however, a significant increase in back pressure is avoidable.

Some factors reduce the total cost to the trucking industry. 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 anyway, and the difference is within the range of a few dollars. Secondly, for those trucks requiring installation of a more efficient fan, the amount of engine power wasted in driving a fan unnecessarily will be reduced. Standard fans on diesel engines typically consume 15 to 25 horsepower[(68)]. The addition of a thermostatically controlled fan clutch can decrease fuel consumption by 1 to 1.5%[(69)] 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.

Component suppliers appear to be capable of providing the needed retrofit components within the one year time period. The muffler manufacturing industry is capable of significantly expanding its muffler production, probably by a factor of two, because it already has the necessary facilities and material[(70)].

In the case of tires a large majority of such trucks will require new tires within a year regardless of the existence of the regulation. There should not, therefore, be a significant increase in the total truck tire production required, though there may be a slight shift in production from some tread patterns to others.

Other retrofit items discussed in Section 3 are in current production, and no significant problems are foreseen in meeting the production levels necessary to retrofit the small percentage of trucks that will need these items in order to comply with the standards.

ENVIRONMENTAL IMPACT OF THE NOISE EMISSION STANDARDS

The noise emission standards impact directly those trucks which presently make the most noise and require 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 continuous noise [71]. These peaks can be 12 dB or more above ambient highway noise levels. Therefore, significant noise reduction will be realized within a year, producing substantial benefits in terms of public health and welfare as indicated by a decrease in community noise levels near highways.

In a study performed under contract to the Environmental Protection Administration [72], L_{dn} levels were computed for an interstate highway, using hourly traffic volume statistics submitted by the Maryland Department of Transportation. This study was carried out using a modified version of the Highway Noise Prediction Model of the Transportation Systems Center, U.S. Department of Transportation. Baseline L_{dn} (day-night sound level) levels were computed using actual distributions of noise levels for various classes of trucks as measured in Maryland. Comparison levels were then computed using noise level distributions corresponding to several alternative regulation strategies.

The results of the study indicated that a 90 dB(A) limit for all trucks above 10,000 lbs GVWR/GCWR will produce a 3.6 dB decrease in L_{dn} for a typical East Coast Interstate highway. This represents a decrease of about 50% in the average sound energy near the highway.

An additional study of the impact of the Federal regulations has been performed using the Highway Research Board Design Guide model. This model is designed to perform an analysis of L_{eq} (A-weighted equivalent sound level) at 50 feet from the right of way of highways during the design hour. The model was used to estimate the impact of the regulations in both highway and normal urban conditions.

It was found that at 50 feet from a typical highway, the L_{eq} during the design hours (peak hour) is 80.9 dB for cruise conditions. This analysis is predicated on the following assumptions:

(1) during the worst traffic hour there are 7200 vehicles per hour traveling at an average speed of 55 m.p.h.

(2) the mixture of vehicles is 10 percent heavy duty trucks and 90 percent medium duty trucks, light trucks, and automobiles.

(3) the typical highway has 6 lanes of traffic.

The effect of the Federal regulations will be a significant reduction in highway noise levels. The results of the analysis indicate that 2 years after the operating rule goes into effect, the L_{eq} for highways during the design hour will have been reduced by 2.3 dB(A). The level will drop from 80.9 to 78.6 dB(A).

An analysis of normal urban conditions indicated that on city streets, the A-weighted equivalent level is 68.1 dB for a mixture of 1 per cent heavy trucks, 6 per cent medium trucks and 93 per cent automobiles, traveling at an average speed of 27 m.p.h.

The Federal regulations will affect only a few trucks on city streets because most of the traffic on urban streets is due to automobiles and light or medium trucks. Thus, the rule will bring about only a 0.3 dB(A) reduction in noise levels. A significant reduction in urban noise levels will not occur until medium duty trucks and automobiles are regulated to lower levels, since they are the dominant noise source in urban areas.

RELATIVE STRINGENCY OF FEDERAL REGULATIONS AND THOSE OF OTHER JURISDICTIONS

Jurisdictions with noise regulations planned or in effect have expressed an interest in the relative stringency of the EPA regulations because their regulations may be preempted by the Federal regulations. Test methodology and all techniques of enforcement must be compared in order to assess different regulations in terms of relative stringency. Maximum noise emission levels alone can be very misleading.

A pronounced effect on noise as measured exists as a result of the surface texture between vehicle and microphone. The EPA standards address this problem in that the stated levels apply to typical roadside sites with acoustically soft reflecting surfaces between the vehicle and the microphone.

Other factors affecting regulatory stringency in terms of measurement methodology can be as important as site variation. Microphone placement has a critical effect on measured noise levels. One city noise regulation calls for a microphone location 25 feet from the lane edge. This is 31 feet from the lane centerline and the regulated level would theoretically need to be 4 dB higher than the EPA standard specifies in order to be of similar stringency (all other factors being equal). In actual practice, at such close distances, ground surface reflections would result in a difference less than 4 dB.

Another area of variability deals with enforcement techniques and policies. The difficulty in assessing relative stringency is compounded by the fact that these techniques and policies, as actually enforced, are sometimes not made clear by the written regulations. A western State has a 90 dB(A) highway noise limit but has chosen not to issue citations if the enforcement officers determine that tire noise predominates. As enforced, this standard would be less stringent than an identically worded one in a jurisdiction enforcing against total noise emission. A New England State has a noise regulation which appears to be as stringent as the EPA standards, and which calls for increased stringency in the next year. Even though the wording of its regulation calls for compliance under all conditions of grade and acceleration, as does the EPA regulation, that State has chosen to enforce the regulation under level-road, no-acceleration conditions. The actual violation rate is for this reason much lower than the predicted violation rate for the EPA regulations and therefore the actual stringency is less.

The categories of vehicles subject to different State and local noise regulations vary. Those regulations which exclude certain classes of vehicles are less stringent as applied than regulations which include these vehicles. Some local regulations are based on measurement tests that are entirely different from the Federal tests. Determination of the relative stringency in such cases would require extensive technical research.

Where measurement methodology is absent from a written regulation, relative stringency cannot be determined. Tolerances in measurement conditions or vaguely defined conditions (e.g., measurement distance defined as "50 feet or nearest property line") and the use of different frequency weighting scales in different regulations also make comparison almost impossible.

Table 11 presents information on the noise limits currently in effect in a large number of State and local jurisdictions. Many of these jurisdictions currently appear to have regulations identical to the Federal regulations, but as mentioned, this can only be verified through a comprehensive analysis of the test measurement and enforcement procedures used in each jurisdiction [73].

TABLE 11

TABLE II QUANTITATIVE NOISE REGULATIONS FOR VEHICLE OPERATION

(Maximum Levels at 50 ft)

Vehicle Type	State, County, or City	Limits Under 35 mph dB(A)				Limits Over 35 mph dB(A)		
		Level Road Only	All Roads Now	Change Year	All Roads Then	All Roads Now	Change Year	All Roads Then
Trucks	California (over 6000 lb)*	82	86	--	--	90	--	--
	Chicago (over 8000 lb)	--	86	--	--	90	--	--
	Colorado (over 6000 lb)	82	86	--	--	90	--	--
	Connecticut	82	86	1975	84	90	1975	88
	Cook County (over 8000 lb)	--	86	--	--	90	--	--
	Idaho†	--	92	--	--	92	--	--
	Indiana (over 7000 lb)	--	88	--	--	90	--	--
	Minneapolis (over 6000 lb)	--	88	1975	86	--	--	--
	Minnesota (over 6000 lb)	--	88	1975	86	90	--	--
	Nebraska (over 10,000 lb)	--	88	1975	86	90	--	--
	Nevada (over 6000 lb)	--	86	--	--	90	--	--
	New York	--	88	--	--	--	--	--
	New York City (over 6000 lb)	--	86	--	--	90	--	--
	Oahu (over 6000 lb)	--	73-86	1974	73-84	86	1974	84
	Pennsylvania (over 7000 lb)	--	90	--	--	92	--	--
	Salt Lake County (over 6000 lb)	--	86	--	--	--	--	--

*No citation if tire noise predominates

†At 20 ft or more

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Appendix:

MEASUREMENT METHODOLOGY

The procedures given herein are intended to permit measurement of the A-weighted sound level of individual motor vehicles under specified conditions. The methods are consistent with the required accuracy of measurement. Suitable instrumentation for the measurements is prescribed; standard (ideal) measurement sites are described; and appropriate operational procedures are given for carrying out the measurements.

Applicable Documents

ANSI S1.4-1971, American National Standard Specification for Sound Level Meters is appropriate for these procedures and is available from American National Standards Institute, 1430 Broadway, New York, New York 10018.

Instrumentation

A precision sound level meter meeting all the requirements of ANSI S1.4-1971 throughout the frequency range from 50 Hz to 10,000 Hz for a Type I or Type SIA instrument should be used for all measurements. However, a magnetic tape recorder, graphic level recorder, or other device to record maximum sound level may be used for the measurement. In all such cases, the overall performance of the total system should conform to the ANSI S1.4-1971 requirements.

The necessary auxiliary equipment for the sound level meter includes a mounting to hold the microphone at a height of 4 ft ± 1 in (1.2 m) above the ground, and a cable at least 15 ft (4.5 m) in length, designed to be used with the sound level meter. The microphone manufacturer's instructions should be followed concerning the maximum permissible cable length.

An acoustical calibrator of the microphone coupler type should be used for calibration of the measurement instrumentation. The frequency of the calibration signal should be 1000 Hz, ± 5%. The calibrator should be checked at least annually by a method traceable to the U.S. National Bureau of Standards to verify the correct performance within ± 0.5 dB.

A windscreen should be used for all measurements to reduce the effects of turbulence at the microphone surface. An anemometer, accurate to within ± 10% at 12 mph (20 kph), should be used to determine the local velocity of wind gusts prevalent at the time of the measurements. The measurement of wind velocity should be taken at the height of the microphone and approximately 10 ft from the microphone.

Calibration

The sound level meter (including the entire sound instrumentation recording system) should be calibrated with the acoustic calibrator immediately before each series of measurements and at approximately 1/2-hour intervals during a measurement period. The manufacturer's directions for the calibration procedure should be followed. The entire measurement system, including all cables, but not the windscreen, should be included in the instrument chain for this calibration.

The entire measurement system should be calibrated, over the frequency range between 50 and 10,000 Hz, at intervals not exceeding one year, by procedures of sufficient precision and accuracy to determine compliance with the requirements of Section 3 of ANSI S1.4-1971. If there is any reason to suspect that the equipment has been altered or damaged, it should be given a complete calibration, regardless of the date of the last complete calibration.

Standard Measurement Site

The measurement site for roadside pass-by and stationary tests should be such that the vehicle radiates sound into an essentially open space above the ground. This condition may be considered fulfilled if the site consists of an open space free of large sound-reflecting objects (such as barriers, walls, fences, hills, hedges, signboards, parked vehicles, bridges or buildings) within the boundaries indicated in Figures A1 and A2 for the pass-by and the stationary vehicle measurements, respectively.

For the purposes of this requirement, "large" means dimensions greater than about one foot (0.3 m). Objects that would not be considered "large," and are therefore permitted within the measurement area, are fire hydrants, telephone or power poles, and rural mail boxes, but not, for example, telephone booths, or trees of any kind.

Weather

Weather conditions may adversely affect measurement precision. Accordingly, measurements should not be made during precipitation. The wind velocity should be read from the anemometer immediately before each series of measurements and at intervals of 1/2 hour during the measurement period, if wind conditions warrant. Measurements should not be made when the average continuous or gust wind speed exceeds 12 mph (20 kph).

Microphone Location

For all measurements, the surface upon which the microphone is located should be within ± 2 ft of the plane of the road surface. The microphone height should be 4 ft ± 1 in (1.2 m ± 2.5 cm) above the surface upon which it is located.

For the pass-by measurements the microphone should be located at a distance of 50 ± 1/2 ft (15 ± 0.15 m) from the centerline of the nearest travel lane. The microphone should have a clear and unobstructed line-of-sight to the entire side of the vehicle for all points along the roadway within 35 feet of the point of nearest approach.

For the stationary vehicle measurement the microphone shall be located 50 ± 1/2 ft (15 ± 0.15 m) from the fore-and-aft centerline of the vehicle, in a plane normal to that centerline and passing within 3 ft (1 m) of the nearest exhaust outlet.

Noise Measurement Procedures

The following procedures should be followed to assure accurate results in the measurement of motor vehicle noise emissions:

(1) The microphone should be oriented with respect to the vehicle being measured in accordance with the instructions or recommendations of the microphone manufacturer for optimum flat frequency response.

(2) To minimize the influence of the observer on the measurements, no person should be positioned within 10 feet of the microphone nor between the vehicle and the microphone.

(3) All noise measurements should be made with A-weighting and the fast meter response of the sound level meter.

(4) The background noise at the site (namely, the noise level measured with A-weighting and fast meter response due to all other sources of noise except the vehicle being measured) should be measured from time to time between vehicle passages. Vehicle noise measurements should not be made when the background noise level is within 10 dB of the permissible noise standard for the measurement in question.

(5) Corrections for measurement at different altitudes above sea-level should be made in accordance with the instructions of the microphone manufacturer.

(6) For vehicle pass-by measurements the maximum sound level observed as the vehicle passes through the measurement site should be recorded.

(7) For stationary engine run-up measurements the vehicle engine should be accelerated as rapidly as possible from a low idle speed to maximum governed speed with wide-open throttle, in neutral gear, and clutch engaged. Measurement of the highest sound level that occurs during the engine acceleration should be made at least twice, but more measurements should be made if necessary to achieve a satisfactory test.

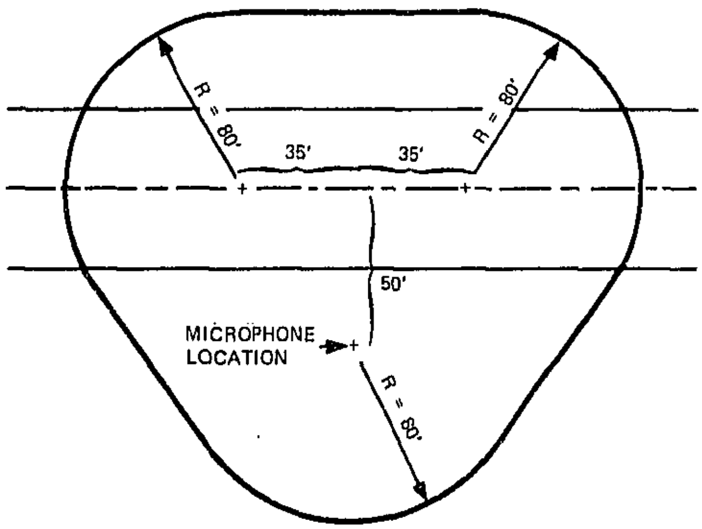

Figure A-1. Test site clearance requirements for pass-by test.

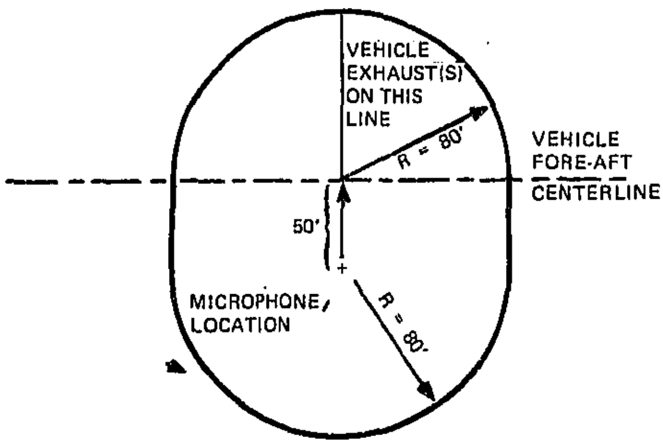

Figure A-2. Test site clearance requirements for stationary run-up test.