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# TECHNICAL ANALYSIS

# ALIGNMENT OF THE INTERSTATE MOTOR CARRIER NOISE REGULATION

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

Since passage of the Noise Control Act of 1972 (Public Law 92-574, 86 Stat. 1234) the Environmental Protection Agency (EPA) has been actively concerned with abatement and control of noise from medium and heavy trucks. Section 18 of the Act directed the Administrator to establish noise emission regulations for motor carriers engaged in interstate commerce. In October of 1974 the Agency promulgated an Interstate Motor Carrier (IMC) noise regulation (40 CFR 202). The regulation prescribed in-use operating noise limits, effective October 15, 1975, for all vehicles with a Gross Vehicle Weight Rating (GVWR) or Gross Combination Weight Rating (GCWR) in excess of 10,000 pounds. On September 8, 1975 the U.S. Department of Transportation (DOT), which has the Federal enforcement responsibility for the IMC regulation, issued a regulation (49 CFR 325) that prescribed test procedures for determining compliance with the (IMC) noise emission standards. The effective date of the DOT regulation also was October 15, 1975. A number of states and local jurisdictions have adopted and enforce the "in-use" noise standards of the IMC regulation as part of their individual noise control ordinances.

Subsequent to the IMC regulation, the Agency promulgated a regulation (40 CFR 205) under the authority of Section 6 of the Act, that established not-to-exceed noise levels for medium and heavy trucks (MHT) manufactured after January 1, 1978.

When the Agency promulgated the IMC regulation, it recognized that certain adjustments to the noise limits would be required in the future to ensure that the benefits anticipated from any "new product" regulation would be realized throughout the operating life of new trucks.

This document analyzes the potential effects of aligning the levels of the "in-use" IMC regulation with the not-to-exceed levels of the "new-product"

MHT regulation. In such an alignment, the IMC noise levels for trucks manufactured on or after January 1, 1978 would be consistent with the noise emission standards of the MHT regulation. Trucks manufactured prior to January 1, 1978 would not be affected.

The analysis of the potential effects of aligning the IMC and MHT standards is based on extensive field data on in-use truck noise levels, supplemented by tire noise and vehicle noise degradation data that were not available when the IMC regulation was promulgated in 1974. The analysis assesses the degree of compliance with the IMC standards by interstate motor carrier vehicles. It further evaluates the change in the in-use noise levels of trucks since promulgation of the IMC regulation and the in-use noise levels of trucks manufactured after January 1, 1978. The analysis concludes with an assessment of the potential costs and benefits of an alignment of the IMC regulation with the MHT regulation for post-1977 trucks.

Background

The Agency has addressed the medium and heavy truck noise problem through both "in-use" and "new product" controls. The "in-use" control was effected through the promulgation of the Interstate Motor Carrier (IMC) regulation which specified not-to-exceed noise levels for vehicles in three operating regimes:

- Low speed operation; passby speed of 35 MPH or less, with soft ground surface between vehicle and microphone - 86 dB(A)
- High speed operation; passby speed over 35 MPH, with soft ground surface between vehicle and microphone - 90 dB(A)
- Stationary run-up test; with hard ground surface between vehicle and microphone - 88 dB(A)

The IMC levels were determined on the basis of the actual distribution of truck noise levels in the early 1970's. The regulatory levels were intended primarily to control the noise from those vehicles that were exceptionally noisy - e.g., trucks operating with defective exhaust systems, without a muffler, or with excessively noisy tires. The regulatory levels effectively set a "cap" on existing truck noise and required operators of exceptionally noisy trucks to correct the causes of the excessive noise, bringing their trucks into conformance with the rest of the fleet. In addition, the regulation provided an incentive for all operators to sustain the noise control performance of their vehicles through proper maintenance.

While the IMC regulation served to remove the especially noisy vehicles ("outliers") from the IMC fleet, it did not require incorporation of new noise control technology in the fleet's vehicles. Consequently, the average noise level of the fleet could not decrease below the average for properly maintained pre-1978 vehicles. The MHT regulation, on the other hand, prescribed lower noise limits for new trucks that required application of new noise control technology. More effective exhaust and muffler systems, quieter air intake systems, and limited engine shielding were the principal methods used to reduce vehicle noise. The intent was to permit only "quieted" trucks to enter the fleet. Thus, over a period of time, if the lower levels of the MHT vehicles were sustained, the average noise level of the fleet would decrease with time, as the quieted trucks comprised more and more of the fleet.

The MHT regulation was promulgated on April 13, 1976, and became effective January 1, 1978. It established a not-to-exceed noise level of 83 dB(A) for medium and heavy trucks manufactured on and after January 1, 1978. An 80 dB(A) level becomes effective in 1986. The MHT regulation specified a full-throttle passby test conducted on an acoustically hard site. This full-throttle passby test is based on the SAE J366 test. Analyses(*) are avail-

(*) Ref

able that relate levels from this test to the noise levels obtained in IMC low-speed passby and stationary tests.

The IMC and MHT regulations together have led to a substantial decrease in truck noise over the past decade. Other factors that also contributed to the reduction in truck noise during this period included the introduction of the 55 mph speed limit which served to reduce high speed tire noise (the principal contributor to truck noise at speeds above 35 mph) and the increased emphasis on fuel economy which resulted in the widespread use of lower-speed engines, turbo-charged engines, and ribbed-tread radial tires.

Figure 1 shows the substantial decrease in truck noise levels that has occurred during recent years. In 1973, prior to the IMC regulation, the average noise level of vehicles over 10,000 pounds was 90 dB(A)* under typical high-speed (over 35 mph) highway operation**. Average noise level dropped to less than 86 dB(A) by the end of 1976, primarily as a result of the IMC regulation. The fleet average noise level has continued to decline since 1977 with the introduction of new trucks that are subject to the 83 dB(A) MHT regulation. This decline is expected to continue until the late 1990's as the pre-1978 trucks in the fleet are replaced by the quieter MHT-regulated trucks. However, this depends on proper maintenance of the vehicles to ensure retention of their low noise characteristics.

Figure 1 further shows that the IMC regulation's high-speed current noise standard of 92 dB(A) is substantially above the present in-use average truck noise level. The effects of the MHT regulation are only beginning to be seen in the in-use average because over one-half of the trucks now in the fleet

*Note: All noise levels reported herein are adjusted ("normalized") to a distance of 50 ft from the vehicle or highway lane centerline and an assumed acoustically "hard" surface between vehicle and microphone.

**A Society of Automotive Engineers (SAE) voluntary standard which reflected this average noise level had been in existence for several years.

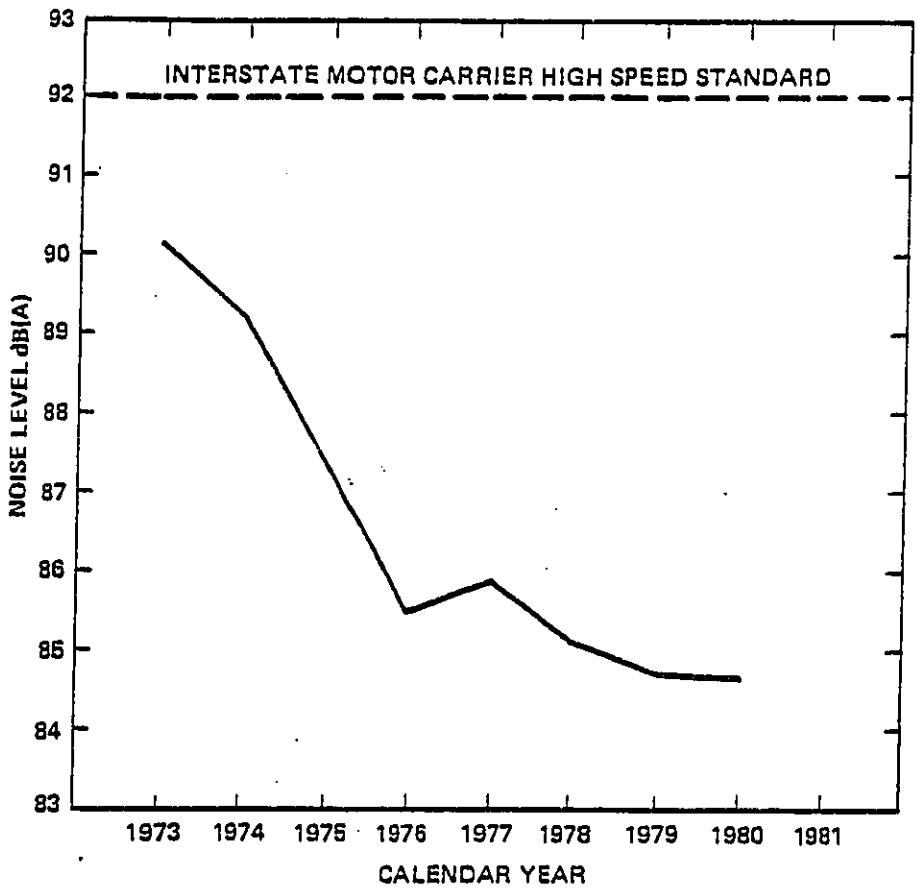


FIGURE 1. AVERAGE IN-USE TRUCK NOISE LEVELS: HIGH SPEED OPERATION, 1973-1981.

still are of pre-1978 manufacture. The typical lifespan of a medium or heavy truck is about 15 years. As the present MHT trucks age their noise levels may increase in the absence of aligned IMC noise standards that will induce proper maintenance.

Levels of Truck Noise

The current high-speed, low-speed, and stationary IMC Noise level limits, of 92, 88, and 88 dB(A) respectively, are based on actual fleet noise levels of the early 1970's. They were selected to eliminate the worst-case offenders from the highway. Table 1 summarizes the "real world" field measurement data and sources on which truck noise levels for the original IMC regulation were based. The fleet average for high-speed noise was between 89 and 90 dB(A) in the early 1970's. Low-speed levels averaged 86.7 dB(A) during that period, while stationary test levels averaged 86.2 dB(A).

The relationship of the IMC regulatory levels to noise levels of the early 1970's truck fleet is shown in Figures 2, 3, and 4. Figure 2 shows that 75 to 80% of the truck fleet was at or below 92 dB(A). Hence, it was anticipated that approximately 20-25% of the fleet would exceed the 92 dB(A) high-speed IMC noise level limit and thus would require corrective action to provide some degree of quieting.

The percentage of trucks at or below different low-speed noise levels is shown in Figure 3. The distribution in Figure 3 is derived from Table 9 in the IMC Background Document [1] and from additional information in the MHT Background Document [4]. While this distribution was not presented in the IMC Background Document, it represents the distribution of actual low-speed truck noise levels during the early 1970's.

The distribution presented in Figure 4 shows that in 1972-1973 approximately 75% of trucks did comply with the IMC stationary test level of 88dB(A). This distribution is derived from low-speed data presented in the MHT Back-

TABLE 1. OBSERVED TRUCK NOISE LEVELS -1972-1974.

| IMC Operating Regime | Source and Year | Measured Average Noise Level (dB) (A) | Regulatory Noise Level Limit (dB) (A) |
|---|---|---|---|
| High Speed | Interstate Motor Carrier Background Document [1], 1965-1972 | 89.0 | 92 |
| | Florida Department of Environmental Regulation [2], 1974 | 89.2 | |
| | New Jersey Turnpike Authority [3] 1973 | 90.2 | |
| Low Speed | Interstate Motor Carrier Background Document [1], 1965-1972 | * | 88 |
| | Medium and Heavy Truck Background Document [4], 1972-1973 | 86.7 | |
| Stationary Test | Interstate Motor Carrier Background Document [1], 1972-1974 | 86.2 | 88 |

*The Interstate Motor Carrier Background Document presents data from several states showing the percentage of vehicles complying with proposed IMC levels, but it does not present average noise levels.

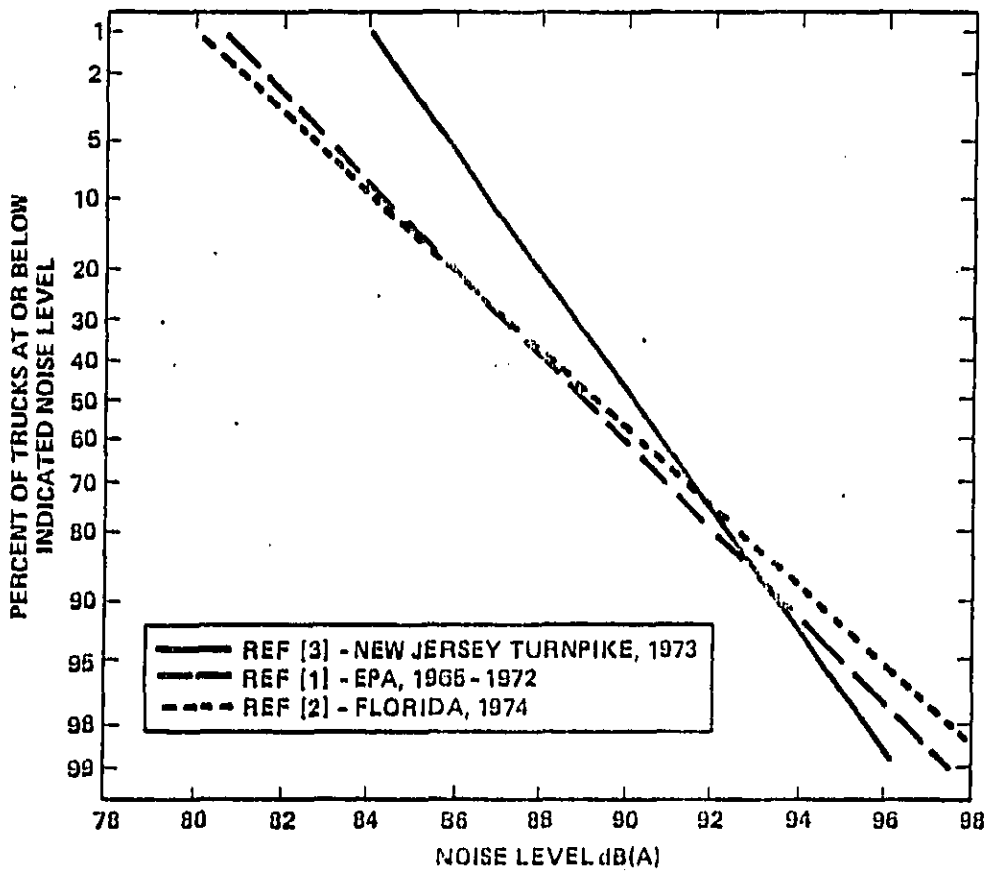


FIGURE 2. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: PRE-INTERSTATE MOTOR CARRIER REGULATION - HIGH SPEED.

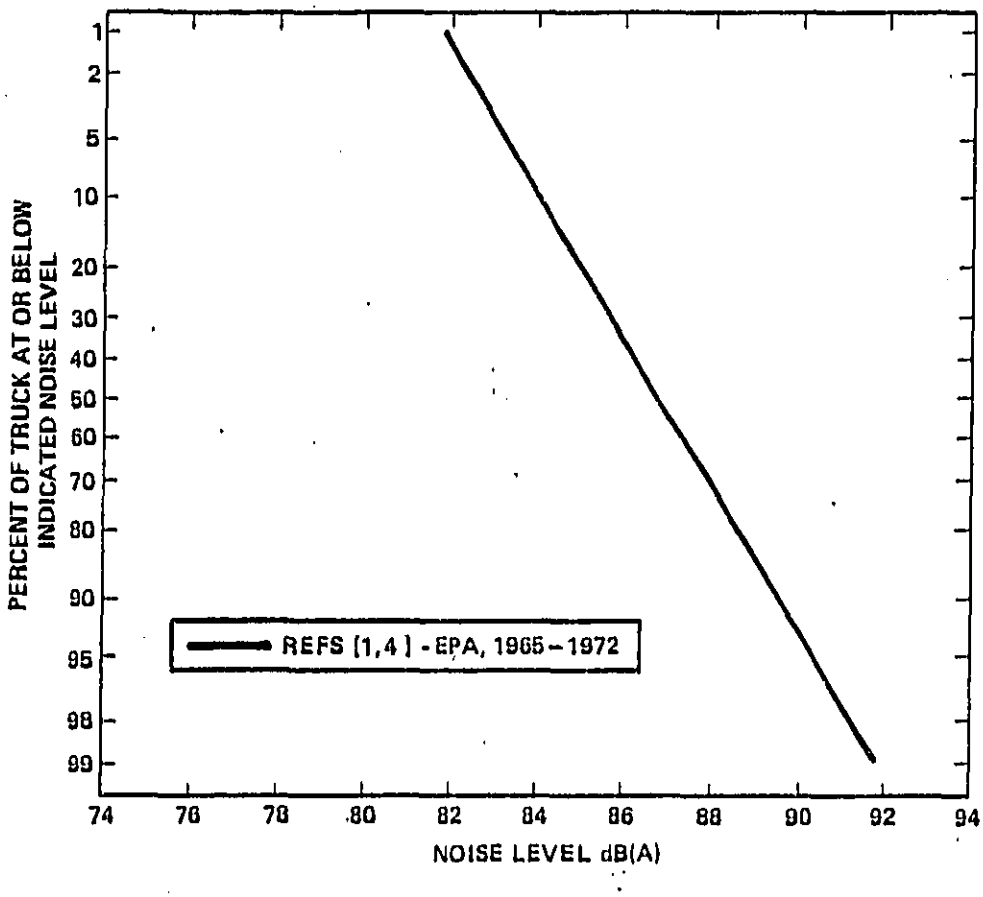


FIGURE 3. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: PRE-INTERSTATE MOTOR CARRIER REGULATION - LOW SPEED.

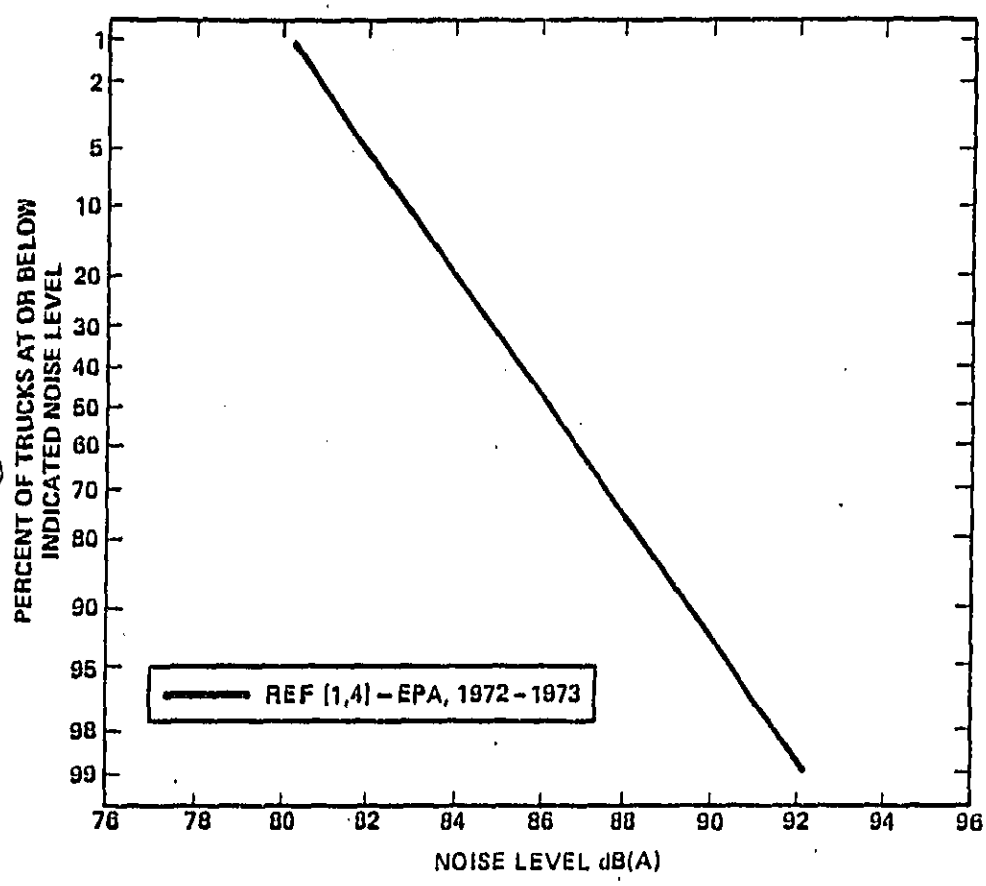


FIGURE 4. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: PRE-INTERSTATE MOTOR CARRIER REGULATION - STATIONARY TEST

ground Document. The distribution is corrected by an amount, shown in the IMC Background Document, which relates stationary levels to low-speed passby levels.

There is extensive information on the current level and distribution of truck noise. The Bureau of Motor Carrier Safety (BMCS) of the U.S. Department of Transportation has enforcement responsibility for the IMC regulation. BMCS has made almost 10,000 noise measurements in the past 2 years in its IMC enforcement activities. These noise measurements are obtained primarily with stationary tests.

EPA enforcement activities for the medium and heavy truck regulation have generated substantial information on the noise levels of trucks manufactured since January 1, 1978. Production verification data supplied to the Agency are closely related to low-speed IMC levels. Surveillance data from MHT enforcement activities provide information on both low-speed and stationary test noise levels.

Table 2 presents a summary of recent measurements of truck noise and the sources of the measurements. The table is comparable to Table 1 except that measurements are reported both for the entire truck fleet and for trucks manufactured since January 1, 1978.

Comparison of Table 1 and Table 2 shows that the average noise level of the entire in-use fleet decreased significantly between the early 1970's and 1977, and decreased further after 1978, as the post-1977 trucks entered the fleet. The average high-speed noise level is now approximately 85 dB(A), compared with 89-90 dB(A) in the early 1970's. The average high-speed level of the MHT fleet is 83.4 dB(A), 1.3 dB below the corresponding BMCS entire in-use fleet average and 9 dB below the current IMC high-speed noise limit.

TABLE 2. OBSERVED TRUCK NOISE LEVELS - 1977-1981.

| IMC Operating Regime | Entire In-Use Fleet | | MHT In-Use Fleet* | | Regulatory Noise Level Limit (dB) |
|---|---|---|---|---|---|
| | Source and Year | Measured Average Noise Level (dB)(A) | Source and Year | Measured Average Noise Level (dB)(A) | |
| High Speed | Bureau of Motor Carrier Safety [5], 1980 | 84.7 | Bureau of Motor Carrier Safety [6], 1980-1981 | 83.4 | 92 |
| | Florida Department of Environmental Regulation [2], 1977 | 85.9 | | | |
| Low Speed | Sufficient Data Not Available | | EPA Product Verification Data [7], 1978 noise contribution | 80.6 | 88 |
| | | | EPA Surveillance Data [8], 1978 | 80.2 | |
| Stationary | Bureau of Motor Carrier Safety [5]; | | Bureau of Motor Carrier Safety [6], 1980-198] | 79.2 | 88 |
| | 1979 | 82.0 | EPA Surveillance Data [8], 1978 | 77.9 | |
| | 1981 | 79.9 | | | |

*Trucks manufactured after Janaury 1, 1978.

Stationary test data show a similar decline in vehicle noise from pre-regulatory levels. The in-use fleet has an average stationary test noise level of 80-82 dB(A), and the MHT fleet has average levels of 77-78 dB(A), or 10 dB below the current standard.

The average low-speed noise level of the MHT fleet is approximately 80 dB(A) or about 8 dB(A) below the current IMC level. However, the BMCS has conducted low-speed measurements for only 60 trucks, an insufficient sample for the prupose of this analysis.

Figures 5, 6, and 7 present the distributions of high-speed, low-speed, and stationary test truck noise levels upon which the average entries in Table 2 are based. Together, these figures show the high degree of compliance with the current IMC noise levels, particularly for trucks manufactured since January 1, 1978. Figure 5 shows that in 1980, 99% of the entire in-use fleet was at or below the IMC high-speed noise level limit of 92 dB(A). In addition, Figure 5 shows that virtually the entire MHT in-use fleet is in compliance with the current high-speed standards.

The distributions of low-speed truck noise shown in Figure 6 are exclusively for the MHT fleet. Both distributions show that the MHT fleet is well below the current low-speed noise level limit of 88 dB(A).

The impact of the MHT regulation is evident from the distributions in Figure 7. The distributions for the overall fleet show the decrease in noise levels between 1979 and 1981 as trucks in compliance with the MHT regulation become a larger proportion of the fleet. The dashed line in Figure 7 is the BMCS distribution for trucks manufactured since January 1, 1978. Again, virtually all these vehicles are at or below the current IMC stationary test noise level limit.

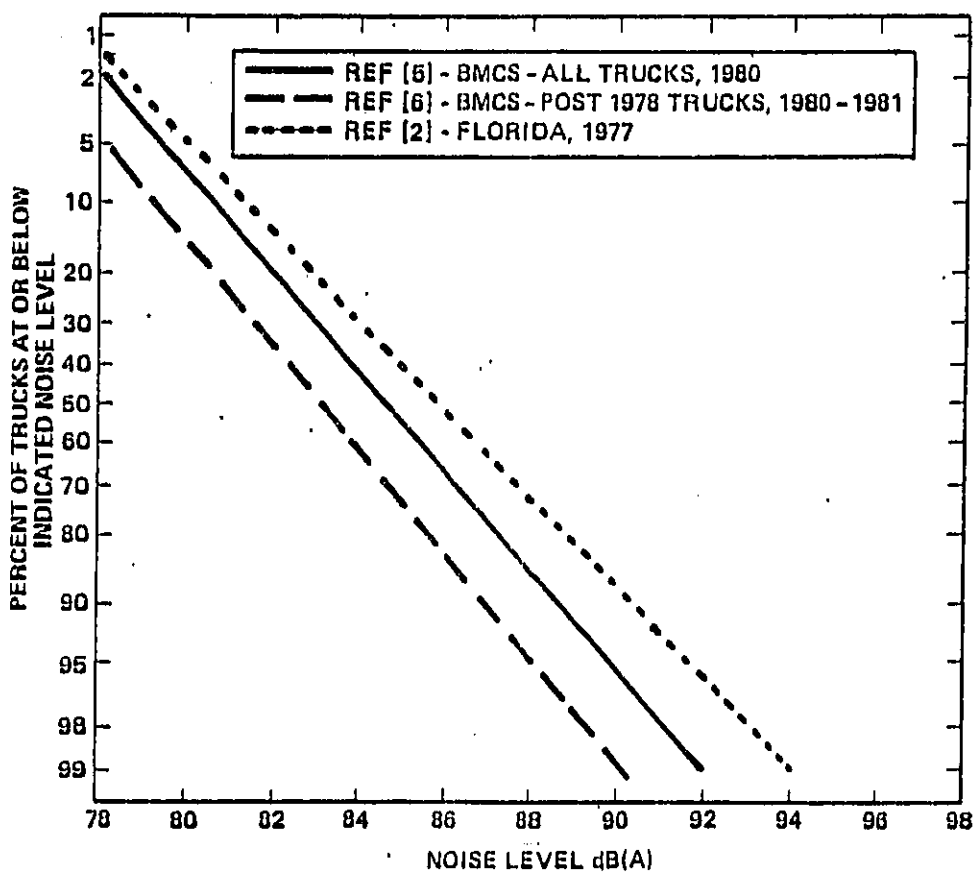


FIGURE 5. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: POST-INTERSTATE MOTOR CARRIER REGULATION - HIGH SPEED.

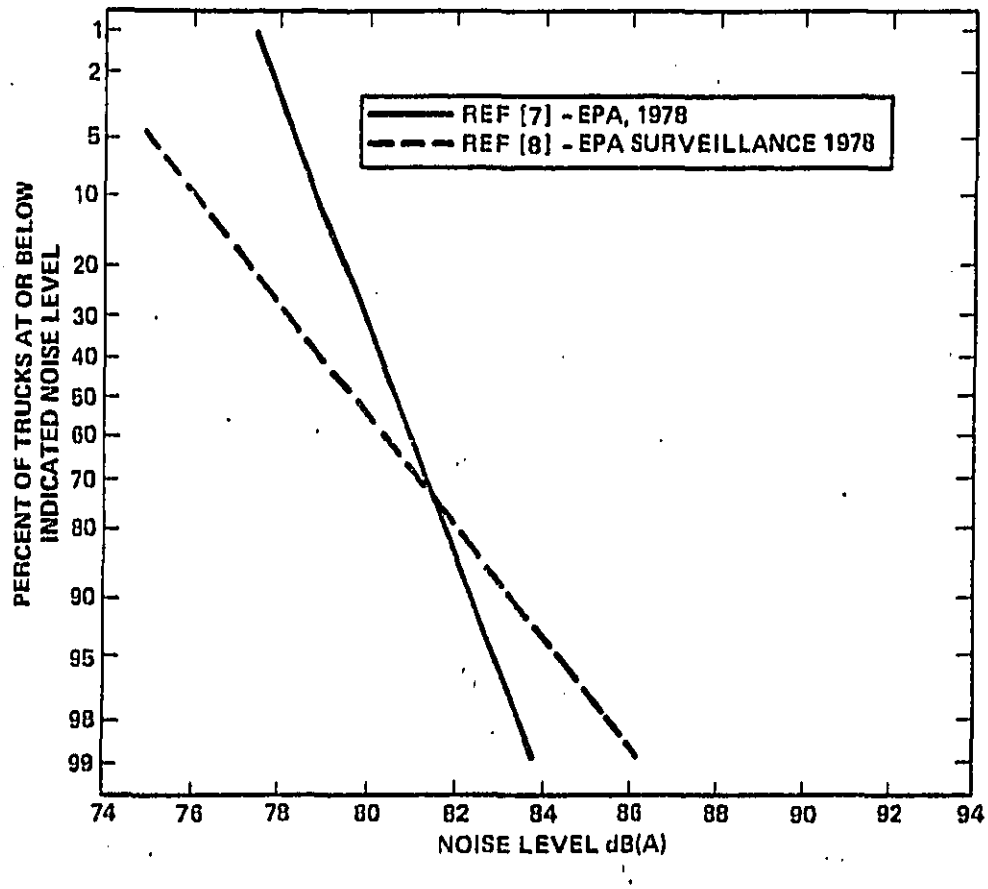


FIGURE 6. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: POST-INTERSTATE MOTOR CARRIER REGULATION - LOW SPEED.

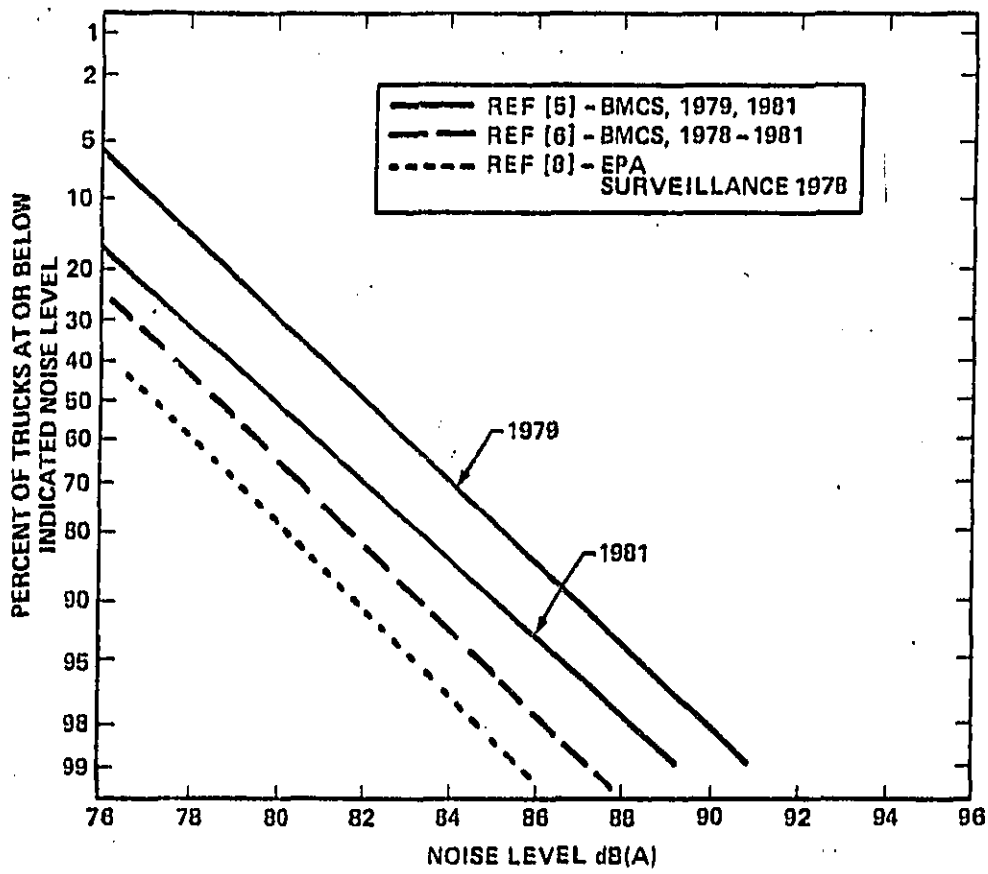


FIGURE 7. CUMULATIVE PERCENTAGE DISTRIBUTION OF TRUCK NOISE LEVELS: POST-INTERSTATE MOTOR CARRIER REGULATION - STATIONARY TEST.

The data presented in Figures 5, 6, and 7 represent the (real world) truck noise information base upon which to develop IMC noise emission standards that are aligned with those in the MHT regulation. The Agency has recently conducted an analysis of vehicle noise degradation. The noise levels of 26 medium and heavy trucks were monitored during 1978 and 1979 to attain data on acoustical degradation. Eight of the trucks were manufactured after January 1, 1978 and complied with the MHT regulation. The results of the analysis are summarized in Figure 8. In general, the results are inconclusive. Some vehicles became as much as 4 dB noisier during the period, while other vehicles became as much as 4 dB quieter. (One anomalous observation was eliminated.) On average, there was no degradation - the increases were offset by decreases. Of the 8 vehicles that complied with the 83 dB(A) regulation, 5 became quieter and 3 became noisier. These observations are shown with the diagonal markings in Figure 8.

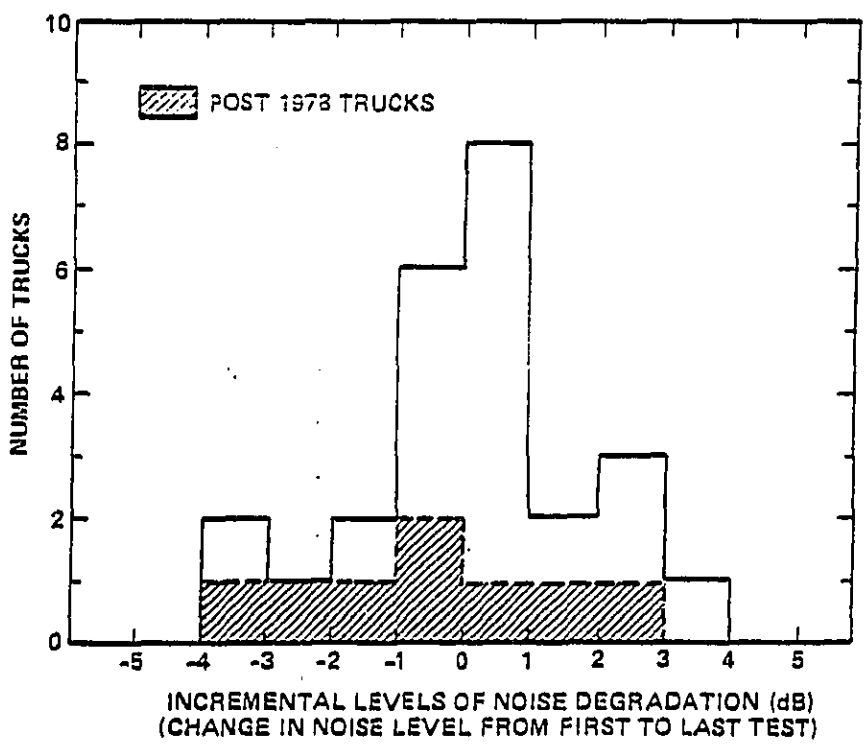


FIGURE 8. DISTRIBUTION OF TRUCK NOISE DEGRADATION. STATIONARY TEST PROCEDURE [9].

Aligned Levels and Projected Compliance

The original low-speed IMC standard was developed to address drive train noise, e.g., engine, transmission, and exhaust system. Drive train noise is exactly what the MHT regulation has reduced. The 4 dB difference between the IMC low-speed and high-speed noise limits was to account for tire noise at higher speeds.* That differential was intended to eliminate excessively noisy tire designs. The stationary test was included in the original IMC regulation in order to facilitate measurements at weigh stations. Note that while the high-speed and low-speed levels are specified for a "soft" site, the stationary test level is specified for a "hard" site.

There were two underlying principles upon which the IMC levels were originally selected:

- The levels were based on the actual noise level of the truck fleet.
- The levels were designed to reduce the noise of the very noisiest trucks, as opposed to that of the average truck.

These same principles have been relied on to project reasonable noise limits for an aligned IMC regulation. Information on the level and distribution of truck noise for vehicles manufactured since January 1, 1978 has been extensively reviewed. Recommended noise limits for an aligned IMC regulation based on this review are presented in Table 3. Consistent with the other data presented herein, the levels are "normalized" to hard-site values.

*The 4 dB differential between the low-speed and high-speed levels still appears valid. Speed limits at the time of the original IMC regulation were 65 mph and above, while the current speed limit is 55 mph. This speed reduction reduces the contribution of tire noise in the high-speed test. A reduction in speed from 65 to 55 mph reduces the noise of a typical tire by approximately 2.5 dB.

TABLE 3. ALIGNED IMC NOISE LEVEL LIMITS

| Operating Regime | Noise Level Limit (dB)(A) Original | Aligned |
|---|---|---|
| High Speed | 92 | 87 |
| Low Speed | 88 | 83 |
| Stationary Test | 88 | 83 |

The aligned noise level limits for all operational modes are below current limits. This represents a 70 percent decrease in sound power, equivalent to reduction of the size of the fleet by 70 percent.

The anticipated compliance of the affected vehicles with the aligned levels is presented in Figures 9, 10, and 11. The distributions in the figures are based on actual field measurements of noise from trucks manufactured after January 1, 1978. The distributions can be interpreted as showing the probability that any MHT truck will comply with a regulatory limit equal to the indicated noise level. Approximately 90 percent of vehicles affected by this alignment already comply with the aligned noise limits. Thus, the aligned limits are consistent with the principles upon which the original limits were based and affect only the very noisiest vehicles. Table 4 summarizes information from the three figures by showing the percentage of trucks at or below alternative high-speed, low-speed and stationary test noise limits.

As is shown in Figure 9, 90 percent of the MHT fleet is in compliance with an IMC high-speed noise level limit of 87 dB(A). In contrast, approximately 20-25% of the fleet exceeded the original IMC high-speed noise level limit.

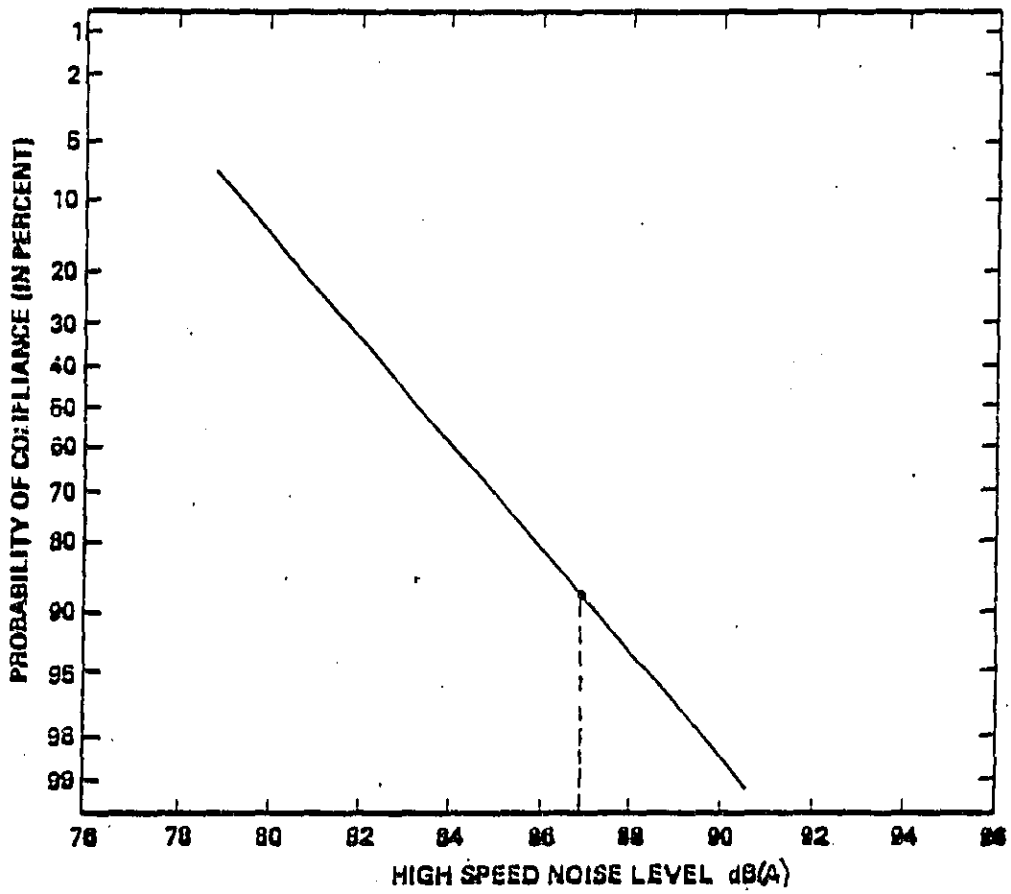


FIG. 9. ESTIMATED PROBABILITY OF POST-1978 MEDIUM AND HEAVY TRUCK COMPLIANCE AS A FUNCTION OF HIGH-SPEED NOISE LEVEL*.

*The distribution is based on 121 field measurements conducted during Bureau Motor Carrier Safety enforcement activities in the 1980-1981 period.

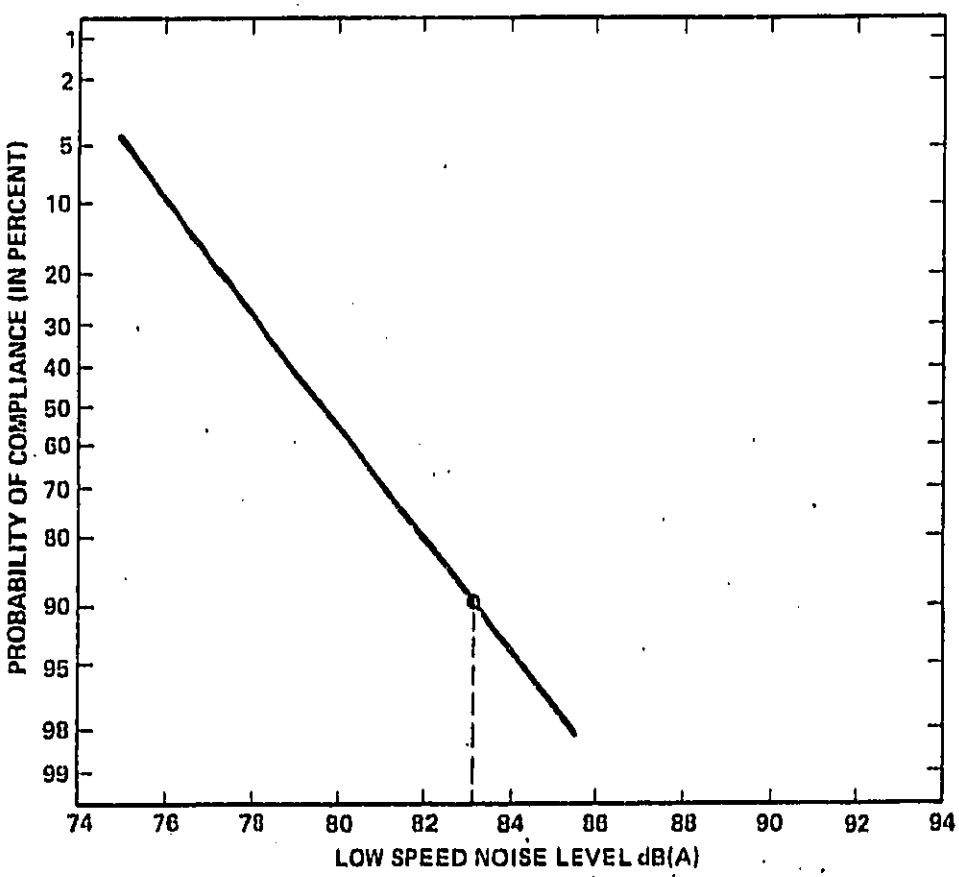


FIG. 10. ESTIMATED PROBABILITY OF POST-1978 MEDIUM AND HEAVY TRUCK COMPLIANCE AS A FUNCTION OF LOW-SPEED NOISE LEVEL*.

*The distribution is based on 152 field measurements obtained of 1978 model year trucks during EPA enforcement surveillance actiities in 1978.

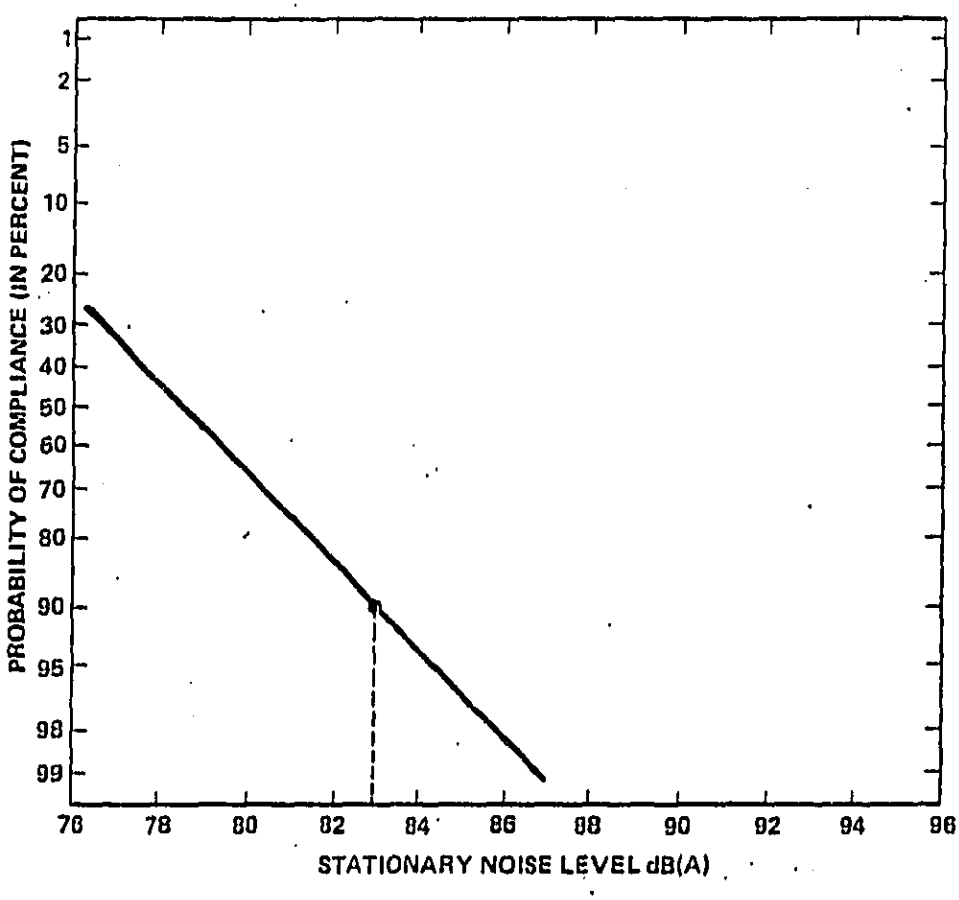


FIG. 11. ESTIMATED PROBABILITY OF POST-1978 MEDIUM AND HEAVY TRUCK COMPLIANCE AS A FUNCTION OF STATIONARY TEST NOISE LEVEL*.

*The distribution is based on 2938 field measurements conducted during Bureau of Motor Carrier Safety Enforcement activities in the 1980-1981 period.

Similarly, 90 percent of the MHT fleet is in compliance with an IMC low-speed noise level limit of 83 dB(A). This is shown in Figure 10. The anticipated compliance with the aligned stationary test level is presented in Figure 11. Approximately 90% of the MHT fleet is in compliance with the aligned limit.

TABLE 4. PERCENTAGE OF TRUCKS AT OR BELOW NOISE LEVELS IN IMC TEST MODES

| Level (dB) | High Speed % | Low Speed % | Stationary % |
|---|---|---|---|
| 80 | 36 | 80 | 66 |
| 81 | 49 | 89 | 76 |
| 82 | 62 | 94 | 85 |
| 83 | 74 | 98 | 90 |
| 84 | 84 | 99 | 94 |
| 85 | 91 | | 96 |
| 86 | 95 | | 98 |
| 87 | 98 | | 99 |
| 88 | 99 | | |
| 89 | | | |
| 90 | | | |

1,274,000 MHT Regulated Trucks as of 1/1/82.

Trucks complying with the 83 dB(A) MHT regulation are subtantially quieter than older, pre-regulatory trucks. Continued realization of the benefits of the low noise emissions of these trucks requires that their noise control treatments be properly maintained. The cost of this maintenance is part of annual operating costs and these costs were accounted for in the estimated cost of compliance for the 83 dB(A) MHT regulation.

The composition of the U.S. medium and heavy truck fleet constantly changes over time as new, quieter vehicles enter the fleet and older, pre-regulatory vehicles retire from service. Trucks typically remain in service for 10-15 years, and some are in service even longer. Therefore, change in vehicle noise has a gradual impact on the overall level of fleet noise.

Table 5 presents a projection of the annual sales of medium and heavy trucks from 1980 and 1996 [10]. This projection was prepared by Chase Econometrics and was the baseline forecast in the recent analysis in support of the deferral of the 80 dB(A) medium and heavy truck regulation. The forecast shows a modest upward sales trend over the forecast period.

Table 6 presents survival rates for trucks. These rates show the percentage of the fleet that "survives" from one year to the next. For example, 97% of 5-year-old trucks will survive to become 6-year-old trucks. The survival rate drops below 50% in year 12.

Table 7 presents the impact of the projected truck sales in Table 5 and of the truck survival rates in Table 6 on the composition of the fleet. Regulated trucks, i.e., those manufactured after January 1, 1978, will account for more than half the fleet by 1987 and the percentage of these trucks in the fleet will continue to increase as pre-1978 trucks leave service at an increasing rate beyond 1990.

Review of the data presented in Figures. 9, 10, and 11, and in Table 4, shows that the aligned levels are consistent with the philosophy of the original IMC regulation. Each of the aligned limits is well above the noise levels of the average truck. Only the very noisiest trucks would have difficulty complying. These very noisy trucks were the focus of the original IMC levels and continue to be the focus in this alignment process. Non-complying trucks could easily be brought into compliance through proper maintenance. The post-1977 (MHT) trucks have been manufactured to meet an 83 dB(A) noise level limit in a low speed acceleration test (with a design target level of 81 dB(A) to account for reduction variability). The alignment of the IMC regulatory levels with the MHT standard is intended to assure that the quiet characteristics of the trucks are maintained.

TABLE 5. PROJECTED ANNUAL SALES OF MEDIUM AND HEAVY TRUCKS. 1980-1996.

| Year | Total (1,000's) |
|---|---|
| 1980 | 250 |
| 1981 | 248 |
| 1982 | 246 |
| 1983 | 282 |
| 1984 | 318 |
| 1985 | 322 |
| 1986 | 326 |
| 1987 | 328 |
| 1988 | 329 |
| 1989 | 334 |
| 1990 | 340 |
| 1991 | 338 |
| 1992 | 336 |
| 1993 | 338 |
| 1994 | 340 |
| 1995 | 357 |
| 1996 | 375 |

Source: Chase Econometrics.

TABLE 6. PROJECTED SURVIVAL RATES.

| Year | Total (1,000's) |
|---|---|
| 1 | 100.0 |
| 2 | 100.0 |
| 3 | 99.98 |
| 4 | 99.27 |
| 5 | 97.11 |
| 6 | 93.29 |
| 7 | 87.83 |
| 8 | 80.89 |
| 9 | 72.72 |
| 10 | 63.64 |
| 11 | 54.02 |
| 12 | 44.24 |
| 13 | 34.69 |
| 14 | 25.76 |
| 15 | 17.80 |
| 16 | 11.13 |
| 17 | 5.98 |
| 18 | 2.48 |
| 19 | 0.62 |
| 20 | 0.13 |

Source: "Nationl Roadway Traffic Noise Exposure Model," U.S. Environmental Protection Agency.

TABLE 7. ESTIMATED FLEET COMPOSITION.

| Year | Total Truck Population (1000's) | Post-1977 Trucks (1000's) | Pre-1978 Trucks (1000's) |
|---|---|---|---|
| 1980 | 4,620 | 1,170 | 3,450 |
| 1981 | 4,790 | 1,418 | 3,372 |
| 1982 | 4,960 | 1,660 | 3,300 |
| 1983 | 5,110 | 1,928 | 3,182 |
| 1984 | 5,270 | 2,217 | 3,053 |
| 1985 | 5,400 | 2,488 | 2,912 |
| 1986 | 5,550 | 2,740 | 2,810 |
| 1987 | 5,660 | 2,968 | 2,692 |
| 1988 | 5,790 | 3,169 | 2,621 |
| 1989 | 5,910 | 3,346 | 2,564 |
| 1990 | 6,030 | 3,499 | 2,531 |
| 1991 | 6,150 | 3,623 | 2,527 |

## HEALTH AND WELFARE BENEFITS

In 1973, pursuant to a directive from Congress [11] and based on a large body of evidence, the Agency determined [12] that a day-night sound level ($L_{dn}$) value of 55 dB represents the lower threshold of noise that can jeopardize the health and welfare of people. Above this level, noise may cause adverse physiological and phychological effects. These effects also often result in personal annoyance and community reaction. Above an $L_{dn}$ value of 75 dB, noise can cause hearing loss. Exposure to noise levels above an $L_{dn}$ of 75 dB is considered to be severe by the Federal Interagency Urban Noise Guidelines and land with such noise levels is considered unacceptable for housing [13].

In order to assess the potential impacts and benefits of possible noise emission regulations, the agency computes the number of people that will be affected at various values of $L_{dn}$ in future years. It also employs the Level-Weighted Population (LWP) descriptor as a measure of noise impacts. LWP expresses in a single number both the extent and severity of noise impact. The extent of impact refers to the number of people who are adversely affected, while the severity represents the degree to which each person is affected. Therefore, LWP provides a simple method to compare benefits of different noise reduction options. This method is recommended by the National Academy of Sciences for use in noise impact assessments [14].

Computation of the LWP is based on combining the number of people exposed to noise levels above $L_{dn}$ of 55 dB with the degree of impact at different noise levels. For day-night sound levels below 55 dB, it is assumed that no adverse impact occurs. "Full" impact is assumed to occur at a 75 dB day-night sound level. Figure 11 is a pictorial representation of the LWP principle. The circle represents a source which emits noise to a populated area

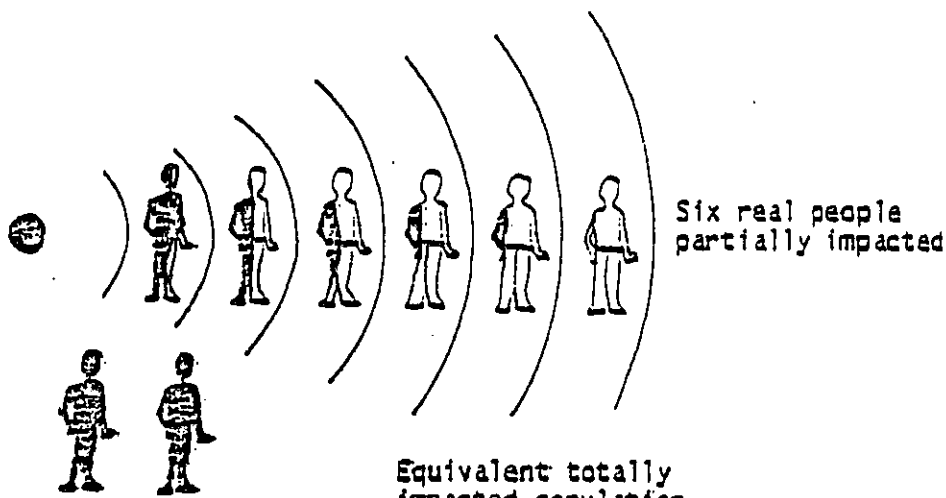


Figure 4.4 LEVEL-WEIGHTED POPULATION: A METHOD TO ACCOUNT FOR THE EXTENT AND SEVERITY OF NOISE IMPACT

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

The Agency, in cooperation with the Federal Highway Administration, has developed a computer model which can be used to estimate the number of people in the U.S. exposed to traffic noise at various values of $L_{dn}$, and to calculate LWP [15]. It accounts for all of the nation's roads and streets, their associated dewelling units and population and the amount of traffic, mix of vehicle type and mode of operation on each roadway type and speed range. It enables annual updates to the vehicle population taking into account the introduction of quieter newly-manufactured vehicles and retirement of old worn-out vehicles.

Prior to the promulgation of the Federal medium and heavy truck noise emission regulation in January 1976, the Agency used an early version of this model to estimate the population that is adversely affected by medium and heavy truck noise [4]. This analysis was redone with an updated model in 1980 [10] and provides the basis for this assessment of the benefits associated with the proposed alignment of the IMC and MHT noise regulations.

In the absence of noise emission regulations to control surface transportation noise, the number of people exposed to day-night sound levels above $L_{dn}$ of 55 dB would be expected to increase by 65% over those similarly

exposed in 1980; the corresponding increase in LWP would be 73.1%. Thus, without controls on the noise emission of vehicles or increased application of noise attenuating devices, i.e., highway noise barriers and improved noise insulation of personal dwellings, it is clearly evident that the surface transportation noise impact would continually worsen.

Within the fleet of vehicles operating on the Nation's roadways, medium and heavy trucks (trucks over 10,000 lbs. Gross Vehicle Weight Rating, GVWR) constitute the primary source of traffic noise. Today, noise impacts from trucks account for approximately 73 percent of those people exposed to day-night sound levels above 55 dB. The large contribution that trucks make to the national noise impact results from their high noise emissions compared to those of other vehicles. For example, Federal Highway Administration data [15] show that, under cruising conditions, a medium truck is equivalent in noise intensity to approximately 10 automobiles, while a heavy truck is equivalent to roughly 32 automobiles. Under low speed acceleration conditions, a medium truck can be equivalent in noise intensity to 35 automobiles, while a heavy truck can be equivalent to 200 automobiles.

We estimate that in the year 2000, 157.5 million people would have been exposed to day-night average sound levels ($L_{dn}$) above 55 decibels in the absence of the MHT regulation. The 83 dB MHT regulation is expected to reduce the number of people so impacted by 21.6 million, to 135.9 million. However, much, if not all, of this reduction could be lost if the IMC regulation is not aligned with the MHT regulation.

Table 8 summarizes the estimated numbers of people impacted at three intervals of noise expsoure, the total number of people exposed to $L_{dn}$ in excess of 55 dB and the corresponding Level-Weighted Population. The potential

for increased impact from trafic noise is significant, particularly in areas of the most severe impact, where the potential increase is approximately one million people, or 48%. The potential increase in Level-Weighted Population in the year 2000 is estimated to be from 42 to 52 million, an increase of 24%. The benefit of this proposed alignment of the IMC regulation with the MHT regulation is the prevention of these increased impacts.

Table 8

Summary of Potential Impacts and Benefits
for People Exposed to Traffic Noise

| $L_{dn}$ (dB) Interval in dB | Noise Exposure Class (13) | Number of People in Millions: Current (1980) | Year 2000 With Aligned IMC Reg. | Potential Year 2000 Without Aligned IMC Reg. | Potential Increase in 2000 if the IMC and MHT Regulations are Not Aligned: No. of People | % |
|---|---|---|---|---|---|---|
| 55-65 | Moderate Exposure | 76.1 | 107.7 | 124.4 | 16.7 | 16 |
| 65-75 | Significant Exposure | 17.8 | 26.1 | 30.0 | 3.9 | 15 |
| 75-85 | Severe Exposure | 1.1 | 2.1 | 3.1 | 1.0 | 48 |
| Total Number Exposed to Greater than $L_{dn}$ 55 dB | | 95.0 | 135.9 | 157.5 | 21.6 | 16 |
| Level-Weighted Population Millions | | 30 | 42 | 52 | 10 | 24 |

FIGURE 11. LEVEL-WEIGHTED POPULATION: A METHOD TO ACCOUNT FOR EXTENT AND SEVERITY OF NOISE IMPACT

## References


[1] "Background Document for Interstate Motor Carrier Noise Emission Regulation," EPA-550/9-74-017, U.S. Environmental Protection Agency, October 1974.

[2] "Evaluation of Effectiveness and Impact of Interstate Motor Carrier Noise Regulations," State of Florida Department of Environmental Regulation, December 1978.

[3] "Background Study: Vehicle Noise Control Regulations," BBN Report No. 2684 for the New Jersey Turnpike Authority, November 1973.

[4] "Background Document for Medium and Heavy Truck Noise Emission Regulations," EPA-550/9-76-008, U.S. Environmental Protection Agency, March 1976.

[5] "Noise Abatement Program," undated memo, U.S. Department of Transportation, Federal Highway Administration.

[6] "Truck Noise Study 1980, 1981 Records," Bureau of Motor Carrier Safety Computer Tape No. undated.

[7] "1978 Model Truck Noise Data," undated tabulation of Product Verification Test Reports.

[8] "Matrix of Truck Noise Data," Aplied Hydro-Acoustics Research, Inc., October 1978.

[9] "Truck Noise Degradation," Wyle Research Report No. WR 80-5, (?) Wyle Laboratories, January 1980.

[10] "Revised Analysis of the Benefits and Costs of the 80 dB Noise Emission Regulation for Medium and Heavy Trucks," U.S. Environmental Protection Agency, Office of Noise Abatement and Control, August 13 1981.




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[11] Noise Control Act of 1972.

[12] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Environmental Protection Agency, 550/9-74-004, March 1974.

[13] "Guidelines for Considering Noise in Land Use Planning and Control," Federal Interagency Committee on Urban Noise, June 1980.

[14] "Guidelines for Preparing Environmental Impact Statements on Noise," Working Group 69, Committee Hearing Bioacoustics and Biomechanics, National Research Council, Washington, D.C., 1977.

[15] "National Roadway Traffic Noise Exposure Model," U.S. Environmental Protection Agency, Office of Noise Abatement and Control, November 1979.

[16] "FHWA Highway Traffice Noise Prediction Model," report.

# APPENDIX A

# INTERSTATE MOTOR CARRIER (IMC) REGULATION

be positioned on a line perpendicular to the track 100 feet from the track centerline.

(2) Rail car noise measurements shall be made when the locomotives have passed a distance of 500 feet or 10 rail cars beyond the point at the intersection of the track and the line which extends perpendicularly from the track to the microphone location, providing any other locomotives are also at least 500 feet or 10 rail car lengths away from the measuring point. The maximum sound level observed in this manner which exceeds the noise levels specified in § 201.13 shall be utilized for compliance purposes.

(3) Measurements shall be taken on reasonably well maintained tracks.

(4) Noise levels shall not be recorded if brake squeal is present during the test measurement.

(d) *Locomotive pass-by test.* (1) For locomotive pass-by tests, the microphone shall be positioned on a line perpendicular to the track at a point 100 feet from the track center line.

(2) The noise level shall be measured as the locomotive approaches and passes by the microphone location. The maximum noise level observed during this period shall be utilized for compliance purposes.

(3) Measurements shall be taken on reasonably well maintained tracks.

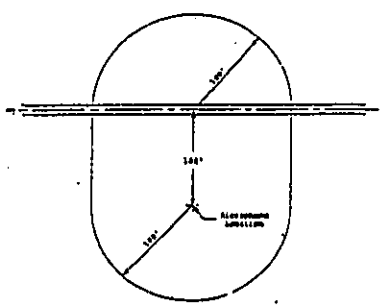

Figure 1.—Test Site Clearance Requirements for Locomotive Stationary, Locomotive Passby, and Rail Car Passby Tests



## PART 202—MOTOR CARRIERS ENGAGED IN INTERSTATE COMMERCE

### Subpart A—General Provisions



### Subpart B—Interstate Motor Carrier Operations Standards



AUTHORITY: Section 18, 36 Stat. 1249, 42 U.S.C. 4917(a).

SOURCE: 39 FR 38215, Oct. 29, 1974, unless otherwise noted.

### Subpart A—General Provisions

§ 202.10 Definitions.

As used in this part, all terms not defined herein shall have the meaning given them in the Act:

(a) "Act" means the Noise Control Act of 1972 (Pub.L. 92-574, 86 Stat. 1234)

(b) "Common carrier by motor vehicle" means any person who holds himself out to the general public to engage in the transportation by motor vehicle in interstate or foreign commerce of passengers or property or any class or classes thereof for compensation, whether over regular or irregular routes.

(c) "Contract carrier by motor vehicle" means any person who engages in transportation by motor vehicle of passengers or property in interstate or foreign commerce for compensation (other than transportation referred to in paragraph (b) of this section) under continuing contracts with one person or a limited number of persons either (1) for the furnishing of transportation services through the assignment of motor vehicles for a continuing period of time to the exclusive use of each person served or (2) for the furnishing of transportation services designed to meet the distinct need of each individual customer.

(d) "Cutout or by-pass or similar devices" means devices which vary the

exhaust system gas flow so as to discharge the exhaust gas and acoustic energy to the atmosphere without passing through the entire length of the exhaust system, including all exhaust system sound attenuation components.

(e) "dB(A) means the standard abbreviation for A-weighted sound level in decibels.

(f) "Exhaust system" means the system comprised of a combination of components which provides for enclosed flow of exhaust gas from engine parts to the atmosphere.

(g) "Fast meter response" means that the fast dynamic response of the sound level meter shall be used. The fast dynamic response shall comply with the meter dynamic characteristics in paragraph 5.3 of the American National Standard Specification for Sound Level Meters, ANSI S1. 4-1971. This publication is available from the American National Standards Institute, Inc., 1420 Broadway, New York, New York 10018.

(h) "Gross Vehicle Weight Rating" (GVWR) means the value specified by the manufacturer as the loaded weight of a single vehicle.

(i) "Gross Combination Weight Rating" (GCWR) means the value specified by the manufacturer as the loaded weight of a combination vehicle.

(j) "Highway" means the streets, roads, and public ways in any State.

(k) "Interstate commerce" means the commerce between any place in a State and any place in another State or between places in the same State through another State, whether such commerce moves wholly by motor vehicle or partly by motor vehicle and partly by rail, express, water or air. This definition of "interstate commerce" for purposes of these regulations is the same as the definition of "interstate commerce" in section 203(a) of the Interstate Commerce Act. [49 U.S.C. Section 303(a)]

(l) "Motor carrier" means a common carrier by motor vehicle, a contract carrier by motor vehicle, or a private carrier of property by motor vehicle as those terms are defined by paragraphs (14), (15), and (17) of section 203(a) of the Interstate Commerce Act [49 U.S.C. 303(a)].

(m) "Motor vehicle" means any vehicle, machine, tractor, trailer, or semitrailer propelled or drawn by mechanical power and used upon the highways in the transportation of passengers or property, or any combination thereof, but does not include any vehicle, locomotive, or car operated exclusively on a rail or rails.

(n) "Muffler" means a device for abating the sound of escaping gases of an internal combustion engine.

(o) "Open site" means an area that is essentially free of large sound-reflecting objects, such as barriers, walls, board fences, signboards, parked vehicles, bridges, or buildings.

(p) "Private carrier of property by motor vehicle" means any person not included in terms "common carrier by motor vehicle" or "contract carrier by motor vehicle", who or which transports in interstate or foreign commerce by motor vehicle property of which such person is the owner, lessee, or bailee, when such transportation is for sale, lease, rent or bailment, or in furtherance of any commercial enterprise.

(q) "Sound level" means the quantity in decibels measured by a sound level meter satisfying the requirements of American National Standards Specification for Sound Level Meters S1.4-1971. This publication is available from the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018. Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood.

### § 202.11 Effective date.

The provisions of Subpart B shall become effective October 15, 1975.

### § 202.12 Applicability.

(a) The provisions of Subpart B apply to all motor carriers engaged in interstate commerce.

(b) The provisions of Subpart B apply only to those motor vehicles of such motor carriers which have a gross vehicle weight rating or gross

combination weight rating in excess of 10,000 pounds, and only when such motor vehicles are operating under the conditions specified in Subpart B.

(c) Except as provided in paragraphs (d) and (e) of this section, the provisions of Subpart B apply to the total sound produced by such motor vehicles when operating under such conditions, including the sound produced by auxiliary equipment mounted on such motor vehicles.

(d) The provisions of Subpart B do not apply to auxiliary equipment which is normally operated only when the transporting vehicle is stationary or is moving at a speed of 5 miles per hour or less. Examples of such equipment include, but are not limited to, cranes, asphalt spreaders, ditch diggers, liquid or slurry pumps, air compressors, welders, and trash compactors.

(e) The provisions of Subpart B do not apply to warning devices, such as horns and sirens; or to emergency equipment and vehicles such as fire engines, ambulances, police vans, and rescue vans, when responding to emergency calls; or to snow plows when in operation.

## Subpart B—Interstate Motor Carrier Operations Standards

### § 202.20 Standards for highway operations.

No motor carrier subject to these regulations shall operate any motor vehicle of a type to which this regulation is applicable which at any time or under any condition of highway trade, load, acceleration or deceleration generates a sound level in excess of 86dB(A) measured on an open site with fast meter response at 50 feet from the centerline of lane of travel on highways with speed limits of 35 MPH or less; or 90 dB(A) measured on an open site with fast meter response at 50 feet from the centerline of lane of travel on highways with speed limits of more than 35 MPH.

### § 202.21 Standard for operation under stationary test.

No motor carrier subject to these regulations shall operate any motor vehicle of a type to which this regulation is applicable which generates a sound leval in excess of 88 dB(A) measured on an open site with fast meter response at 50 feet from the longitudinal centerline of the vehicle, when its engine is accelerated from idle with wide open throttle to governed speed with the vehicle stationary, transmission in neutral, and clutch engaged. This § 202.21 shall not apply to any vehicle which is not equipped with an engine speed governor.

### § 202.22 Visual exhaust system inspection.

No motor carrier subject to these regulations shall operate any motor vehicle of a type to which this regulation is applicable unless the exhaust system of such vehicle is (a) free from defects which affect sound reduction; (b) equipped with a muffler or other noise dissipative device; and (c) not equipped with any cut-out, bypass, or similar device.

### § 202.23 Visual tire inspection.

No motor carrier subject to these regulations shall at any time operate any motor vehicle of a type to which this regulation is applicable on a tire or tires having a tread pattern which as originally manufactured, or as newly retreaded, is composed primarily or cavities in the tread (excluding sipes and local chunking) which are not vented by grooves to the tire shoulder or circumferentially to each other around the tire. This § 202.23 shall not apply to any motor vehicle which is demonstrated by the motor carrier which operates it to be in compliance with the noise emission standard specified for operations on highways with speed limits of more than 35 MPH in § 202.20 of this Subpart B, if the demonstration is conducted at the highway speed limit in effect at the inspection location, or, if speed is unlimited, the demonstration is conducted at a speed of 65 MPH.

# PART 203—LOW-NOISE-EMISSION PRODUCTS

Sec.
203.1 Definitions.
203.2 Application for certification.

# APPENDIX B

# MEDIUM AND HEAVY TRUCK (MHT) NOISE REGULATION

(c) For purposes of section 11(d) of the Noise Control Act, the Administrator may consider any export exemption under Section 10(b)(2) as void ab initio with respect to each new product intended solely for export which is distributed in commerce for use in any State.

(d) In deciding whether to institute proceedings against a manufacturer pursuant to section 11(d)(1) of the Act with respect to any product originally intended solely for export but distributed in commerce for use in any state, the Administrator will consider:

(1) Whether the manufacturer had knowledge that such product would be distributed in commerce for use in any state; and

(2) Whether the manufacturer made reasonable efforts to ensure that such product would not be distributed in commerce for use in any state. Such reasonable efforts would include consideration of prior dealings with any person which resulted in introduction into commerce of a product manufactured for export only, investigation of prior instances known to the manufacturer of introduction into commerce of a product manufactured for export only, and contract provisions which minimize the probability of introduction into commerce of a product manufactured for export only.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61457, Dec. 5, 1977]

§ 205.5-6 Granting of exemptions.

(a) If upon completion of the review of an exemption request, the granting of an exemption is deemed appropriate, a memorandum of exemption will be prepared and submitted to the manufacturer requesting the exemption. The memorandum will set forth the basis for the exemption, its scope, and such terms and conditions as are deemed necessary to protect the public health and welfare. Such terms and conditions will generally include, but are not limited to, agreements by the applicant to conduct the exempt activity in the manner described to EPA, create and maintain adequate records accessible to EPA at reasonable times, employ labels for the exempt products setting forth the nature of the exemption, take appropriate measures to assure that the terms of the exemption are met, and advise EPA of the termination of the activity and the ultimate disposition of the products. EPA may limit the scope of any exemption by placing restrictions on time, location and duration.

(b) Any exemption granted pursuant to paragraph (a) of this section, shall be deemed to cover any subject product only to the extent that the specified terms and conditions are complied with. A breach of any term or condition shall cause the exemption to be void *ab initio* for purposes of section 11(d) of the Act and may give rise to an order by the Administrator with respect to any product subject to such exemption, whether distributed before or after such breach. The Administrator may also, upon notice and opportunity for a hearing, withdraw the exemption at any time if he determines that the public health or welfare is endangered.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61457, Dec. 5, 1977]

§ 205.5-7 Submission of exemption request.

Requests for exemption or further information concerning exemptions and/or the exemption request review procedure should be addressed to:

Director, Noise Enforcement Division (EN387), U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460.

[41 FR 15544, Apr. 13, 1976, as amended at 43 FR 12326, Mar. 24, 1978]

## Subpart B—Medium and Heavy Trucks

NOTE: Effective January 1, 1978, the provisions of 40 CFR 205.50-205.59 shall not apply with respect to any fire apparatus. This action is a stay pending reconsideration of the regulation, and shall continue until 90 days following publication of notice in the FEDERAL REGISTER, as to EPA's final decision of the petition of the Truck Body and Equipment Association dated July 29, 1977. (See 43 FR 1796, Jan. 12, 1978.)

§ 205.50 Applicability.

(a) Except as otherwise provided for in these regulations the provisions of this subpart apply to any vehicle

which has a gross vehicle weight rating (GVWR) in excess of 10,000 pounds, which is capable of transportation of property on a highway or street and which meets the definition of the term "new product" in the Act.

(b) The provisions of the subpart do not apply to highway, city, and school buses or to special purpose equipment which may be located on or operated from vehicles. Tests performed on vehicles containing such equipment may be carried out with the special purpose equipment in nonoperating condition. For purposes of this regulation special purpose equipment includes, but is not limited to, construction equipment, snow plows, garbage compactors and refrigeration equipment.

**§ 205.51 Definitions.**

(a) As used in this subpart, all terms not defined herein shall have the meaning given them in the Act or in other subparts of this part.

(1) "Acceptable Quality Level" means the maximum percentage of failing vehicles that for purposes of sampling inspection, can be considered satisfactory as a process average.

(2) "Acceptance of a batch" means that the number of noncomplying vehicles in the batch sample is less than or equal to the acceptance number as determined by the appropriate sampling plan.

(3) "Batch" means the collection of vehicles of the same category, configuration or subgroup thereof as designated by the Administrator in a test request, from which a batch sample is to be drawn, and inspected to determine conformance with the acceptability criteria.

(4) "Batch size" means the number as designated by the Administrator in the test request of vehicles of the same category or configuration in a batch.

(5) "Batch sample" means the collection of vehicles of the same category, configuration or subgroup thereof which are drawn from a batch and from which test samples are drawn.

(6) "Batch sample size" means the number of vehicles of the same category or configuration in a batch sample.

(7) "Cab over axle" or "cab over engine" means the cab which contains the operator/passenger compartment is directly above the engine and front axle and the entire cab can be tilted forward to permit access to the engine compartment.

(8) "Category" means a group of vehicle configurations which are identical in all material aspects with respect to the parameters listed in § 205.55-2.

(9) "Configuration" means the basic classification unit of a manufacturer's product line and is comprised of all vehicle designs, models or series which are identical in material aspects with respect to the parameters listed in § 205.55-3.

(10) "Acceptance of a Batch sequence" means that the number of rejected batches in the sequence is less than or equal to the acceptance number as determined by the appropriate sampling plan.

(11) "Rejection of a Batch sequence" means that the number of rejected batches in a sequence is equal to or greater than the rejection number as determined by the appropriate sampling plan.

(12) "Capable of Transportation of Property on a street or highway" means that the vehicle:

(i) Is self propelled and is capable of transporting any material or fixed apparatus, or is capable of drawing a trailer or semi-trailer;

(ii) Is capable of maintaining a cruising speed of at least 25 mph over level, paved surface;

(iii) Is equipped or can readily be equipped with features customarily associated with practical street or highway use, such features including but not being limited to: A reverse gear and a differential, fifth wheel, cargo platform or cargo enclosure, and

(iv) Does not exhibit features which render its use on a street or highway impractical, or highly unlikely, such features including, but not being limited to, tracked road means, an inordinate size or features ordinarily associated with combat or tactical vehicles.

(13) "Exhaust System" means the system comprised of a combination of components which provides for enclosed flow of exhaust gas from engine exhaust port to the atmosphere.

(14) "Gross Combination Weight Rating" (GCWR) means the value

specified by the manufacturer as the loaded weight of a combination vehicle.

(15) "Gross Vehicle Weight Rating" (GVWR) means the value specified by the manufacturer as the loaded weight of a single vehicle.

(16) "Inspection Criteria" means the rejection and acceptance numbers associated with a particular sampling plan.

(17) "Model year" means the manufacturer's annual production period which includes January 1 of such calendar year: Provided, that if the manufacturer has no annual production period, the term "model year" shall mean the calendar year.

(18) "Noise Control System" includes any vehicle part, component or system the primary purpose of which is to control or cause the reduction of noise emitted from a vehicle.

(19) "Noise emission test" means a test conducted pursuant to the measurement methodology specified in this subpart.

(20) "Production verification vehicle" means any vehicle selected for testing, tested or verified pursuant to the production verification requirements of this subpart.

(21) "Rejection of a batch" means the number of noncomplying vehicles in the batch sample is greater than or equal to the rejection number as determined by the appropriate sampling plan.

(22) "Shift" means the regular production work period for one group of workers.

(23) "Test sample" means the collection of vehicles from the same category, configuration or subgroup thereof which is drawn from the batch sample and which will receive noise emissions tests.

(24) "Failing vehicle" means that the measured emissions of the vehicle, when measured in accordance with the applicable procedure, exceeds the applicable standard.

(25) "Acceptance of a vehicle" means that the measured emissions of the vehicle when measured in accordance with the applicable procedure, conforms to the applicable standard.

(26) "Tampering" means those acts prohibited by section 10(a)(2) of the Act.

(27) "Test sample size" means the number of vehicles of the same category or configuration in a test sample.

(28) "Test Vehicle" means a vehicle in a test sample or a production verification vehicle.

(29) "Vehicle" means any motor vehicle, machine or tractor, which is propelled by mechanical power and capable of transportation of property on a street or highway and which has a gross vehicle weight rating in excess of 10,000 pounds and a partially or fully enclosed operator's compartment.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, 61458, Dec. 5, 1977]

### § 205.52 Vehicle noise emission standards.

(a) Low Speed Sound Emission Standard. Vehicles which are manufactured after the following effective dates, shall be designed, built and equipped so that they will not produce sound emissions in excess of the levels indicated.

| Effective date | Level |
|---|---|
| (i) Jan. 1, 1978 | 83 dBA. |
| (ii) Jan. 1, 1983 | 80dBA. |
| (iii) Jan. 1, 1985 | [Reserved] |

(b) The standards set forth in paragraph (a) of this section refer to the sound emissions as measured in accordance with the procedures prescribed in § 205.54-1,2.

(c) Every manufacturer of a new motor vehicle subject to the standards prescribed in this paragraph shall, prior to taking any of the actions specified in section 10(a)(1) of the Act, comply with the other provisions of this subpart or Subpart A, as applicable.

(d) In-Use Standard. [Reserved]

(e) Low Noise Emission Product. [Reserved]

(Sec. 6, Pub. L. 92-574, 86 Stat. 1237 (42 U.S.C. 4906))

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, Dec. 5, 1977; 46 FR 8504, Jan. 27, 1981]

### § 205.53 Maintenance of records: Submittal of information.

(a) Except as otherwise provided for in this regulation the manufacturer of

any new vehicle subject to any of the standards or procedures prescribed in this subpart shall establish, maintain and retain the following adequately organized and indexed records:

(1) General records: (i) Identification and description by category and configuration parameters of all vehicles composing the manufacturer's product line including the identification and description of all devices incorporated into the vehicle for the purpose of noise control and attenuation.

(ii) A description of any procedures other than those contained in these regulations used to perform noise tests on any test vehicle.

(iii) A record of the calibration of the acoustical instrumentation as is required by § 205.54.

(2) Individual records for test vehicles: (i) A complete record of all noise emission tests performed (except tests performed by EPA directly), including all individual worksheets and/or other documentation relating to each test, or exact copies thereof.

(ii) A record and description of all repairs, maintenance and other servicing which were performed before successful testing of the vehicle pursuant to these regulations and which could affect the noise emissions of the product, giving the date and time of the maintenance or service, the reason for it, the person authorizing it, and the names of supervisory personnel responsible for the conduct of the maintenance or service.

(3) A properly filed production verification report following the format prescribed by the Administrator fulfills the requirements of paragraph (a)(1) (i), (ii), (iii) and (a)(2)(i) of this section.

(4) All records required to be maintained under this part shall be retained by the manufacturer for a period of three (3) years from the production verification date. Records may be retained as hard copy or alternatively reduced to microfilm, punch cards, etc., depending on the record retention procedures of the manufacturer; however, all of the information contained in the hard copy shall be retained in the alternative method if this method is used.

(b) The manufacturer shall, pursuant to a request made by the Administrator, submit to the Administrator the following information with regard to new vehicle production:

(1) Number of vehicles, by category or configuration, scheduled for production for the time period designated in the request.

(2) Number of vehicles, by category or configuration, produced during the time period designated in the request.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61458, Dec. 5, 1977]

### § 205.54 Test procedures.

The procedures described in this and subsequent sections will be the test program to determine the conformity of vehicles with the standards set forth in § 205.52.

### § 205.54-1 Low speed sound emission test procedures.

(a) *Instrumentation.* The following instrumentation shall be used, where applicable.

(1) A sound level meter which meets the Type 1 requirements of ANSI S1.4-1971; Specification for Sound Level Meters, or a sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter, providing the system meets the requirements of § 205.54-2.

(2) A sound level calibrator. The calibrator shall produce a sound pressure level, at the microphone diaphragm, that is known to within an accuracy of ±0.5 dB. The calibrator shall be checked annually to verify that its output has not changed.

(3) An engine-speed tachometer which is accurate within ±2 percent of meter reading.

(4) An anemometer or other device for measurement of ambient wind speed accurate within ±10 percent.

(5) A thermometer for measurement of ambient temperature accurate within ±1 C.

(6) A barometer for measurement of ambient pressure accurate within ±1 percent.

(b) (1) The test site shall be such that the truck radiates sound into a free field over a reflecting plane. This condition may be considered fulfilled

if the test site consists of an open space free of large reflecting surfaces, such as parked vehicles, signboards, buildings or hillsides, located within 100 feet (30.4 meters) of either the vehicle path or the microphone.

(2) The microphone shall be located 50 feet ±4 in. (15.2±0.1 meter) from the centerline of truck travel and 4 feet ±4 in. (1.2±0.1 meters) above the ground plane. The microphone point is defined as the point of intersection of the vehicle path and the normal to the vehicle path drawn from the microphone. The microphone shall be oriented in a fixed position to minimize the deviation from the flattest system response over the frequency range 100 Hz to 10 kHz for a vehicle traversing from the acceleration point through the end zone.

The microphone shall be oriented with respect to the source so that the sound strikes the diaphragm at the angle for which the microphone was calibrated to have the flattest frequency response characteristic over the frequency range 100 Hz to 10 kHz.

(3) An acceleration point shall be established on the vehicle path 50 feet (15 m) before the microphone point.

(4) An end point shall be established on the vehicle path 100 feet (30 m) from the acceleration point and 50 feet (15 m) from the microphone point.

(5) The end zone is the last 40 feet (12 m) of vehicle path prior to the end point.

(6) The measurement area shall be the triangular paved (concrete or sealed asphalt) area formed by the acceleration point, the end point, and the microphone location.

(7) The reference point on the vehicle, to indicate when the vehicle is at any of the points on the vehicle path, shall be the front of the vehicle except as follows:

(i) If the horizontal distance from the front of the vehicle to the exhaust outlet is more than 200 inches (5.1 meters), tests shall be run using both the front and rear of the vehicle as reference points.

(ii) If the engine is located rearward to the center of the chassis, the rear of the vehicle shall be used as the reference point.

(8) The plane containing the vehicle path and the microphone location (plane ABCDE in Figure 1) shall be flat within ±2 inches (.05 meters).

(9) Measurements shall not be made when the road surface is wet, covered with snow, or during precipitation.

(10) Bystanders have an appreciable influence on sound level meter readings when they are in the vicinity of the vehicle or microphone; therefore not more than one person, other than the observer reading the meter, shall be within 50 feet (15.2 meters) of the vehicle path or instrument and the person shall be directly behind the observer reading the meter, on a line through the microphone and observer. To minimize the effect of the observer and the container of the sound level meter electronics on the measurements, cable should be used between the microphone and the sound level meter. No observer shall be located within 1 m in any direction of the microphone location.

(11) The maximum A-weighted fast response sound level observed at the test site immediately before and after the test shall be at least 10 dB below the regulated level.

(12) The road surface within the test site upon which the vehicle travels, and, at a minimum, the measurements area (BCD in figure 205.1) shall be smooth concrete or smooth sealed asphalt, free of extraneous material such as gravel.

(13) Vehicles with diesel engines shall be tested using Number 1D or Number 2D diesel fuel possessing a cetane rating from 42 to 50 inclusive.

(14) Vehicles with gasoline engines shall use the grade of gasoline recommended by the manufacturer for use by the purchaser.

(15) Vehicles equipped with thermostatically controlled radiator fans may be tested with the fan not operating.

(c) *Procedure*—(1) *Vehicle operation for vehicles with standard transmissions.* Full throttle acceleration and closed throttle deceleration tests are to be used. A beginning engine speed and proper gear ratio must be determined for use during measurements. Closed throttle deceleration tests are

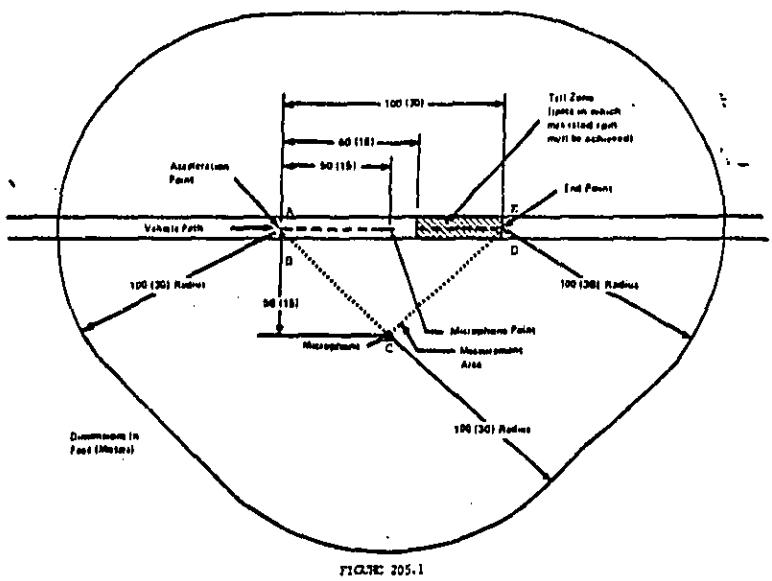


FIGURE 205.1

required only for those vehicles equipped with an engine brake.

(i) Select the highest rear axle and/or transmission gear ("highest gear" is used in the usual sense; it is synonymous to the lowest numerical ratio) and an initial vehicle speed such that at wide-open throttle the vehicle will accelerate from the acceleration point.

(*a*) Starting at no more than two-thirds (66 percent) of maximum rated or of governed engine speed.

(*b*) Reaching maximum rated or governed engine speed within the end zone.

(*c*) Without exceeding 35 mph (56 k/h) before reaching the end point.

(*1*) Should maximum rated or governed rpm be attained before reaching the end zone, decrease the approach rpm in 100 rpm increments until maximum rated or governed rpm is attained within the end zone.

(*2*) Should maximum rated or governed rpm not be attained until beyond the end zone, select the next lower gear until maximum rated or governed rpm is attained within the end zone.

(*3*) Should the lowest gear still result in reaching maximum rated or governed rpm beyond the permissible end zone, unload the vehicle and/or increase the approach rpm in 100 rpm increments until the maximum rated or governed rpm is reached within the end zone.

(ii) For the acceleration test, approach the acceleration point using the engine speed and gear ratio selected in paragraph (c)(1) of this section and at the acceleration point rapidly establish wide-open throttle. The vehicle reference shall be as indicated in paragraph (b)(7) of this section. Acceleration shall continue until maximum rated or governed engine speed is reached.

(iii) Wheel slip which affects maximum sound level must be avoided.

(2) *Vehicle operation for vehicles with automatic transmissions.* Full throttle acceleration and closed throttle deceleration tests are to be used. Closed throttle deceleration tests are required only for those vehicles equipped with an engine brake.

(i) Select the highest gear axle and/or transmission gear (highest gear is used in the usual sense; it is synonymous to the lowest numerical ratio) in which no up or down shifting will occur under any operational conditions of the vehicle during the test run. Also, select an initial vehicle speed such that at wide-open throttle the vehicle will accelerate from the acceleration point.

(*a*) Starting at two-thirds (66 percent) of maximum rated or of governed engine speed.

(*b*) Reaching maximum rated or governed engine speed within the end zone.

(*c*) Without exceeding 35 mph (56 k/h) before reaching the end point.

(*1*) Should maximum rated or governed rpm be attained before reaching the end zone, decrease the approach rpm in 100 rpm increments until maximum rated or governed rpm is attained within the end zone.

(*2*) Should maximum rated or governed rpm not be attained until beyond the end zone, select the next lower gear until maximum rated or governed rpm is attained within the end zone.

(*3*) Should the lowest gear still result in reaching maximum rated or governed rpm beyond the permissible end zone, unload the vehicle and/or increase the approach rpm in 100 rpm increments until the maximum rated or governed rpm is reached within the end zone, notwithstanding that approach engine speed may now exceed two-thirds of maximum rated or of full load governed engine speed.

(*4*) Should the maximum rated or governed rpm still be attained before entering the end zone, and the engine rpm during approach cannot be further lowered, begin acceleration at a point 10 feet closer to the beginning of the end zone. The approach rpm to be used is to be that rpm used prior to the moving of the acceleration point 10 feet closer to the beginning of the end zone.

(*5*) Should the maximum rated or governed rpm still be attained before entering the end zone, repeat the instructions in paragraph (c)(2)(i)(*c*)(*4*) of this section until maximum rated or governed rpm is attained within the end zone.

(ii) For the acceleration test, approach the acceleration point using the engine speed and gear ratio selected in paragraph (c)(2)(i) of this section and at the acceleration point rapidly establish wide-open throttle. The vehicle reference shall be as indicated in paragraph (b)(7) of this section. Acceleration shall continue until maximum rated or governed engine speed is reached.

(iii) Wheel slip which affects maximum sound level must be avoided.

(3) *Measurements.* (i) The meter shall be set for "fast response" and the A-weighted network.

(ii) The meter shall be observed during the period while the vehicle is accelerating or decelerating. The applicable reading shall be the highest sound level obtained for the run. The observer is cautioned to rerun the test if unrelated peaks should occur due to extraneous ambient noises. Readings shall be taken on both side of the vehicle.

(iii) The sound level associated with a side shall be the average of the first two pass-by measurements for that side, if they are within 2 dB(A) of each other. Average of measurements on each side shall be computed separately. If the first two measurements for a given side differ by more than 2 dB(A), two additional measurements shall be made on each side, and the average of the two highest measurements on each side, within 2 dB(A) of each other, shall be taken as the measured vehicle sound level for that side. The reported vehicle sound level shall be the higher of the two averages.

(d) *General requirements.* (1) Measurements shall be made only when wind velocity is below 12 mph (19 km/hr).

(2) Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or

other literature furnished by the instrument manufacturer shall be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be adequately considered are:

(i) The effects of ambient weather conditions on the performance of the instruments (for example, temperature, humidity, and barometric pressure).

(ii) Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

(iii) Proper acoustical calibration procedure to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

(3) (i) A complete calibration of the instrumentation and external acoustical calibrator over the entire frequency range of interest shall be performed at least annually and as frequently as necessary during the yearly period to insure compliance with the standards cited in American National Standard S1.4-1971 "Specifications for Sound Level Meters" for a Type 1 instrument over the frequency range 50 Hz-10,000 Hz.

(ii) If calibration devices are utilized which are not independent of ambient pressure (e.g., a piston-phone) corrections must be made for barometric or altimetric changes according to the recommendation of the instrument manufacturer.

(4) The truck shall be brought to a temperature within its normal operating temperature range prior to commencement of testing. During testing appropriate caution shall be taken to maintain the engine temperatures within such normal operating range.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 11836, Mar. 1, 1977; 42 FR 61456, Dec. 5, 1977]

### § 205.54-2 Sound data acquisition system.

(a) Systems employing tape recorders and graphic level recorders may be established as equivalent to a Type I—ANSI S1.4-1971 sound level meter for use in determining compliance with this regulation by meeting the requirements of this section (§ 205.54-2(b)). This sound data acquisition system qualification procedure is based primarily on ANSI S6.1-1973.

(1) *Performance requirements*—(i) *System frequency response.* It is required that the overall steady-state frequency response of the data acquisition system shall be within the tolerances prescribed in Table 205.1 when measured in accordance with section (2). The tolerances in Table 205.1 are applicable to either flat or A-weighted response. (See paragraph (3)(iii) of this section.

(ii) *Detector response.* To ensure that a (true) rms indication is provided, the difference between the level indicated for a 1000 Hz sinusoidal signal equivalent to a sound level of 86 dB (rms) and the level indicated for an octave band of random noise of equal energy as the sinusoidal signal centered at 1000 Hz shall be no greater than 0.5 dB. A true rms voltmeter shall be used to determine equivalence of two input signals.

(iii) *Indicating meter.* If an indicating meter is used to obtain sound levels or band pressure levels, it must meet the requirements of paragraph (a)(1)(ii) and (a)(1)(vi)(B) of this section and the following.

TABLE 205.1.—*System response data*

| Freq. (hertz) | A-weighted response (Re-1000 Hz, dB) | Tolerance (decibels) | |
|---|---|---|---|
| | | Plus— | Minus— |
| 31.5 | −39.4 | 1.5 | 1.5 |
| 40.0 | −34.6 | 1.5 | 1.5 |
| 50.0 | −30.2 | 1.0 | 1.0 |
| 63.0 | −26.2 | 1.0 | 1.0 |
| 80.0 | −22.5 | 1.0 | 1.0 |
| 100.0 | −19.1 | 1.0 | 1.0 |
| 125.0 | −16.1 | 1.0 | 1.0 |
| 160.0 | −13.4 | 1.0 | 1.0 |
| 200.0 | −10.9 | 1.0 | 1.0 |
| 250.0 | −8.6 | 1.0 | 1.0 |
| 315.0 | −6.6 | 1.0 | 1.0 |
| 400.0 | −4.8 | 1.0 | 1.0 |
| 500.0 | −3.2 | 1.0 | 1.0 |
| 630.0 | −1.9 | 1.0 | 1.0 |
| 800.0 | −.8 | 1.0 | 1.0 |
| 1,000.0 | 0 | 1.0 | 1.0 |
| 1,250.0 | .6 | 1.0 | 1.0 |
| 1,600.0 | 1.0 | 1.0 | 1.0 |
| 2,000.0 | 1.2 | 1.0 | 1.0 |
| 2,500.0 | 1.3 | 1.0 | 1.0 |
| 3,150.0 | 1.2 | 1.0 | 1.0 |
| 4,000.0 | 1.0 | 1.0 | 1.0 |
| 5,000.0 | .5 | 1.5 | 2.0 |

TABLE 205.1.—*System response data*—Continued

| Freq. (hertz) | A-weighted response (Re-1000 Hz, dB) | Tolerance (decibels) | |
|---|---|---|---|
| | | Plus— | Minus— |
| 6,300.0 | −.1 | 1.5 | 2.0 |
| 8,000.0 | −1.1 | 1.5 | 3.0 |
| 10,000.0 | −2.5 | 2.0 | 4.0 |
| 12,500.0 | −4.3 | 3.0 | 6.0 |

(A) The scale shall be graduated in 1 dB steps.

(B) No scale indication shall be more than 0.2 dB different from the true value of the signal when an input signal equivalent to 86 dB sound level indicates correctly.

(C) Maximum indication for an input signal of 1000 Hz tone burst of 0.2 sec duration shall be within the range of −2 to 0 dB with respect to the steady-state indication for a 1000 Hz tone equivalent to 86 dB sound level.

(iv) *Microphone.* If microphone is used which has not been provided as a component of a precision sound level meter, it must be determined to meet the microphone characteristics described in IEC Publication 179, Precision Sound Level Meters.

(v) *Magnetic tape recorders.* No requirements are described in this document pertaining to tape recorders, except for frequency response. Generally, recorders of adequate quality to provide the frequency response performance required will also meet other minimum requirements for distortion, signal-to-noise ratio, etc.

(vi) *Graphic level recorder dynamic response.* When using a graphic level recorder, it is necessary to select pen response settings such that the readings obtained are statistically equivalent to those obtained by directly reading a meter which meets the "fast" dynamic requirement of a precision sound level meter indicating meter system for the range of vehicles to be tested. To ensure statistical equivalence, at least 30 comparative observations of real test data shall be made and the average of the absolute value of the differences observed shall be less than 0.5 dB. The settings described in this paragraph likely assure appropriate dynamic response; however, different settings may be selected on the basis of the above requirement.

(A) Use a pen writing speed of nominally 60-100 dB/sec. If adjustable, low frequency response should be limited to about 20 Hz.

(B) Indicated overshoot for a suddenly applied 1000 Hz sinusoidal signal equivalent to 86 dB sound level shall be no more than 1.1 dB and no less than 0.1 dB.

(2) *Frequency response qualification procedure.* (i) Typical noise measurement and analysis configurations are shown in Figures 205.2 through 205.4. The qualification procedure described herein duplicates these configurations, but with the microphone replaced by an electronic sinewave oscillator. Caution should be exercised when connecting an oscillator to the input of a sound level meter to ensure, perhaps by using a resistive voltage divider network, that the input is not overloaded (see § 205.54-2(a)(2)(ii)).

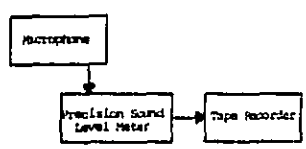


Figure 205.2 Data Recording

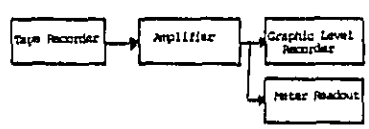


Figure 205.3 Data Analysis and Test Analysis


Figure 205.4 Test Recording

(ii) Calibrate the oscillator to be used by measuring its output relative to the voltage which is equivalent to 86 dB sound level at each of the 27 frequencies listed in Table 205.1 using an electronic voltmeter of known calibration. Record the result in voltage level in dB re voltage corresponding to 86 dB sound level at 1000 Hz. This will describe the frequency response characteristics of the oscillator.

(iii) If a graphic level recorder is to be used, connect it to the oscillator output. If the oscillator and graphic level recorder can be synchronized, slowly sweep the frequency over the range of 31.5 to 12,500 Hz, recording the oscillator output. If they cannot be synchronized, record oscillator output for signals at the 27 frequencies given in Table 205.1. The differences between the combined response thus obtained and the oscillator response obtained previously will describe the frequency response of the graphic level recorder.

(iv) If visual observation of an indicating meter is to be used for obtaining data, the oscillator should be connected to the indicating meter input (such as the microphone input of a sound level meter) and the meter reading observed for a fixed oscillator output voltage setting for signals at the 27 frequencies given in Table 205.1.

(v) To check a tape recorder, connect the instruments as shown in Figure 205.4. Using a 1000 Hz tone, adjust the oscillator output level to obtain a reading 15 dB below maximum record level. If the synchronized oscillator/graphic level recorder system is to be used for analysis, record an oscillator sweep over the range of 31.5 to 12,500 Hz, using an appropriate tape recorder input attenuator setting. Alternatively, tape-record frequency tones at the 27 frequencies given in Table 205.1. Replay the tape recordings using the setup shown in Figure 205.3. Record the data on a graphic level recorder or through visual observation of the indicating meter. Subtract the oscillator frequency response in paragraph (b)(2) of this section from the response obtained through the record-playback sequence to obtain the record/reproduce frequency response of the system except for the microphone.

(vi) To obtain the overall system frequency response, add the manufacturer's microphone calibration data to the response just obtained. This may be the frequency response for the specific microphone to be used, including calibration tolerances. Alternatively, use the manufacturer's "typical" microphone response plus and minus the maximum deviation expected from "typical" including calibration tolerances. Use the microphone response curve which corresponds to the manner in which it is used in the field. It may be required to add a correction to the response curves provided to obtain field response; refer to the manufacturer's manual.

(vii) Adjustment or repair of equipment may be required to obtain response within the requirements of paragraph (a) of this section. After any adjustments, the system shall be requalified according to paragraph (b) of this section.

(3) *General comments.* (i) Calibrate tape recorders using the brand and type of magnetic tape used for actual data acquisition. Differences in tape can cause an appreciable variation in the recorder/reproduce frequency response characteristics of tape recorder.

(ii) It shall be ensured that the instrumentation used will perform within specifications and applicable tolerances over the temperature, humidity, and other environmental variation ranges which may be encountered in vehicle noise measurement works.

(iii) Qualification tests shall be performed using equipment (including cables) and recording and playback techniques identical with those used while recording vehicle noise. For example, if weighted sound level data are normally recorded use similar weighting and apply the tolerances of Table 205.1 to the weighting curve for comparison with record-playback curves. Precautions should also be taken to ensure that source and load impedances are appropriate to the device being tested. Other data acquisition systems may use any combination of microphones, sound level meters, amplifiers, tape recorders,

graphic level recorders, or indicating meters. The same approach to qualifying such a system shall be taken as described in this document for the systems depicted in Figures 205.2, 205.3 and 205.4.

(b) Systems other than those specified in §§ 205.54-1(a) and 205.54-2(a) may be used for establishing compliance with this regulation. In each case the system must yield sound levels which are equivalent to those produced by a sound level meter Type 1 ANSI S1.4-1971. The manufacturer bears the burden of demonstrating such equivalence. The manufacturer shall notify the Administrator pursuant to §§ 205.55-4(b)(5) and 205.57-5(c)(4) of the use of such a sound data acquisition system.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, Dec. 5, 1977]

### § 205.55 Production verification.

### § 205.55-1 General requirements.

(a) Every new vehicle manufactured for distribution in commerce in the United States which is subject to the standards prescribed in this subpart and not exempted in accordance with § 205.5:

(1) Shall be verified in accordance with the production verification procedures described in this subpart;

(2) Shall be represented in a product verification report, as required by § 205.55-4 or this subpart;

(3) Shall be labeled in accordance with the requirements of § 205.55-12 of this subpart; and

(4) Shall conform to the applicable noise emission standard established in § 205.52 of this regulation.

(b) The requirements of paragraph (a) apply to new products which conform to the definition of vehicles in these regulations and at the time such new products are assembled to that state of completeness in which the manufacturer distributes them in commerce.

(c) Subsequent manufacturers of a new product which conforms to the definition of vehicle in these regulations when received by them from a prior manufacturer, need not fulfill the requirements of paragraph (a)(1), (2) or (3) where such requirements have already been complied with by a prior manufacturer.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, Dec. 5, 1977]

### § 205.55-2 Production verification: Compliance with standards.

(a) (1) Prior to distribution into commerce of vehicles of a specific configuration, the first manufacturer of such vehicles shall verify such configuration in accordance with this subpart.

(2) Notwithstanding paragraph (a)(1) of this section, the manufacturer may distribute in commerce vehicles of that configuration for up to 90 days if weather or other conditions beyond the control of the manufacturer make production verification of a configuration impossible, provided that the following conditions are met:

(i) The manufacturer shall perform the tests required under paragraph (b) or (c) of this section on such configuration as soon as conditions permit;

(ii) The manufacturer shall maintain records of the conditions which make production verification impossible;

(iii) If on the 45th day following distribution in commerce of vehicles of a configuration the manufacturer has not performed the tests required by paragraph (b) or (c) of this section, the manufacturer shall within 5 days notify the Administrator in writing that such vehicles have been distributed in commerce and shall provide to the Administrator documentation of the conditions which have made production verification impossible.

(3) At any time following receipt of notice under paragraph (a)(2)(iii) of this section with respect to a configuration, the Administrator may require that the manufacturer ship test vehicles to the EPA test facility in order for the Administrator to perform the tests required for production verification.

(b) The production verification requirements with regard to each vehicle configuration consist of:

(1) Testing in accordance with § 205.54 of a vehicle selected in accordance with § 205.55-5;

(2) Compliance of the test vehicle with the applicable standards when tested in accordance with § 205.54; and

(3) Submission of a production verification report pursuant to § 205.55-4.

(c) (1) In lieu of testing vehicles of every configuration as described in paragraph (b) of this section, the manufacturer may elect to verify the configuration based on representative testing, the requirements of which consist of:

(i) Grouping configurations into a category where each category will be determined by a separate combination of at least the following parameters (a manufacturer may use more parameters):

(*a*) *Engine type.*

(*1*) Gasoline—two stroke cycle.

(*2*) Gasoline—four stroke cycle.

(*3*) Diesel—two stroke cycle.

(*4*) Diesel—four stroke cycle.

(*5*) Rotary—wankel.

(*6*) Turbine.

(*7*) Other.

(*b*) *Engine manufacturer.*

(*c*) *Engine displacement.*

(*d*) *Engine configuration* (e.g., L-6, V-8, etc.).

(*e*) *Series* (i.e., cab design) including but not limited to conventional, cab over engine, and cab forward.

(ii) Identifying the configuration within each category which emits the highest sound pressure level (dBA) based on his best technical judgment and/or emission test data;

(iii) Testing in accordance with § 205.54 of a vehicle selected in accordance with § 205.55-5 which must be a vehicle of the configuration which is identified pursuant to paragraph (c)(1)(ii) of this section as having the highest sound pressure level (estimated or actual) within the category;

(iv) Compliance of the test vehicle with applicable standards when tested in accordance with § 205.54; and

(v) Submission of a production verification report pursuant to § 205.55-4.

(2) Where the requirements of paragraph (c)(1) of this section are complied with, all those configurations contained within a category are considered represented by the tested vehicle and are considered to be production verified.

(3) Where the manufacturer tests a vehicle configuration which has not been determined as having the highest sound pressure level of a category, but all other requirements of paragraph (c)(1) of this section are complied with, all those configurations contained within that category which are determined to have sound pressure levels no greater than the tested vehicle are considered to be represented by the tested vehicle and are considered to be production verified; however, a manufacturer must production verify according to the requirements of paragraph (b)(1) and/or (c)(1) of this section any configurations in the subject category which have a higher sound pressure level than the vehicle configuration tested.

(d) A manufacturer may elect to production verify using representative testing pursuant to paragraph (c) of this section, all or part of his product line.

(e) The manufacturer may, at his option, proceed with any of the following alternatives with respect to any vehicle determined not in compliance with applicable standards.

(1) Delete that configuration from the production verification report. Configurations so deleted may be included in a later report under § 205.55-4. However, in the case of representative testing a new test vehicle from another configuration must be selected and production verified according to the requirements of paragraph (c) of this section, in order to production verify the configurations represented by the non-compliant vehicle.

(2) Modify the test vehicle and demonstrate by testing that it meets applicable standards. All modifications and test results must be reported in the production verification report. The manufacturer must modify all production vehicles of the same configuration in the same manner as the test vehicle before distribution into commerce.

(f) Upon request, by Director, Noise Enforcement Division, the manufacturer shall notify such Director of any production verification testing scheduled by the manufacturer pursuant to this section so that EPA Enforcement Officers may be present and observe such testing or conduct the testing in lieu of the manufacturer.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61458, Dec. 5, 1977; 43 FR 12326, Mar. 24, 1978]

§ 205.55-3 Configuration identification.

(a) A separate vehicle configuration shall be determined by each combination of the following parameters:

(1) *Exhaust system configuration.* (i) Single vertical.

(ii) Dual vertical.

(iii) Single horizontal.

(iv) Dual horizontal.

(2) *Air induction system (engine).* (i) Natural.

(ii) Turbocharged.

(3) *Fan.* (i) Diameter.

(ii) Drive.

(*a*) Direct.

(*b*) Thermostatic.

(iii) Max fan rpm.

(4) *Engine manufacturer's horsepower rating.*

(5) *Cab characteristic.* (i) Sleeper.

(ii) Non sleeper.

(6) *Category parameters listed in § 205.55-2.*

§ 205.55-4 Production verification report; required data.

(a) The manufacturer shall submit a production verification report to the Director, Noise Enforcement Division (EN-387), U.S. Environmental Protection Agency, 401 M. St., S.W., Washington, D.C. 20460. A manufacturer may choose to submit separate production verification reports for different parts of his product line.

(b) The report shall be signed by an authorized representative of the manufacturer and shall include the following:

(1) The name, location and description of the manufacturer's noise emission test facilities which meet the specification of § 205.54 and have been utilized to conduct testing pursuant to this subpart b; except, that a test facility that has been described in a previous submission under this subpart need not again be described but must be identified as such.

(2) A description of normal predelivery maintenance procedure.

(3) A description of all vehicle configurations as determined in accordance with § 205.55-3, to be distributed in commerce by the manufacturer including a list identifying or defining any device or element of design (including its location and method of operation) incorporated into vehicles for the purpose of noise control and attenuation including the following information for each configuration:

(i) Muffler (exhaust). (*a*) Manufacturer.

(*b*) Manufacturer part number.

(ii) Air induction system (engine). (*a*) Muffler manufacturer name.

(*b*) Muffler manufacturer part number.

(iii) Governed or maximum rated rpm.

(iv) Any device which affects noise emissions from the vehicle and does not operate during the normal operating modes of the vehicle (e.g., over temperature protection).

The manufacturer may satisfy the vehicle configuration description requirements of this paragraph by submitting as part of the production verification report a copy of his sales data literature which describes his product line including options: Provided, that this literature is supplemented with any additional information to fulfill the requirements of this section. If a manufacturer elects to production verify pursuant to § 205.55-2(c) the configuration, within each category, which is estimated to have the highest sound pressure level (dBA) shall be identified. The manufacturer may estimate the sound pressure level based on his best technical judgment and/or data. The criteria used to estimate each sound pressure level shall be stated with the estimates.

(4) The following information for each noise emission test conducted:

(i) The completed individual record for the test vehicle required by § 205.53 (a)(2) for all official tests.

(ii) A complete description of any preparation, maintenance or testing which could affect the noise emissions of the vehicle, and which was performed on the test vehicle but will not be performed on all other production vehicles.

(iii) The reason for replacement where a replacement vehicle was necessary, and test results, if any, for replaced vehicle.

(5) A complete description of the sound data acquisition system if other than those specified in § 205.54-1(a) and § 205.54-2(a).

(6) The following statement and endorsement:

This report is submitted pursuant to section 6 and section 13 of the Noise Control Act of 1972. To the best of _____ (company name) knowledge, all testing for which data is reported herein was conducted in strict conformance with applicable regulations under 40 CFR 205.1 et seq., all the data reported herein are a true and accurate representation of such testing and all other information reported herein is true and accurate. I am aware of the penalties associated with violations of the Noise Control Act of 1972 and the regulations thereunder.

_____
(authorized representative)

(c) Where a manufacturer elects to submit separate production verification reports for portions of his product line as provided for in paragraph (a) of this section, information provided in previous reports need not be resubmitted. Except, that information necessary to update or make current previously submitted information must be submitted.

(d) Any change with respect to any information reported pursuant to this subpart shall be reported as soon as the information becomes available.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, 61458, Dec. 5, 1977; 43 FR 12326, Mar. 24, 1978]

§ 205.55-5 Test vehicle sample selection.

(a) Test vehicles of a configuration for which production verification testing is required by § 205.55.2 shall be a vehicle of the subject configuration which has been assembled using the manufacturer's normal production processes and will be sold or offered for sale in commerce.

(b) Should a situation arise in which the configuration to be tested consists of only vehicles with automatic transmissions, they shall be tested in accordance with § 205.54-1(c)(2).

(c) If the configuration to be tested consists of both automatic transmission and standard transmission vehicles, the test vehicle shall be a standard transmission vehicle unless the manufacturer has reason to believe that the automatic transmission vehicle emits a greater sound level.

§ 205.55-6 Test vehicle preparation.

(a) Prior to the official test, the test vehicle selected in accordance with § 205.55-5 shall not be prepared, tested, modified, adjusted, or maintained in any manner unless such adjustments, preparation, modification and/or tests are part of the manufacturer's prescribed manufacturing and inspection procedures, and are documented in the manufacturer's internal vehicle assembly and inspection procedures or unless such adjustments and/or tests are required or permitted under this subpart or are approved in advance by the Administrator. For purposes of this section and § 205.55-5, prescribed manufacturing and inspection procedures include quality control testing and assembly procedures normally performed by the manufacturer on like products during early production so long as the resulting testing is not biased by this procedure. In the case of imported products, the manufacturer may perform adjustments, preparations, modification and/or tests normally performed at the port of entry by the manufacturer to prepare the vehicle for delivery to a dealer or customer.

(b) Equipment or fixtures necessary to conduct the test may be installed on the vehicle: *Provided*, That such equipment or fixtures shall have no effect on the noise emissions of the vehicle, as determined by measurement methodology.

(c) In the event of vehicle malfunction (i.e., failure to start, misfiring cylinder, etc.) the manufacturer may perform the maintenance that is necessary to enable the vehicle to operate in a normal manner: *Provided*, That such maintenance is documented and reported in the final report prepared and submitted in accordance with this subpart.

(d) No quality control, testing, assembly or selection procedures shall be used on the completed vehicle or any portion thereof, including parts and subassemblies, that will not normally be used during the production and assembly of all other vehicles of the category which will be distributed in commerce, unless such procedures are required or permitted under this subpart.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61458, Dec. 5, 1977]

§ 205.55-7 Testing.

(a) The manufacturer shall conduct one valid test in accordance with the test procedures specified in § 205.54. In the event a vehicle is unable to complete the emission test, the manufacturer may replace the vehicle with a vehicle of the same configuration as the replaced vehicle or a noisier configuration and will be subject to all the provisions of these regulations. Any replacement shall be reported in the production verification report including the reason for the replacement.

(b) No maintenance will be performed on test vehicles except as provided for by § 205.55-6. In the event a vehicle is unable to complete the emission test, the manufacturer may replace the vehicle. Any replacement vehicle will be a production vehicle of the same configuration as the replaced vehicle or a noisier configuration and will be subject to all the provisions of these regulations. Any replacement shall be reported in the production verification report including the reason for the replacement.

(c) In the event a vehicle fails to comply with the standards of this subpart when tested in accordance with the procedures specified in paragraph (a) of this section, the manufacturer may proceed in accordance with § 205.55-2(e) of this subpart.

§ 205.55-8 Addition of, changes to and deviation from a vehicle configuration during the model year.

(a) Any change to a configuration with respect to any of the parameters stated in § 205.55-3 shall constitute the addition of a new and separate configuration or category to the manufacturer's product line.

(b) (1) When a manufacturer introduces a new category or configuration to his product line, he shall proceed in accordance with § 205.55-2.

(2) If the configuration to be added can be grouped within a verified category and the new configuration is estimated to have a lower sound pressure level than a previously verified configuration within the same category, the configuration shall be considered verified: Provided, that the manufacturer submits a report pursuant to § 205.55-4 with respect to such configuration.

§ 205.55-9 Production verification based on data from previous model years.

(a) Production verification of each configuration will be required at the beginning of production of that configuration each model year except that in certain instances, the Administrator, upon request by the manufacturer, may permit the use of production verification data for specific configurations from previous production verification reports. Considerations relevant to his decision are:

(1) The level of the standard in effect for the model years in question;

(2) Performance based on production verification data for previous years;

(3) Performance based on data obtained from selective enforcement testing during previous model years; and

(4) The number and type of noise emission design changes incorporated in the new models.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61458, Dec. 5, 1977]

§ 205.55-10 Cessation of distribution.

(a) If a category or configuration is found to be nonconforming with these regulations by reason of failure to be properly verified, as required by § 205.55-2, the Administrator may issue an order to the manufacturer to cease to distribute in commerce vehicles of that category or configuration: Provided, however, that such an order shall not be issued if the manufacturer has made a good faith attempt to properly production verify the category or configuration. The burden of establishing such good faith shall rest with the manufacturer.

(b) Any such order shall be issued after notice and opportunity for a hearing.

§ 205.55-11 Labeling-compliance.

(a) (1) The manufacturer of any vehicle subject to the provisions of § 205.52 shall, at the time of manufacture, affix a permanent, legible label,

of the type and in the manner described below, containing the information hereinafter provided, to all such vehicles to be distributed in commerce. The labels shall be affixed in such a manner that they cannot be removed without destroying or defacing them, and shall not be affixed to any equipment which is easily detached from such vehicle.

(2) A label shall be permanently attached, in a readily visible position, in the operator's compartment.

(3) Labels for vehicles not manufactured solely for use outside the United States shall contain the following information lettered in the English language in block letters and numerals, which shall be of a color that contrasts with the background of the label:

(i) The label heading: Vehicle Noise Emission Control Information;

(ii) Full corporate name and trademark of manufacturer;

(iii) Month and year of manufacture;

(iv) The statement:

This Vehicle Conforms to U.S. EPA Regulations for Noise Emission Applicable to Medium and Heavy Trucks.

The following acts or the causing thereof by any person are prohibited by the Noise Control Act of 1972: (A) The removal or rendering inoperative, other than for purposes of maintenance, repair, or replacement, of any noise control device or element of design (listed in the owner's manual) incorporated into this vehicle in compliance with the Noise Control Act; (B) The use of this vehicle after such device or element of design has been removed or rendered inoperative.

(b) Labels for vehicles manufactured solely for use outside the United States shall contain the words "For Export Only."

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, 61458, Dec. 5, 1977]

§ 205.55-12 Labeling-Exterior. [Reserved]

§ 205.56 Testing by the administrator.

(a) (1) The Administrator may require that any vehicles to be tested pursuant to the Act be submitted to him, at such place and time as he may reasonably designate and in such quantity and for such time as he may reasonably require for the purpose of conducting tests in accordance with test procedures described in § 205.54 to determine whether such vehicles or a manufacturer's test facility conform to applicable regulations. It is a condition of the requirements under this section that the manner in which the Administrator conducts such tests, the EPA test facility itself, and the test procedures he employs shall be based upon good engineering practice and meet or exceed the requirements of § 205.54 of the regulations.

(2) The Administrator may specify that he will conduct such testing at the manufacturer's facility, in which case instrumentation and equipment of the type required by these regulations shall be made available by the manufacturer for test operations. The Administrator may conduct such tests with his own equipment, which shall equal or exceed the performance specifications of the instrumentation or equipment specified by the Administrator in these regulations.

(3) The manufacturer may observe tests conducted by the Administrator pursuant to this section on vehicles produced by such manufacturer and may copy the data accumulated from such tests. The manufacturer may inspect any such vehicles before and after testing by the Administrator.

(b) (1) If, based on tests conducted by the Administrator or other relevant information, the Administrator determines that the test facility does not meet the requirements of § 205.54-1 (a) and (b) he will notify the manufacturer in writing of his determination and the reasons therefor.

(2) The manufacturer may at any time within 15 days after receipt of a notice issued under paragraph (b)(1) of this section request a hearing conducted in accordance with 5 U.S.C. 554 on the issue of whether his test facility was in conformance. Such notice will not take effect until 15 days after receipt by the manufacturer, or if a hearing is requested under this paragraph, until adjudication by the hearing examiner.

(3) After any notification issued under paragraph (b)(1) of this section has taken effect, no data thereafter derived from such test facility will be acceptable for purposes of this Part.

(4) The manufacturer may request in writing that the Administrator reconsider his determination under paragraph (b)(1) of this section based on data or information which indicates that changes have been made to the test facility and such changes have resolved the reasons for disqualification.

(5) The Administrator will notify the manufacturer of his determination and an explanation of the reasons underlying it with regard to the requalification of the test facility within 10 working days after receipt of the manufacturer's request for reconsideration pursuant to paragraph (b)(4) of this section.

(c) (1) The Administrator will assume all reasonable costs associated with shipment of vehicles to the place designated pursuant to paragraph (a) of this section except with respect to:

(i) Any production verification testing performed at a place other than the manufacturer's facility as provided for in § 205.55-2(a)(3), or as a result of the manufacturer's not owning or having access to a test facility;

(ii) Testing of a reasonable number of vehicles for purposes of selective enforcement auditing under § 205.57 or testing of smaller numbers of vehicles, if the manufacturer has failed to establish that there is a correlation between its test facility and the EPA test facility or the Administrator has reason to believe, and provides the manufacturer a statement of such reasons, that the vehicles to be tested would fail to meet the standard prescribed in this subpart if tested at the EPA test facility, but would meet such standard if tested at the manufacturer's test facility;

(iii) Any testing performed during a period when a notice of nonconformance of the manufacturer's test facility issued pursuant to paragraph (b) of this section is in effect;

(iv) Any testing performed at place other than the manufacturer's facility as a result of the manufacturer's failure to permit the Administrator to conduct or monitor testing as required by this part; and

(v) In addition to any vehicles included in paragraph (c)(1), (i), (ii), (iii), or (iv) of this section, up to 10 percent of the manufacturers' production verification test vehicles to be tested during a model year if the Administrator determines it is necessary to test such vehicles at the EPA test site in order to assure that a manufacturer has acted or is acting in compliance with the Act.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, 61459, Dec. 5, 1977]

## § 205.57 Selective enforcement auditing requirements.

### § 205.57-1 Test request.

(a) The Administrator will request all testing under § 205.57 by means of a test request addressed to the manufacturer.

(1) Except as provided in paragraphs (a) (2) and (3) of this section, the Administrator will not issue to a manufacturer during any model year more test requests than a number determined by dividing the total number of vehicles subject to this regulation which the manufacturer projects he will produce during that model year by 25,000 and rounding to the next higher whole number: Except, that the Administrator may issue one additional test request beyond the annual limit to any manufacturer for each time a batch sequence for any category, configuration or subgroup thereof of such manufacturer's production is rejected in accordance with § 205.57-7.

(2) Any test request issued against a category, configuration or subgroup thereof which the Administrator has reason to believe does not meet the standards specified in § 205.52 will not be counted against the annual limit on test requests described in paragraph (a)(1) of this section. Any such request shall include a statement of the Administrator's reason for such belief.

(3) Any test request under which testing is not completed will not be counted against the annual limit on test requests described in paragraph (a)(1) of this section.

(b) The test request will be signed by the Assistant Administrator for Enforcement or his designee. The test request will be delivered by an EPA Enforcement Officer to the plant manager or other responsible official as designated by the manufacturer.

(c) The test request will specify the vehicle category, configuration or subgroup thereof selected for testing, the batch from which sampling is to begin, the batch size, the manufacturer's plant or storage facility from which the vehicles must be selected, the time at which a vehicle must be selected. The test request will also provide for situations in which the selected configuration or category is unavailable for testing. The test request may include an alternative category or configuration selected for testing in the event that vehicles of the first specified category or configuration are not available for testing because the vehicles are not being manufactured at the specified plant and/or are not being manufactured during the specified time or not being stored at the specified plant or storage facility.

(d) Any manufacturer shall, upon receipt of the test request, select and test a batch sample of vehicles from two consecutively produced batches of the vehicle category or configurations specified in the test request in accordance with these regulations and the conditions specified in the test request.

(e) (1) Any testing conducted by the manufacturer pursuant to a test request shall be initiated within such period as is specified within the test request: Except, that such initiation may be delayed for increments of 24 hours or one business day where ambient test site weather conditions, or other conditions beyond the control of the manufacturer, in any 24-hour period do not permit testing: *Provided*, That these conditions for that period are recorded.

(2) The manufacturer shall complete emission testing on a minimum of five vehicles per day unless otherwise provided for by the Administrator or unless ambient test site conditions only permit the testing of a lesser number: Provided, that ambient test site weather conditions for that period are recorded.

(3) The manufacturer will be allowed 24 hours to ship vehicles from a batch sample from the assembly plant to the testing facility if the facility is not located at the plant or in close proximity to the plant: Except, that the Administrator may approve more time based upon a request by the manufacturer accompanied by a satisfactory justification.

(f) The Administrator may issue an order to the manufacturer to cease to distribute into commerce vehicles of a specified category or configuration being manufactured at a particular facility if:

(1) The manufacturer refuses to comply with the provisions of a test request issued by the Administrator pursuant to this section; or

(2) The manufacturer refuses to comply with any of the requirements of this section.

(g) A cease-to-distribute order shall not be issued under paragraph (f) of this section if such refusal is caused by conditions and circumstances outside the control of the manufacturer which renders it impossible to comply with the provisions of a test request or any other requirements of this section. Such conditions and circumstances shall include, but are not limited to, any uncontrollable factors which result in the temporary unavailability of equipment and personnel needed to conduct the required tests, such as equipment break-down or failure or illness of personnel, but shall not include failure of the manufacturer to adequately plan for and provide the equipment and personnel needed to conduct the tests. The manufacturer will bear the burden of establishing the presence of the conditions and circumstances required by this paragraph.

(h) Any such order shall be issued only after a notice and opportunity for a hearing.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61459, Dec. 5, 1977; 43 FR 12326, Mar. 24, 1978]

### § 205.57-2 Test vehicle sample selection.

(a) Vehicles comprising the batch sample which are required to be tested pursuant to a test request in accordance with this subpart will be selected in the manner specified in the test request from a batch of vehicles of the category or configuration specified in the test request. If the test request specifies that the vehicles comprising the batch sample must be selected ran-

domly, the random selection will be achieved by sequentially numbering all of the vehicles in the batch and then using a table of random numbers to select the number of vehicles as specified in paragraph (c) of this section based on the batch size designated by the Administrator in the test request. An alternative random selection plan may be used by a manufacturer: Provided, that such a plant is approved by the Administrator. If the test request does not specify that test vehicles must be randomly selected, the manufacturer shall select test vehicles consecutively. The provisions of § 205.55 (b) and (c) shall also pertain to this section.

(b) The Acceptable Quality Level is 10 percent. The appropriate sampling plans associated with the designated AQL are contained in Appendix I, Table II.

(c) The appropriate batch sample size will be determined by reference to Appendix I, Table I and II. A code letter is obtained from Table I based on the batch size designated by the Administrator in a test request. The batch sample size will be obtained from Table II. The batch sample size will be equal to the maximum cumulative sample size for the appropriate code letter obtained from Table I plus an additional 10 percent rounded off to the next highest number.

(d) If the test request specifies that vehicles comprising the batch sample must be selected randomly, individual vehicles comprising the test sample will be randomly selected from the batch sample using the same random selection plan as in paragraph (a) of this section. Test sample size will be determined by entering Table II.

(e) The test vehicle of the category, configuration or subgroup thereof selected for testing shall have been assembled by the manufacturer for distribution in commerce using the manufacturer's normal production process in accordance with § 205.55-5(a).

(f) Unless otherwise indicated in the test request, the manufacturer will select the batch sample from the production batch, next scheduled after receipt of the test request, of the category or configuration specified in the test request.

(g) Unless otherwise indicated in the test request, the manufacturer shall select the vehicles designated in the test request for testing.

(h) At their discretion, EPA Enforcement Officers, rather than the manufacturer, may select the vehicles designated in the test request.

(i) The manufacturer will keep on hand all vehicles in the batch sample until such time as the batch is accepted or rejected in accordance with § 205.57-6: Except, that vehicles actually tested and found to be in conformance with these regulations need not be kept.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61459, Dec. 5, 1977]

### § 205.57-3 Test vehicle preparation.

(a) Prior to the official test, the test vehicle selected in accordance with § 205.57-2 will be prepared in accordance with § 205.55-6.

### § 205.57-4 Testing procedures.

(a) The manufacturer shall conduct one valid test in accordance with the test procedures specified in § 205.54 of this subpart for each vehicle selected for testing pursuant to this subpart.

(b) No maintenance will be performed on test vehicles except as provided for by § 205.57-3. In the event a vehicle is unable to complete the emission test, the manufacturer may replace the vehicle. Any replacement vehicle will be a production vehicle of the same configuration as the replaced vehicle. It will be randomly selected from the batch sample and will be subject to all the provisions of these regulations.

### § 205.57-5 Reporting of the test results.

(a) Within 5 working days after completion of testing of all vehicles in a batch sample the manufacturer shall submit to the Administrator a final report which will include the information required by the test request in the format stipulated in the test request in addition to the following:

(1) The name, location, and description of the manufacturer's emission test facilities which meet the specifications of § 205.54 and were utilized to conduct testing reported pursuant to this section: Except, that a test facility

that has been described in a previous submission under this subpart need not again be described but must be identified as such.

(2) A description of the random vehicle selection method used, referencing any tables of random numbers that were used, name of the person in charge of the random number selection, if the vehicle test request specifies a random vehicle selection.

(3) The following information for each noise emission test conducted.

(i) The completed data sheet required by § 205.54 for all noise emission tests including: for each invalid test, the reason for invalidation.

(ii) A complete description of any modification, repair, preparation, maintenance, and/or testing which could affect the noise emissions of the vehicle and which was performed on the test vehicle but will not be performed on all other production vehicles.

(iii) The reason for the replacement where a replacement vehicle was authorized by the Administrator, and, if any, the test results for the replaced vehicles.

(4) A complete description of the sound data acquisition system if other than those specified in §§ 205.54-1(a) and 205.54-2(a).

(5) The following statement and endorsement:

This report is submitted pursuant to section 6 and section 13 of the Noise Control Act of 1972. To the best of _____ (company name) knowledge, all testing for which data are reported herein was conducted in strict conformance with applicable regulations under 40 CFR 205.1 et seq., all the data reported herein are a true and accurate representation of such testing and all other information reported herein is true and accurate. I am aware of the penalties associated with violations of the Noise Control Act of 1972 and the regulations thereunder.

_____
(authorized representative)

(b) All information required to be forwarded to the Administrator pursuant to this section shall be addressed to Director, Noise Enforcement Division (EN-387), U.S. Environmental Protection Agency, Washington, D.C. 20460.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61459, Dec. 5, 1977; 43 FR 12326, Mar. 24, 1978]

### § 205.57-6 Acceptance and rejection of batches.

(a) The batch from which a batch sample is selected will be accepted or rejected based upon the number of failing vehicles in the batch sample. A sufficient number of test samples will be drawn from the batch sample until the cumulative number of failing vehicles is less than or equal to the acceptance number or greater than or equal to the rejection number appropriate for the cumulative number of vehicles tested. The acceptance and rejection numbers listed in Appendix I, Table II at the appropriate code letter obtained according to § 205.57-2 will be used in determining whether the acceptance or rejection of a batch has occurred.

(b) Acceptance or rejection of a batch takes place when the decision that a vehicle is a failing vehicle is made on the last vehicle required to make a decision under paragraph (a) of this section.

### § 205.57-7 Acceptance and rejection of batch sequence.

(a) The manufacturer will continue to inspect consecutive batches until the batch sequence is accepted or rejected based upon the number of rejected batches. A sufficient number of consecutive batches will be inspected until the cumulative number of rejected batches is less than or equal to the sequence acceptance number of greater than or equal to the sequence rejection number appropriate for the cumulative number of batches inspected. The acceptance and rejection numbers listed in Appendix I, Table III at the appropriate code letter obtained according to § 205.57-2 will be used in determining whether the acceptance or rejection of a batch sequence has occurred.

(b) Acceptance or rejection of a batch sequence takes place when the decision that a vehicle is a failing vehicle is made on the last vehicle required to make a decision under paragraph (a) of this section.

(c) If the batch sequence is accepted, the manufacture will not be required

to perform any additional testing on vehicles from subsequent batches pursuant to the initiating test request.

(d) The Administrator may terminate testing earlier than required in paragraph (b) of this section based on a request by the manufacturer accompanied by voluntary cessation of distribution in commerce, of vehicles from the category, configuration or subgroup in question manufactured at the plant which produced the vehicles under test: *Provided*, That before reinitiating distribution in commerce of vehicles from such plant of such vehicle category, configuration or subgroup, the manufacturer must take the action described in § 205.57-9 (a)(1) and (a)(2).

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61460, Dec. 5, 1977]

§ 205.57-8 Continued testing.

(a) If a batch sequence is rejected in accordance with paragraph (b) of § 205.57-7, the Administrator may require that any or all vehicles of that category, configuration of subgroup thereof produced at that plant be tested before distribution in commerce.

(b) The Administrator will notify the manufacturer in writing of his intent to require such continued testing of vehicles pursuant to paragraph (a) of this section.

(c) The manufacturer may request a hearing on the issues of whether the selective enforcement audit was conducted properly; whether the criteria for batch sequence rejection in § 204.57-7 have been met; and, the appropriateness or scope of a continued testing order. In the event that a hearing is requested, the hearing shall begin no later than 15 days after the date on which the Administrator received the hearing request. Neither the request for a hearing nor the fact that a hearing is in progress shall affect the reponsibility of the manufacturer to commence and continue testing required by the Administrator pursuant to paragraph (a) of this section.

(d) Any tested vehicle which demonstrated conformance with the applicable standards may be distributed into commerce.

(e) Any knowing distribution into commerce of a vehicle which does not comply with the applicable standards is a prohibited act.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61460, Dec. 5, 1977; 44 FR 54298, Sept. 19, 1979]

§ 205.57-9 Prohibition on distribution in commerce; manufacturer's remedy.

(a) The Administrator will permit the cessation of continued testing under § 205.57-8 once the manufacturer has taken the following actions:

(1) Submits a written report which identifies the reason for the noncompliance of the vehicles, describes the problem and describes the proposed quality control and/or quality assurance remedies to be taken by the manufacturer to correct the problem or follows the requirements for an engineering change pursuant to § 205.55-8, and

(2) Demonstrates that the specified vehicle category, configuration or subgroup thereof has passed a retest conducted in accordance with § 205.57 and the conditions specified in the initial test request.

(3) The manufacturer may begin testing under paragraph (a)(2) of this section upon submitting such report, and may cease continued testing upon making the demonstration required by paragraph (a)(2) of this section, provided that the Administrator may require resumption of continued testing if he determines that the manufacturer has not satisfied the requirements of paragraphs (a) (1) and (2) of this section.

(b) Any vehicle failing the prescribed noise emission tests conducted pursuant to this Subpart B may not be distributed in commerce until necessary adjustments or repairs have been made and the vehicle passes a retest.

(c) No vehicles of a rejected batch which are still in the hands of the manufacturer may be distributed in commerce unless the manufacturer has demonstrated to the satisfaction of the Administrator that such vehicles do in fact conform to the regulations: Except, that any vehicle that has been tested and does, in fact, conform with these regulations may be distributed in commerce.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61460, Dec. 5, 1977]

§ 205.58 In-use requirements.

*§ 205.58-1 Warranty.*

(a) The vehicle manufacturer who is required to production verify under this part shall include in the owner's manual or in other information supplied to the ultimate purchaser the following statement:

NOISE EMISSIONS WARRANTY

(Name of vehicle manufacturer warrants to the first person who purchases this vehicle for purposes other than resale and to each subsequent purchaser that this vehicle as manufactured by (name of vehicle manufacturer),was designed, built and equipped to conform at the time it left (name of manufacturer)'s control with all applicable U.S. EPA noise control regulations.

This warranty covers this vehicle as designed , built and equipped by (name of manufacturer), and is not limited to any particular part, component or system of the vehicle manufactured by (name of manufacturer). Defects in the design, assembly, or in any part, component, or system of the vehicle as manufactured by (name of vehicle manufacturer), which, at the time it left (name of vehicle manufacturer)'s, control, caused noise emission levels to exceed Federal standards, are covered by this warranty for the life of the vehicle.

(b) Not later than the date of submission of the product verification report required by § 205.55-4, the manufacturer shall submit to the Administrator two (2) copies of the written noises emission warranty required by paragraph (a) of this section and two (2) copies of all other information provided to the ultimate purchaser which could reasonably be construed as impacting on the warranty.

(c) Not later than ten (10) days after dissemination, the manufacturer shall submit two (2) representative copies of all information of a general nature, or modifications thereto, which is provided to dealers, zone representatives, or other agents of the manufacturer regarding the administration and application of the noise emission warranty. Information regarding noise emission warranty claims which is provided to a dealer or representative in response to a particular warranty claim or dealer inquiry is not considered to be information of a general nature, if such information does not receive broad dissemination to dealers.

(d) All information required to be forwarded to the Administrator pursuant to this section shall be addressed to:

Director, Noise Enforcement Division (EN-387), U.S. Environmental Protection Agency, 401 M St. SW., Washington, D.C. 20460.

[41 FR 15544, Apr. 13, 1976; 41 FR 17732, Apr. 26, 1976, as amended at 43 FR 12326, Mar. 24, 1978; 44 FR 67659, Nov. 27, 1979]

*§ 205.58-2 Tampering.*

(a) For each model year and for each configuration of vehicles covered by this part, the manufacturer shall submit to the Administrator a list of those acts which, in the manufacturer's estimation, might be done to the vehicle in use, on more than an occasional basis, and result in an increase in noise emissions above the standards prescribed in § 205.52. The manufacturer should indicate, wherever possible, the amount of this increase in noise level.

(b) The above information shall be submitted to the Administrator within adequate time prior to the introduction into commerce of each configuration to allow for the development and printing of tampering lists, as provided in paragraphs (c) and (d), of this section.

(c) On the basis of the above information, the Administrator will develop a list of acts which, in the Administrator's judgment, constitute the removal or rendering inoperative, other than for purposes of maintenance, repair, or replacement, of noise control devices or elements of design of the vehicle. This list shall be provided to the manufacturer and may be updated from time to time. The list shall be included in the statement to the ultimate purchaser as required by paragraph (d)(2) of this section. If the list is not provided by the Administrator within 30 days of the date on which the information required in paragraph (a) of this section is submitted, the manufacturer shall include only the statement in paragraph (d)(1) of this section until such time as the list has

been provided and the owner's manual is reprinted for other purposes.

(d) The manufacturer shall include in the owner's manual the following information:

(1) The statement:

TAMPERING WITH NOISE CONTROL SYSTEM PROHIBITED

Federal law prohibits the following acts or the causing thereof: (1) The removal or rendering inoperative by any person other than for purposes of maintenance repair, or replacement, of any device or element of design incorporated into any new vehicle for the purpose of noise control prior to its sale or delivery to the ultimate purchaser or while it is in use, or (2) the use of the vehicle after such device or element of design has been removed or rendered inoperative by any person.

(2) The statement:

Among those acts presumed to constitute tampering are the acts listed below.

Immediately following this statement, the manufacturer shall include the list developed by the Administrator under paragraph (c) of this section.

(e) Any act included in the list prepared pursuant to paragraph (c) of this section is presumed to constitute tampering; however, in any case in which a proscribed act has been committed and it can be shown that such act resulted in no increase in the noise level of the vehicle or that the vehicle still meets the noise emission standard of § 205.52, such act will not constitute tampering.

(f) The provisions of this section are not intended to preclude any State or local jurisdiction from adopting and enforcing its own prohibitions against the removal or rendering inoperative of noise control systems on vehicles subject to this part.

(g) All information required by this section to be furnished to the Administrator shall be sent to the following address:

Director, Noise Enforcement Division (EN-387), U.S. Environmental Protection Agency, 401 M St. SW., Washington, D.C. 20460.

[41 FR 15544, Apr. 13, 1976, as amended at 43 FR 12326, Mar. 24, 1978]

§ 205.58-3 Instructions for maintenance, use and repair.

(a) (1) The manufacturer shall provide to the ultimate purchaser of each vehicle covered by this subpart written instructions for the proper maintenance, use and repair of the vehicle in order to provide reasonable assurance of the elimination or minimization of noise emission degradation throughout the life of the vehicle.

(2) The purpose of the instructions is to inform purchasers and mechanics of those acts necessary to reasonably assure that degradation of noise emission level is eliminated or minimized during the life of the vehicle. Manufacturers should prepare the instructions with this purpose in mind. The instructions should be clear and, to the extent practicable, written in nontechnical language.

(3) The instructions must not be used to secure an unfair competitive advantage. They should not restrict replacement equipment to original equipment or service to dealer service. Manufacturers who so restrict replacement equipment should be prepared to make public any performance specifications on such equipment.

(b) For the purpose of encouraging proper maintenance, the manufacturer shall provide a record or log book which shall contain a schedule for the performance of all required noise emission control maintenance. Space shall be provided in this record book so that the purchaser can note what maintenance was done, by whom, where and when.

(c) Not later than the date of submission of the production vertification report required by § 205.55-4, the manufacturer shall submit to the Administrator two (2) copies of the maintenance instructions (including the record book) required by paragraphs (a) and (b) of this section.

(d) (1) The Administrator will require modifications to the instructions if they are not both necessary and reasonable.

(2) The manufacturers may file a petition for review of such modifications.

(3) The manufacturer's proposed instructions shall be provided to the consumer pursuant to § 205.58-3(a)(1).

pending review of the proposed instructions by the Agency.

(e) Information required to be submitted to the Administrator pursuant to this section shall be sent to the following address:

Director, Noise Enforcement Division (EN-387), U.S. Environmental Protection Agency, 401 M St., SW., Washington, D.C. 20460.

[41 FR 15544, Apr. 13, 1976, as amended at 42 FR 61456, Dec. 5, 1977; 43 FR 12326, Mar. 24, 1978]

§ 205.59 Recall of noncomplying vehicles.

(a) Pursuant to section 11(d)(1) of the Act, the Administrator may issue an order to the manufacturer to recall and repair or modify any vehicle distributed in commerce not in compliance with this subpart.

(b) A recall order issued pursuant to this section shall be based upon a determination by the Administrator that vehicles of a specified category or configuration have been distributed in commerce which do not conform to the regulations. Such determination may be based on:

(1) A technical analysis of the noise emission characteristics of the category or configuration in question; or

(2) Any other relevant information, including test data.

(c) For the purposes of this section, noise emissions may be measured by any test prescribed in § 205.54 for testing prior to sale or any other test which has been demonstrated to correlate with the prescribed test procedure.

(d) Any such order shall be issued only after notice and an opportunity for a hearing.

(e) All costs, including labor and parts, associated with the recall and repair or modification of non-complying vehicles under this section shall be borne by the manufacturer.

(f) This section shall not limit the discretion of the Administrator to take any other actions which are authorized by the Act.

APPENDIX I

TABLE I.—*Sample size code letters*

| Batch size | Code letter |
|---|---|
| 4 to 8 | A |
| 9 to 15 | B |
| 16 to 25 | C |
| 26 and larger | D |

TABLE II.—*Sampling plans for inspecting batches*

| Sample size code letter | Test sample | Test sample size | Cumulative test sample size | Batch inspection criteria | |
|---|---|---|---|---|---|
| | | | | Acceptance No. | Rejection No. |
| A | 1st | 4 | 4 | 0 | 1 |
| B | 1st | 3 | 3 | 0 | 1 |
| C | 1st | 3 | 3 | 0 | 2 |
| | 2d | 3 | 6 | 1 | 2 |
| D | 1st | 2 | 2 | (1) | 2 |
| | 2d | 2 | 4 | (1) | 2 |
| | 3d | 2 | 6 | 0 | 2 |
| | 4th | 2 | 8 | 0 | 3 |
| | 5th | 2 | 10 | 1 | 3 |
| | 6th | 2 | 12 | 1 | 3 |
| | 7th | 2 | 14 | 2 | 3 |

[1] Batch acceptance not permitted at this sample size.

TABLE III.—*Batch sequence plans*

| Sample size code letter | Number of batches | Cumulative number of batches | Sequence inspection criteria | |
|---|---|---|---|---|
| | | | Acceptance No. | Rejection No. |
| A | 2 | 2 | 1 | (1) |
| | 2 | 4 | 2 | 4 |
| | 2 | 6 | 3 | 5 |
| | 2 | 8 | 4 | 5 |

# APPENDIX C

## DISTINCTION BETWEEN "HARD AND SOFT" SITES

Appendix C.

The IMC regulation promulgated on October 21, 1974 by EPA established noise emission standards for motor carriers engaged in interstate commerce (40 CFR 202). The regulation itself does not distinguish between "hard" and "soft" sites, although the difference between these sites was explicitly recognized in the Preamble to the regulation (39 FR 38212).

The Bureau of Motor Carrier Safety (BMCS) of the Department of Transportation is responsible for ensuring compliance with the IMC regulations. BMCS issued regulations establishing measurement methodologies for determining whether commercial motor vehicles conform to the IMC emission standards (49 CFR 325). The BMCS regulations explicitly distinguish between "hard" and "soft" sites. Table 1 summarizes the relationship between the EPA emission standards (40 CFR 202) and the DOT enforcement standards (49 CFR 325). Note the 2 dB(A) differential between hard and soft sites.

Table 1 - Current IMC Noise Levels

| Test | EPA Regulatory Level dB(A) | DOT Enforcement Levels, dB(A) | |
|---|---|---|---|
| | | Hard Site | Soft Site |
| Low Speed | 86 | 88 | 86 |
| High Speed | 90 | 92 | 90 |
| Stationary | 88 | 88 | 86 |

The distinction between hard and soft sites is responsive to the need for uniformity and consistency in the enforcement activities of BMCS. However, this distinction has introduced a degree of confusion since the IMC low speed and high speed levels,

86 and 90 dB(A), are "soft" site, whereas the stationary test level, 88 dB(A), is "hard" site.

The three aligned IMC levels are explicitly stated as "hard" site levels. This is intended to eliminate the confusion associated with having the two operating levels as soft site and the stationary as hard site. Table 2 summarizes the relationship between the original and aligned levels.

Table 2

| | Original Levels dB(A) | | Aligned Levels dB(A) | |
|---|---|---|---|---|
| | Hard | Soft | Hard | Soft |
| Low | 88 | 86 | 83 | 81 |
| High | 92 | 90 | 87 | 85 |
| Stationary | 88 | 86 | 83 | 81 |

All analyses in this background document are expressed in hard site levels.

# APPENDIX D

# TIRE NOISE CONSIDERATION

Appendix D - Tire Noise

The issue of tire noise was specifically addressed by the Agency as part of supporting technical analyses of various technical issues associated with the aligned IMC levels. There is a 4 dB(A) differential between the original low speed and high speed IMC levels in order to account for tire noise at high speeds. The Agency reviewed information on tire noise that has become available since the original IMC regulation was promulgated. The purpose of the review was to assess whether this 4 dB(A) differential should be changed.

Two reports proved to be particularly helpful:

- "Tire Noise Data Bank," Bolt Beranek and Newman Inc., Report 4411, June 1980.
- "Empirical Model for Predicting In-Service Truck Tire Noise Levels," U.S. Department of Transportation, Report DOT-TST-76T-5, July 1976.

The BBN report, prepared for the Agency's office of Noise Abatement and Control, presents standardization noise measurements for 80 sets of tires, including 35 truck tires. The DOT report, prepared by the National Bureau of Standards, presents information that can be used to predict in service noise levels for various types of tires (e.g., ribbed vs. crossbar) on different types of trucks (e.g., straight truck vs. double axle

trailer). Both reports are technical documents and results are presented for so many combinations of tires, vehicles, and road conditions that it is no single set of results or conclusions.

Review of data presented in these reports indicated that it is appropriate to retain the 4 dB(a) differential. This is particularly true because of the 55 mph speed limit that has come into effect since the original IMC regulation was promulgated. Tire noise is a strong function of vehicle speed and a reduction in speed from 65 to 55 mph reduces the noise of a typical tire by approximately 2.5 dB. Accordingly, the 4 dB(A) differential between low speed and high speed tests has been retained.

# APPENDIX E

## ASSESSMENT OF ENVIRONMENTAL NOISE IMPACT BY THE FRACTIONAL IMPACT METHOD

Adapted, in part, from Goldstein, J., "Assessing the Impact of Transportation Noise: Human Response Measures," Proceedings of the 1977 National Conference on Noise Control Engineering, G. C. Mailing (ed.), NASA Langley Research Center, Hampton, Virginia, 17-19 October 1977, pp. 79-98.

APPENDIX E

# ASSESSMENT OF ENVIRONMENTAL NOISE IMPACT BY THE FRACTIONAL IMPACT METHOD

Because noise is an extremely pervasive pollutant, it may adversely affect people in a number of different ways. Certain effects ae well documented. Noise can:

- o cause damange to the ear resulting in permanent hearing loss
- o interfere with spoken communication
- o disrupt or prevent sleep
- o be a source of annoyance.

Other effects of noise are less well documented but may become increasingly important as more information is gathered. They include the nonauditory health aspects as well as performance and learning effects. These affects are documented in the EPA levels document, reference E-1, which shows the basis for assessing the impact of noise exposure on the affected population.

## Distribution of Population and Noise Expsoure

An integral element of an environmental noise assessment is to determine or estimate the distribution of the exposed population to given levels of noise for given lengths of time. Thus, before implementing a project or action, one should first characterize the existing noise exposure distribution of the affected population by estimating the numbers of people exposed to differing magnitudes of noise. Next, for each project alternative, the distribution of people who would be exposed to the noise should be predicted or estimated. The relative environmental impacts of project alternatives may be assessed by comparing these population noise-exposure distributions.

Adapted, in part, from Goldstein, J., "Assessing the Impact of Transportation Noise: Human Response Measures," Proceedings of the 1977 National Conference on Noise Control Engineering, G. C. Mailing (ed.), NASA Langley Research Center, Hampton, Virginia, 17-19 October 1977, pp. 79-98.

This concept is illustrated in Figure E-1 which compares the estimated distribution of exposure for the population prior to inception of a hypothetical project (Curve a) with the population distribution after implementation of the project (Curve b). For each of these two statistical distributions, the numbers of people are plotted versus noise exposure (In the figure, $L_i$ represents a specific noise exposure in decibels on an arbitrary scale). The figure illustrates that the numbers of people at all comparisons of population exposure distributions allow us to determine the levels of noise exposure is greater after the hypothetical project (curve b) extent of noise impact in terms of changes in the number of people exposed to than before its inception (curve a).

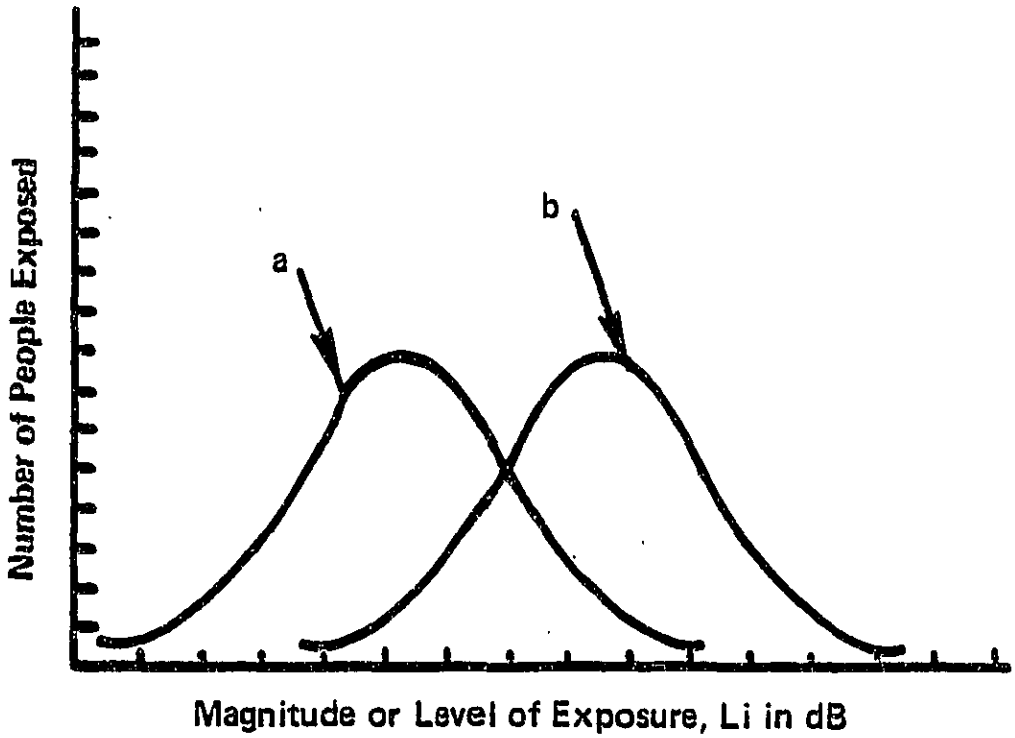


FIGURE E-1

EXAMPLE ILLUSTRATION OF THE NOISE DISTRIBUTION OF POPULATION AS A FUNCTION OF NOISE EXPOSURE

The intensity or severity of a noise expsosure may be evaluated by the use of suitable noise effects criteria, which exist in the form of statistically derived dose-response (or cause-effect) relationships. Using these criteria, the probability or magnitude of an anticipated effect can be predicted statistically from knowledge of the noise exposure. Examples of different forms of noise effects criteria are displayed in Figure E-2. In general, dose-response functions are plotted as simple linear or curvilinear relationships, or combinations thereof. The statistical probability or anticipated magnitude of an effect for a given noise expsorue can be estimated using the appropriate function. As an example, using the linear function in Figure E-2, the incidence of a specific response occurring within a population with a noise exposure value of $L_i$ as indicated by the veritical arrow would be predicted to be 50 percent.

Environmental noise impact may be assessed by cross-tabulating indices of both extent (number of people exposed) and intensity (severity) of impact. Such an assessment method requires an estimate of the impact upon the populations exposed at each given level, $L_i$, the proportional impact upon the exposed population may be seen by comparing the number of people exposed with the magnitude (or probability) of the anticipated response. The data may be expressed by using an array or matrix such as the hypothetical example in Table E-1.

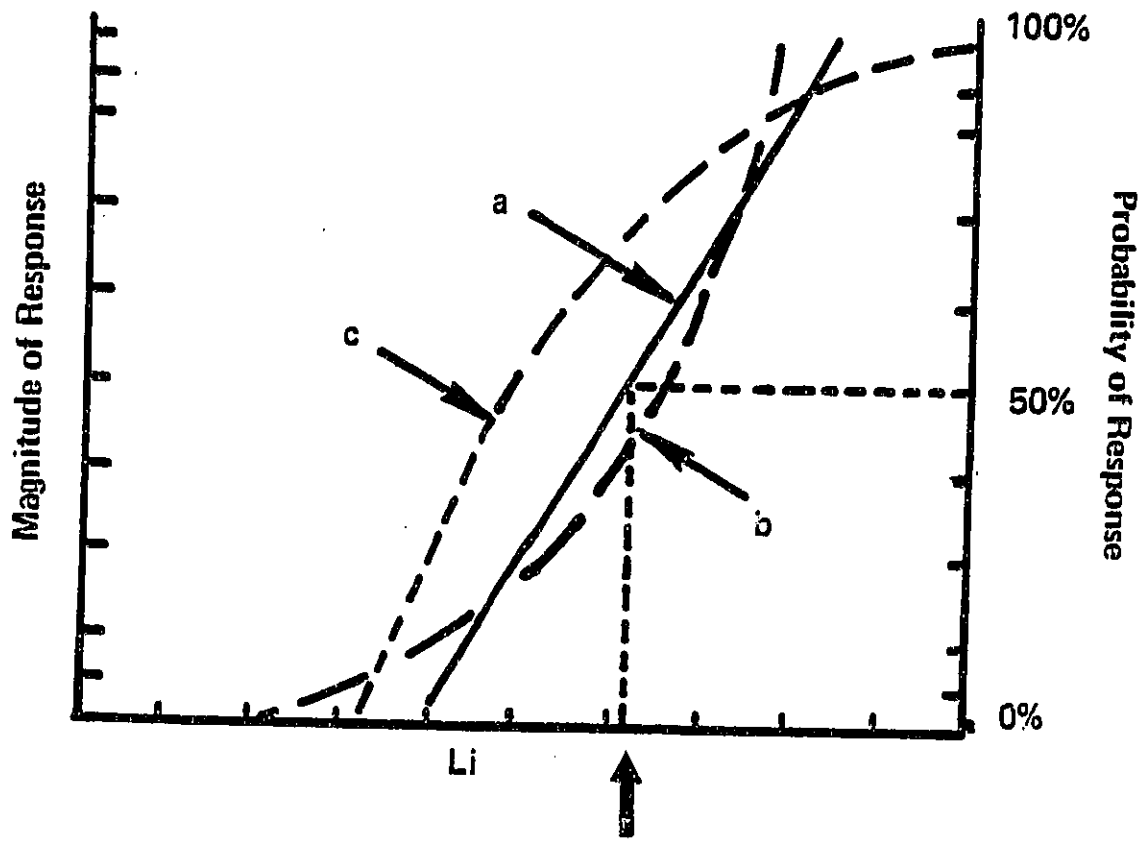


FIGURE E-2

EXAMPLE OF FORMS OF NOISE EFFECTS CRITERIA
(a) LINEAR, (b) POWER, (c) LOGARITHMIC

TABLE E-1

EXAMPLE OF IMPACT MATRIX FOR A HYPOTHETICAL SITUATION

| Exposure | Number of people | Magnitude or Probability of Response in Percent |
|---|---|---|
| $L_i$ | 1,200,000 | 4 |
| $L_{i+1}$ | 900,000 | 10 |
| $L_{i+2}$ | 200,000 | 25 |
| $L_{1+3}$ | 50,000 | 50 |
| . . . | | |
| $L_{i+n}$ | 2,000 | 85 |

Fractional Impact Method

An environmental noise assessment usually involves analysis, evaluation and comparison of several different planning alternatives. Comparing multiple arrays of population impact information is cumbersome, and consequently evaluating the relative effectiveness of each of the alternatives can become complex and confusing. The comparisons can be simplified by resorting to a single number scale which is a measure of the noise impact, correctly incorporating both attributes of extent and intensity of noise exposure.

The National Academy of Sciences, Committee on Bioacoustics and Biomechanics (CHABA), has recommended a procedure for assessing environmental noise impact which mathematically takes into account both extent and intensity of noise exposure (Reference E-2). This procedure is called the fractional impact method. It computes total noise impact by simply counting the number of people exposed to each level, multiplying this population number by a noise weighting, that is assigned to each noise level commensurate with the intensity of response to the noise exposure, and summing the results. This procedure yields a single number value which proports to represent the overall magnitude of the impact.

The purpose of the fractional impact analysis method is to obtain a single number that defines the impact of noise upon the population exposed. This, in turn, facilitates trade-off studies and comparisons of the impact between different projects or alternative solutions. To accomplish this objective, the fractional impact method defines a series of "partial noise impacts" within a number of neighborhoods or groups, each of which is exposed to a specified level of noise. The partial noise impact of each group is determined by multiplying the number of people in the group by the "fractional impact" of that associated with the noise exposure level of that group. In the CHABA procedure, the fractional impact is proportional to the probability or magnitude of an anticipated response based on statistically-derived dose-response functions. The total noise impact is then determined by simply summing the partial impacts of all groups (Reference E-2).

In many cases, much of the noise impact is found in large groups which have noise exposure of moderate severity. Although people living close to a noise source generally are more severely impacted than those living further away, the latter should not be excluded in evaluating noise impact.

People exposed to moderate levels of noise experience adverse impacts, even though that the magnitude of an individual's impact may be small. The fractional impact method considers the total impact upon all people exposed to noise taking into account that some individuals incur greater noise exposure than others, ascribing more importance to the more severely affected population.

To summarize, these are two basic elements of impact assessment. The impact of noise may be intensive (i.e., it may severely affect a few people) or extensive (i.e., it may affect a larger population less severely). Implicit in the fractional impact concept is that the magnitude of human response varies commensurately with the degree of noise exposure, i.e., the greater the exposure, the more significant the response. Another major assumption is that a moderate noise exposure for a large population has approximately the same noise impact upon the entire community as would a greater noise exposure upon a smaller number of people. Because the weightings which produce these results are not infalible information regarding the distribution of the population as a function of noise exposure should always be developed and presented in conjunction with use of the fractional impact method.

Mathematical Relationships for the Fractional Impact Method

The function for weighting the intensity of noise impact with respect to general adverse reaction (annoyance) is displayed in Figure E-3 (Ref. E-2). The curved (or nonlinear) weighting function is arbitrarily normalized to unity at $L_{dn}$ = 75 dB. For convenience of calculation, the weighting function may be expressed as representing percentages of impact in accordance with the following equation:

$$W(L_{dn}) = \frac{[3.364 \times 10^{-6}\ [10^{0.103\ L_{dn}}]}{[0.2]\ [10^{0.03\ L_{dn}}] + [1.43 \times 10^{-4}]\ [10^{0.08\ L_{db}}]} \qquad \text{(E-1)}$$

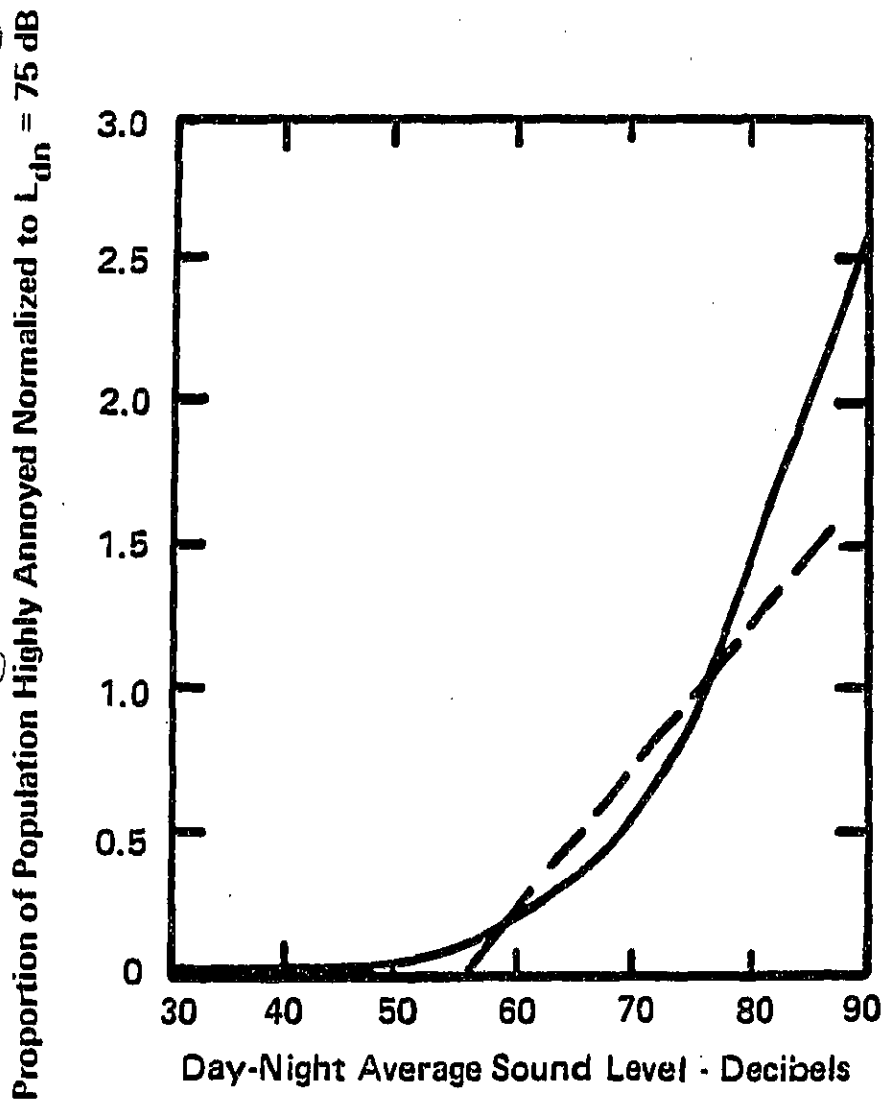


FIGURE E-3

WEIGHTING FUNCTION FOR ASSESSING
THE GENERAL ADVERSE RESPONSE TO NOISE

A simple linear approximation that is also normalized to unity at $L_{dn}$ = 75 dB can be used with reasonable accuracy in cases where day-night sound levels range between 55 and 80 dB. This approximation is shown as the dashed line in Figure E-3, and is defined as:

$$W(L_{dn}) = \begin{cases} 0.05\ (L_{dn} - 55) & \text{for } L_{dn} > 55 \\ 0 & \text{for } L_{dn} < 55 \end{cases} \qquad \text{(E-2)}$$

Using the fractional impact concept, an index referred to as the Level-Weighted Population (LWP)* may be derived by multiplying the number of people exposed to a given level of traffic noise by the fractional impact associated with that level as follows:

$$LWP_i = W(L_{dn}i) \times P_i \qquad \text{(E-3)}$$

where $LWP_i$ is the magnitude of the impact on the population exposed at $L_{dn}i$, $W(L_{dn}i)$ is the fractional impact (weighting) associated with a noise exposure of $L_{dn}i$, and $P_i$ is the number of people exposed to $L_{dn}i$.

Because a noise impact situation is characterized by a distribution of people exposed to different levels of noise, the magnitude of the total impact may be computed by determining the partial impact at each level and summing over each of the levels. This may be expressed as:

$$LWP = \sum_i LWP_i = \sum_i W(L_{dn}i) \times P_i \qquad \text{(E-4)}$$

The average severity of impact over the entire population may be stated in term of the Noise Impact Index (NII), defined as follows:

$$NII = \frac{LWP}{P_{total}} \qquad \text{(E-5)}$$

*Terms such as Equivalent Population (Peq), and Equivalent Noise Impact (ENI), have often been used interchangeably with LWP. The other indices are conceptually identical to the LWP notation.

In the case of general adverse response, NII represents the normalized percentage of total population who describe themselves as highly annoyed.

Another concept, the Relative Change in Impact (RCI) is useful for cmparing the relative difference between two alternatives. This concept takes the following form, when expressed as a percent change in impact:

$$RCI = 100 \frac{(LWP_i - LWP_j)}{LWP_i} \qquad \text{(E-6)}$$

where $LWP_i$ and $LWP_j$ are the calculated impacts under two different conditions.

A quantative example of the fractional impact method is presented in Table C-2.

## References


E-1. U.S. Environmental Protection Agency, "Information Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adqueate Margin of Safety." EPA Report 550/9-74-004, March 1971.

E-2. "Guidelines for Preparing Environmental Impact Statements on Noise," National Academy of Sciences, Committee on Bioacoustics and Biomechanics, Working Group Number 69, February, 1967.

APPENDIX F

# NATIONAL ROADWAY TRAFFIC NOISE EXPOSURE MODEL

This appendix contains a detailed discussion of the National Roadway Traffic Noise Exposure Model. The discussion begins with a general overrun, then proceeds to the date groups, the calculations, and assumptions that underlie the model and its process for connecting noise expsosure to impact.

The model accounts for the distribution of population throughout the United States, and matches each person to all the roadways within his own population/density cell, predicting his total noise from these roadways. The logic flow after model proceeds from vehicles, to roadways, to propagation, to the noise level experienced at each residential location in the United States. The analysis continues with the sorting of all person/noise pairs, and the conversion from noise levels to impact estimates. These impact estimates are then summed into total, nationwide impact.

Full details and expansions of this discussion are inlcuded in the single volume documentation report of the National Roadway Traffic Noise Exposure Model (Reference F-1).

## I. GENERAL OVERVIEW OF THE MODEL

The model consists of two parts: The General Adverse Response part and the Single Event Response part. These two parts of the model appear side-by-side in Figure F-1, to emphasize their similarity.

Both parts of the model start with user-defined input, keyed as $\lceil \underline{U} \rceil$ in the figure. For example, such input can include the potential emission limits for newly manufactured vehicles as they are typically operated.

Both parts of the model then mathematically combine this user-defined input with large quantitites of additional data that reside within the computer program. These additional data inlcude noise emissions of other vehicles, as well as traffic data, roadway configuration data, noise propagation data, and residential population data.*

Both parts of the model then combine these data to predict the particular noise levels of interest. The General Adverse Response part predicts the day-night noise level, $L_{dn}$, averaged over a full year. In a parallel manner, the Single Event Response part predicts both Sound Exposure Level, $L_s$ and the single-event Equivalent Sound Level, $L_{eq(T)}$, for each vehicle passby on a typical day during the year.

* The remainder of the discussion will not distinguish between user defined input and input data that resides within the program. See reference F-1 for further details.

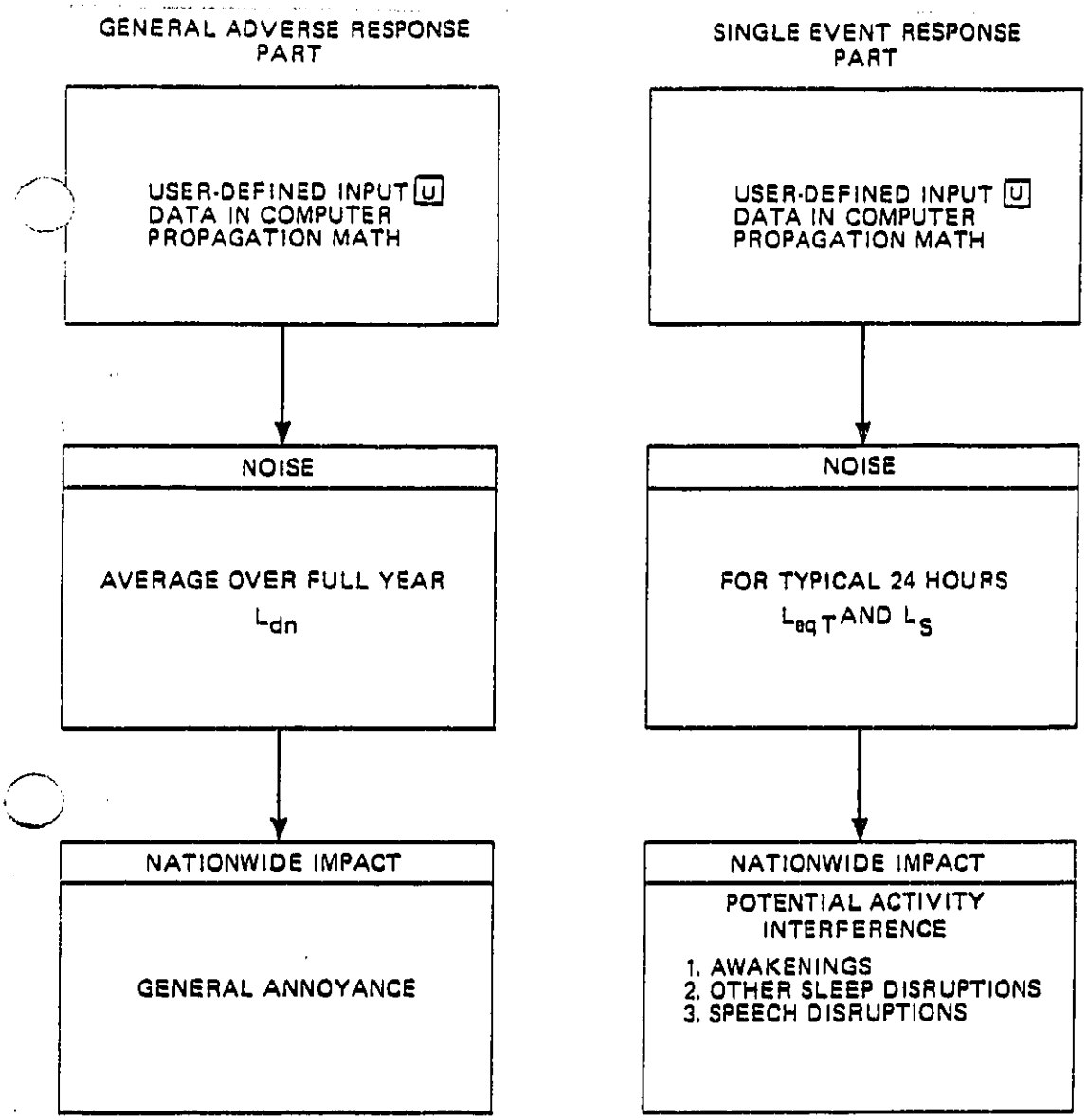


FIGURE F-1 THE NATIONAL ROADWAY TRAFFIC NOISE EXPOSURE MODEL

As discussed previously, the yearly-average noise level correlates well with noise-induced annoyance in and around the home -- that is, with a person's general adverse response. On the other hand, the noise from individual vehicles, not averaged into the ambient noise background due to other sources, often predicts additional impact due to particularly noisy or isolated single events.

As shown in the last module in Figure F-1, the model converts the computed noise levels into measures of estimated impact. The General Adverse Response part of the model estimates the extent to which people in the United States will be highly annoyed by traffic noise experienced at or near their homes. The Single Event part estimates the potential of a single noise source (in this case buses) to awaken people from sleep, to otherwise disrupt their sleep, and to interfere with people's speech at home, both indoors and outdoors.

In summary, the flow in Figure F-1 progresses from user-defined input, through the data and mathematics within the computer program, to the predicted noise levels -- and then estimates potential noise impacts. The two parts of the model estimate two different aspects of noise impact: yearly-average and single-event. Both aspects are estimated nationwide.

Overview of the Noise Exposure Predictions: General Adverse Response

Figure illustrates the manner in which noise predictions are made for the National Roadway Traffic Noise Exposure Model, for General Adverse Response. The figure is keyed (1) through (3) to coordinate with the detailed discussions to follow.

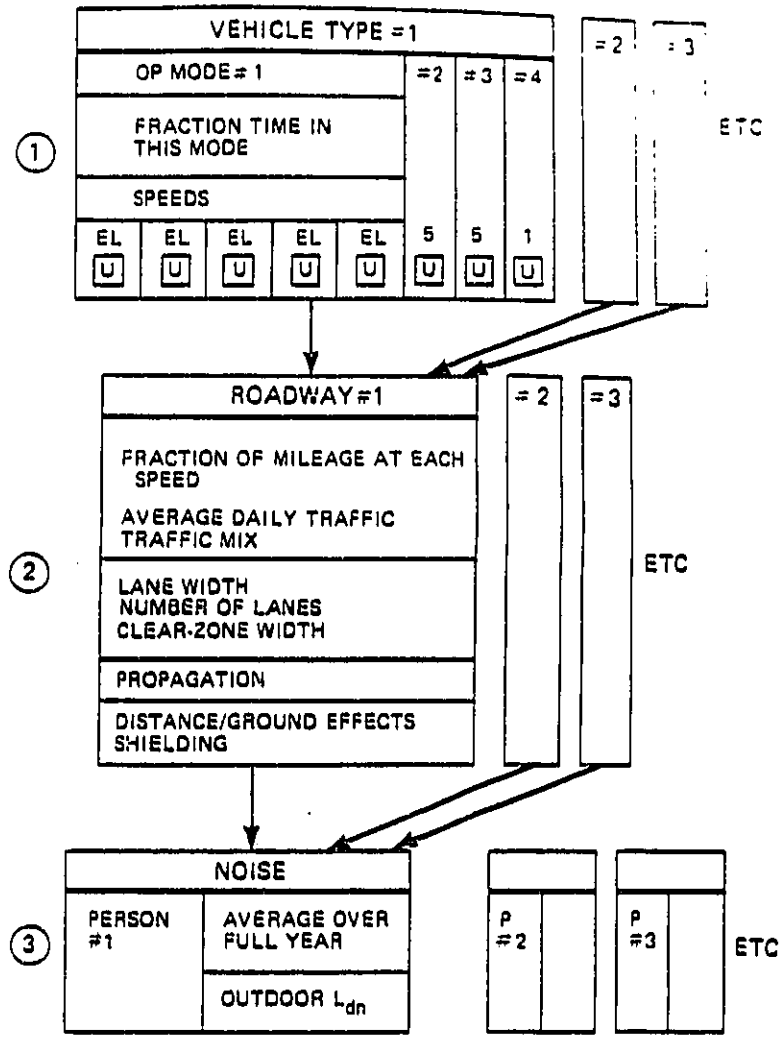


**FIGURE F-2 NOISE EXPOSURE PREDICTIONS: GENERAL ADVERSE RESPONSE**

EL IS THE NOISE EMISSION LEVEL. EACH OF THE 5 SPEED RANGES HAS A SPECIFIC EL ASSOCIATED WITH IT. IDLE MODE HAS ONLY ONE EL.

This predicative procedure is best explained by starting with key (3) which addresses the predicted noise exposure for Person #1. As shown in Figure F-2, noise exposures are predicated for Person #2, Person #3, etc. In essence, the model statistically predicts the noise for every person in the United States -- a 1974 total population of 216.7 million persons, and rising.

Rather than predicating the noise exposure of each individual, the computer groups people into homogeneous areas by city size and population density. Similar groupings occur throughout all blocks in Figure F-2 , though they are not indicated. The concepts involved in the prediction model are clearer without the details and approximations of grouping. These details and approximations are postponed for now.

In essence, then, the model statistically predicts the traffic noise environment experienced by everyone in the United States. The model does take into account population growth for future years.

The noise level at Person #1 emanates from <u>all</u> the roadways within his hearing. (Key (2) in Figure F-2 . Each roadway also has specified as input its average daily traffic and its average mix of vehicle types. Each roadway also has associated with it a large range of typical vehicle speeds. Although vehicle speeds vary on each roadway from moment to moment, the program considers their average speed for any given mile of roadway. The fractions of the total roadway mileage at each of five speed ranges are specific input used within the computer program, for each roadway.

In addition, each roadway has a specific lane width, a specific number of lanes, and a specific clear-zone width. The latter is generally the right-of-way width. It encloses the region within which no one lives.

Roadway noise, close by the roadway, is dependent upon vehicle speed, average daily traffic, traffic mix, lane width, number of lanes, and clear zone width. As this noise propagates outwards from the roadway to the person of interest, it is influenced by a number of propagation parameters. Two principal parameters are the distance between the person and the roadway, and the shielding that intervenes between the person and the roadway. These two parameters are specified for each person/roadway pair -- in groupings, as mentioned above.

From Key (3) to Key (2) the noise level at each person's residence depends upon the source strength of each roadway, and upon the propagation of the noise from the roadway.

In addition to the above parameters, roadway source strength also depends in part, on a number of other factors. As noted in Key (1) each roadway contains a series of vehicle types. Each vehicle type operates in four modes, numbered in the Figure. These modes are: acceleration, deceleration, cruise and idle. Each vehicle spends a definite fraction of its time in each of the four modes. These fractions are specified for each operating mode and separately for each vehicle type. Then each mode fraction is split into the five speed fractions specific to that roadway (Key (2) again).

The final entries at Key (1) are the noise emission levels. These differ for each of the four operating modes, and for each of the five speeds. These emission levels are a user-defined input, and are keyed therefore as [U] in the Figure. Specifically, the user defines the noise emission levels for new vehicle sales in any given year. Then the computer adds those vehicles to the ones already on the road, and depletes the general population of vehicles by those vehicles that retire from service.

The noise emission values put into the model constitute the mechanism by which we can investigate consequences (impacts) of a potential vehicle noise emission regulation. The model is applied for successive years, as more and more of the quieter vehicles are introduced into service. The year-to-year effect on predicted noise impact is a direct measure of the effectiveness of a regulation. (Figure F-2 does not indicate this year-to-year application.)

In practice, then, Figure F-2 flows from top to bottom. For the regulated vehicle type, emission levels corresponding to the regulatory levels are entered, separately for the four operating modes and separately for the five speed ranges within each operating mode (except idle). As shown in Figure F-2. sixteen values of emission level are entered for each vehicle type.

These emissions are combined with the fractions of time spent by that vehicle type in each mode/speed, to obtain that vehicle's contribution to the traffic noise. The computer carries out these calculations for each vehicle type on that roadway. Then all vehicles are combined for Roadway #1, according to the average daily traffic and vehicle mix.

This process is repeated for each roadway type.

Each roadway's noise is then propagated to each person's residence. At each residence the noise levels from all roadways are combined into one total noise level.

This entire process is repeated for all persons in the United States (approximated by residential population density information), as shown to the right at Key (3) in Figure F-2.

Overview of the Noise Exposure Predictions: Single Event Response

Figure F-3 illustrates noise prediction flow chart for the Single Event Response portion of the model. Differences between Figure 6-10 and Figure F-3 are few, but important. Here, only one vehicle type or class is examined at a time, since only its passby noise is assessed.

Key (1) data requirements are identical to the General Adverse Response portion of the model.

At Key (2) , only the average daily traffic for that vehicle type is required, rather than the full traffic and vehicle mix. Also at Key (2) , building noise isolation values are needed to propagate the noise from outdoors to indoors. These building noise isolation values are specified inputs.

The major differences between the Single Event and General Adverse Response portions of the model occur at Key (3) . For each person, the single-event equivalent sound level, $L_{eq(T)}$, is computed for indoors, both day and night, and for outdoors, day only. These predictions then apply to the fraction of time the average person is at home day/night and indoors/outdoors. In addition, the sound exposure level, $L_s$, is computed for indoors, both day and night -- and then applied to the fraction of time that person is asleep, either day or night.

Key (3) summarizes the types of noise calculations made.

Overview of Noise Impact Estimates: General Adverse Response

The flow chart for noise impact estimates of the General Adverse Response portion of National Roadway Traffic Noise Exposure Model is presented in Figure F-4 . The Figure is keyed (3) through (6) , to coordinate with the discussions.

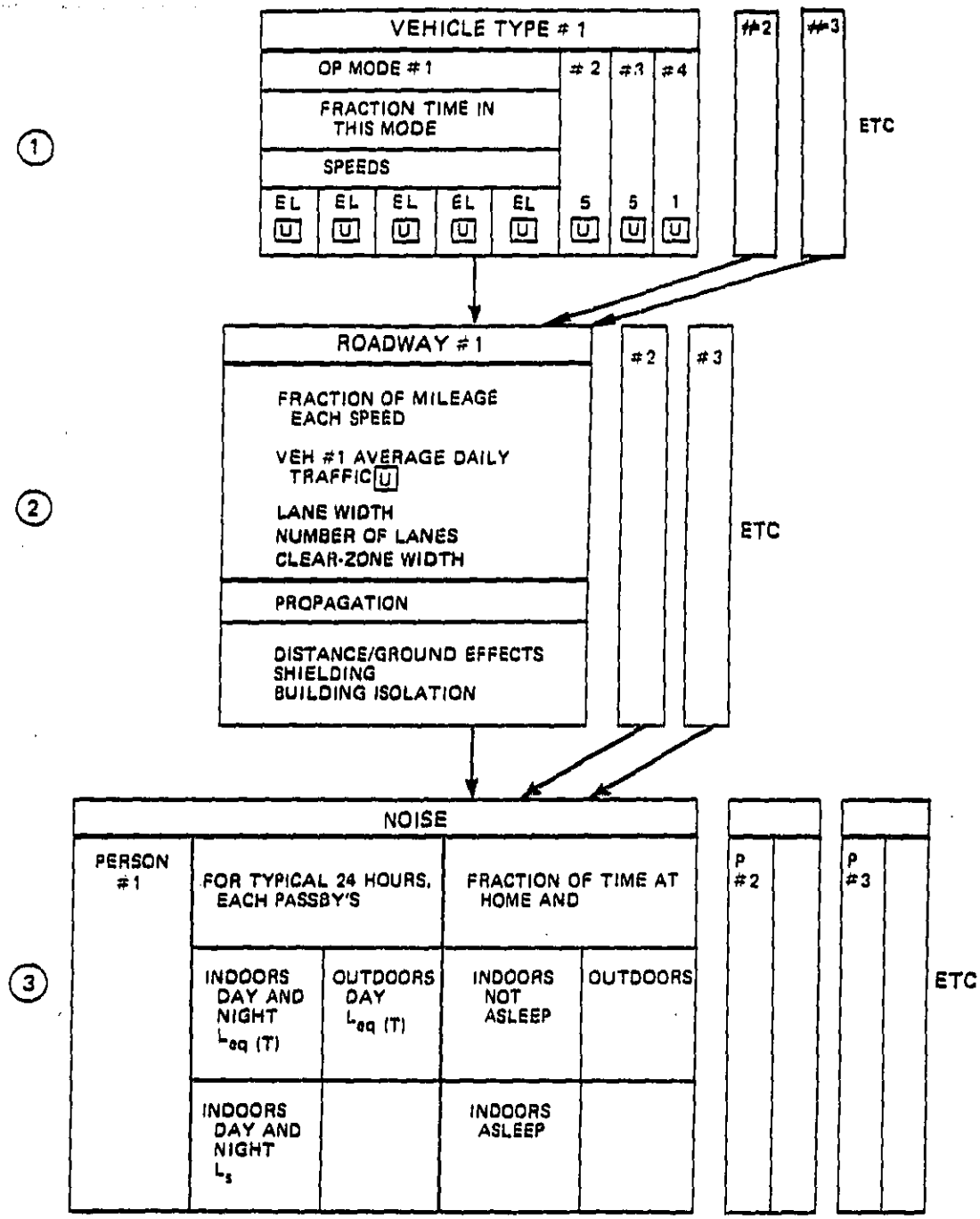


FIGURE F-2 NOISE PREDICTIONS: SINGLE EVENT RESPONSE

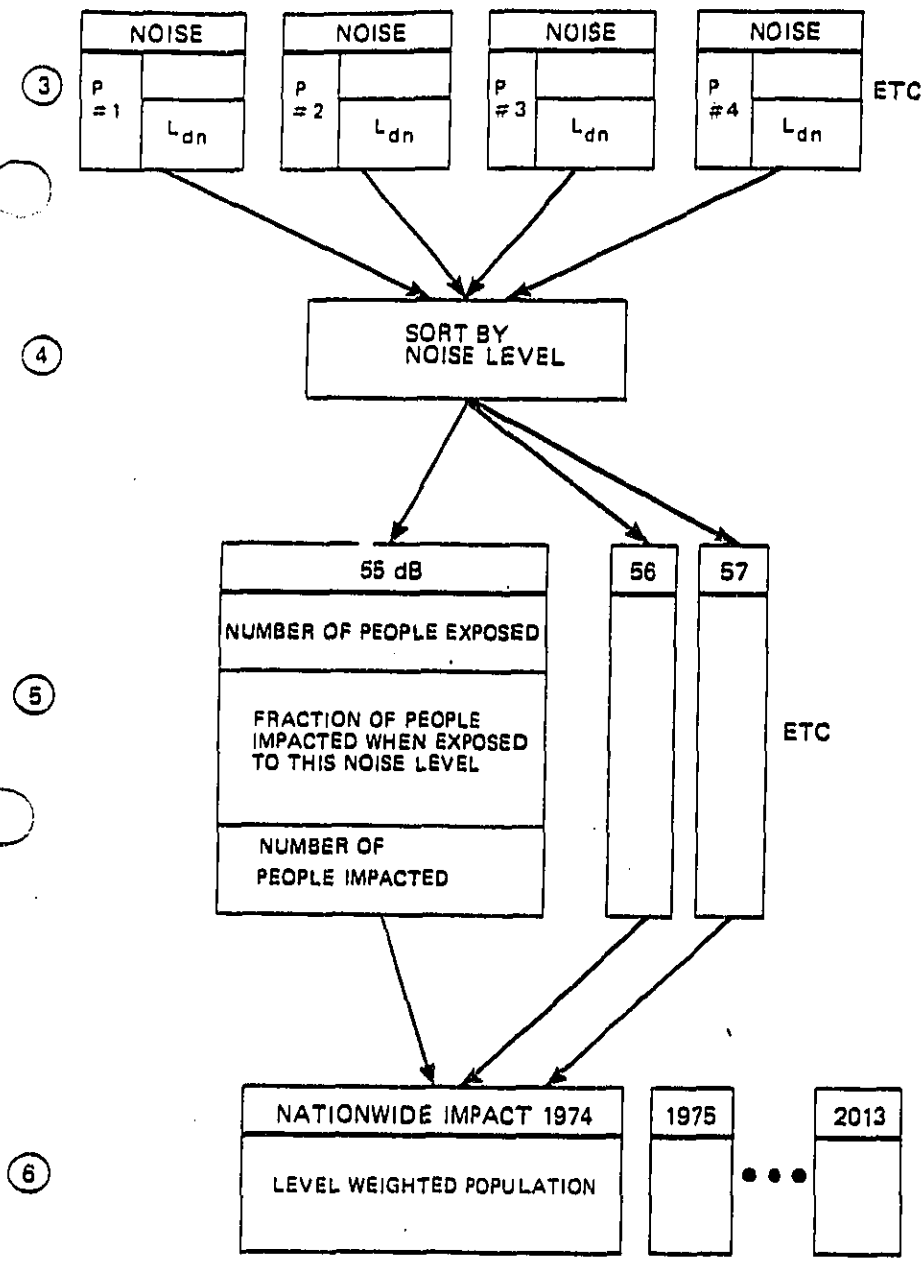


FIGURE F-3 NOISE IMPACT ESTIMATES: GENERAL ADVERSE RESPONSE

The top set of modules, Key (3) duplicates the bottom set in Figure F-2. It consists of all the person/noise pairs for the entire United States, as predicted by the model.

At Key (4), this very large set of person/noise pairs is sorted by noise level. For example, all the persons in the U.S. exposed to an outdoor $L_{dn}$ of 55 dB are grouped together in this sorting process. The next set of boxes (top of Key (5)) results.

The top of each module in Key (5) contains all the persons exposed to that particular noise level. Noise impact is calculated by multiplying the number of people exposed at each noise level by the fractions next shown in the Figure (middle of Key (5)). These are the fractional weighting values used to represent the number of people expected to be highly annoyed by that particular noise level. (See the subsection entitled "HEALTH AND WELFARE CRITERIA - GENERAL ADVERSE RESPONSE" for explanation of the fractional weighting values.) These fractions are essentially zero at 55 dB, and increase to nearly unity around 75 dB.

To complete the mathematics at Key (5), the number of people exposed times the appropriate fraction or weighting equals the Level Weighted Population (LWP) for General Adverse Response (equation 8) for each noise exposure band. For example, if 28,000 people are exposed to an $L_{dn}$ of 60 dB, then this number of people, times the fraction 0.25, yields an LWP of 7,000. This number shows that not everyone is impacted to the same degree primarily because some may be less susceptible to noise intrusion. These fractions summarize, therefore, the variability among all persons in their reactions to the same noise level.

As the final step in the impact estimate (Key (6)), the expected impacts at each exposure level are added to obtain the total expected impact in the

United States. The resulting number is the total Level Weighted Population (LWP). It combines population and noise level into a single impact value.

Also at Key (6) in Figure F-4 are the impact estimates for the remainder of the 40-year time stream. As more and more of the quieter vehicles are introduced into service, the estimated impact should drop. The change in this impact from year-to-year is a direct measure of the regulation's benefit.

To rerun the program for subsequent years, additional noise emission values must be entered. The computer will then add these quieter vehicles to the ones already on the road, and will deplete the general population of vehicles by those vehicles that retire from service. These sales and depletion rates reside in the computer. In addition, the model also accounts for changes in United States population each year.

Overview of Noise Impact Estimates: Single Event Response

Figure F-5 illustrates the logic flow that provides impact estimates for the Single Event Response portion of the model. Differences between Figure F-4 and Figure F-5 are minor. Here, each person is exposed not just to one noise level, but to a series of single-event noise levels that occur over a typical 24 hour period. In other words, each person is paired with many noise levels, each predicted as described earlier. After sorting, then, the tabulation of Key (5) is not of persons, but is of noise events. A single person will be exposed to many noise events, all sorted by noise level.

The fractions in Key (5) are the fractions (or probability) of these single events that are expected to actually impact the person who is exposed. The measures used represent the potential to awaken people from sleep, or otherwise to disrupt sleep, or to interfere with one's speech communications. (See the subsection entitled "HEALTH AND WELFARE CRITERIA - SINGLE EVENT RESPONSE" for explanation of the fractions).

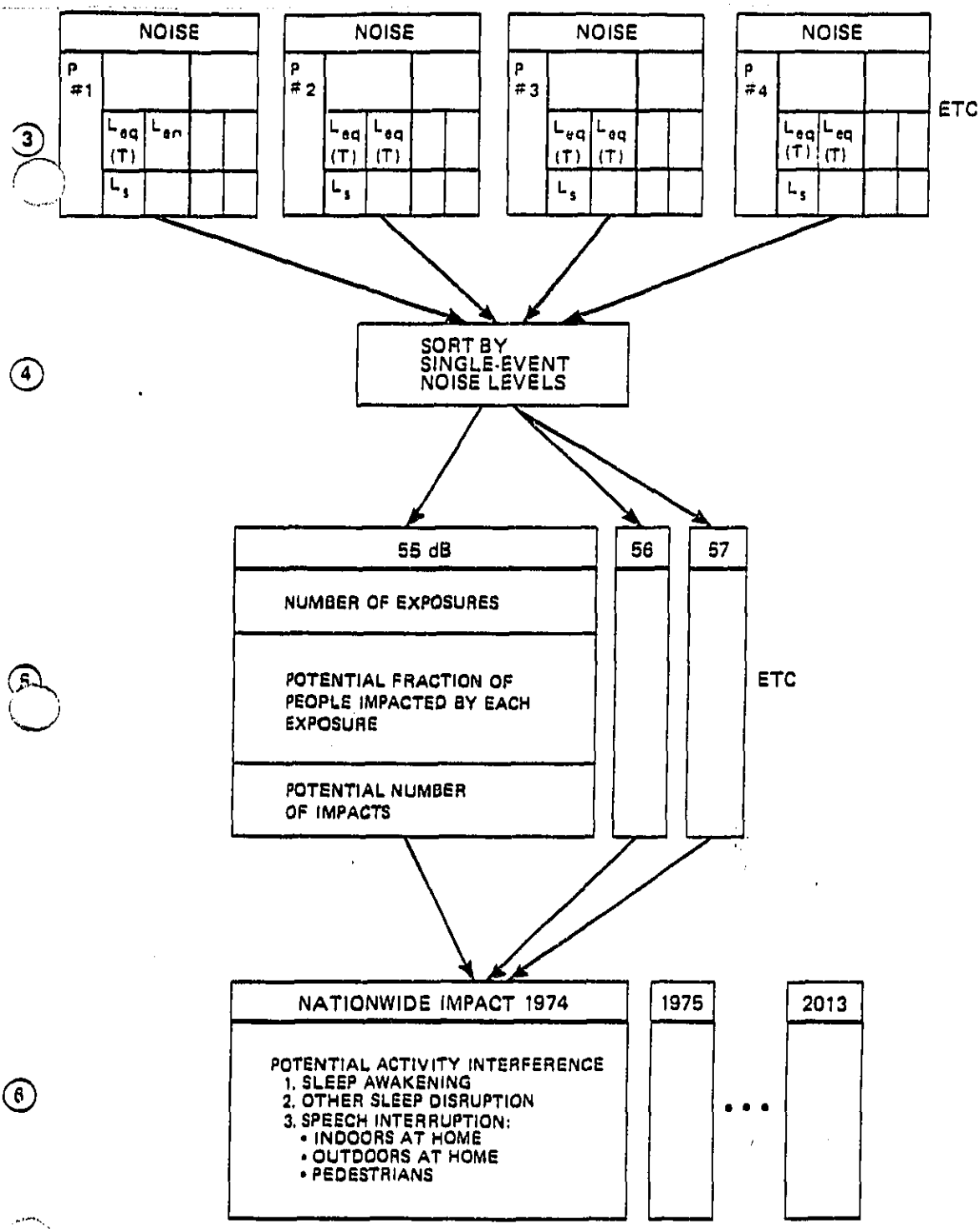


FIGURE F-5 NOISE IMPACT ESTIMATES: SINGLE EVENT RESPONSE

separately.

II. DATA GROUPS

As mentioned earlier, the computer program groups much of its data. Such grouping occurs throughout all modules in Figures F-2 and F-3 though grouping is not indicated in either figure.

The grouping of data within the model appear in Table F-1 for:

- The 14 vehicle types
- The 4 operating modes
- The 5 speed ranges
- The 6 roadway types
- The 9 population groups
- The 4 population/density groups
- The 33 population/density "cells"
- The 40 years of the time stream

Vehicle types were selected based on those used for all EPA studies of roadway noise. They are strongly suggested by similarity in noise emission within a type, due to similarity in engineering or operational characteristics.

Operating modes are based upon extensive vehicle noise tests and appropriate data reduction methods (References F-2 to F-4). Speed ranges are based upon these same tests.

Roadway types are the functional categories of the Federal Highway Administration (Reference F-5).

Population groups are based on the data base assembled by the Federal Highway Administration (References F-5 to F-7), and were refined using 1970 census

TABLE F-1 DATA GROUPS WITHIN THE MODEL

| PARAMETER | GROUP NAME | TYPE DESCRIPTION |
|---|---|---|
| Vehicle Types | Car/8/automatic | Passenger car, 8 cylinder, gas, automatic |
| | Car/6/automatic | Passenger car, 6 cylinder, gas, automatic |
| | Car/manual | Passenger car, 6 or 8 cylinder, gas, manual |
| | Car–LT/auto | Passenger car and light truck, 4 cylinder, gas, automatic |
| | Car–LT/manual | Passenger car and light truck, 4 cylinder, gas, manual |
| | LT | Light truck, 6 and 8 cylinder, gas |
| | Car–LT/diesel | Passenger car and light truck, diesel |
| | MT | Medium truck, two axle (GVWR 10,000 lb) |
| | HT | Heavy truck, three or more axles (GVWR 26,000 lb) |
| | Intercity bus | Intercity bus |
| | Transit bus | Transit bus |
| | School bus | School bus |
| | Unmod MC | Unmodified motorcycle |
| | Mod MC | Modified motorcycle |
| Operating Modes | Acceleration | Acceleration from zero to speed "S" |
| | Deceleration | Deceleration from speed "S" to zero |
| | Cruise | Cruise at speed "S" |
| | Idle | Idle |
| Speed Ranges | 20 mph | Less than 25 mph |
| | 30 mph | Between 25 and 35 mph |
| | 40 mph | Between 35 and 45 mph |
| | 50 mph | Between 45 and 55 mph |
| | 60 mph | More than 55 mph |
| Roadway Types | Interstate Highways | Per FHWA definition |
| | Freeways and Expressways | Per FHWA definition |
| | Major Arterials | Per FHWA definition |
| | Minor Arterials | Per FHWA definition |
| | Collectors | Per FHWA definition |
| | Local Roads and Streets | Per FHWA definition |
| Population Groups | Population over 2M | |
| | 1M to 2M | |
| | 500K to 1M | |
| | 200K to 500K | |
| | 100K to 200K | |
| | 50K to 100K | |
| | 25K to 50K | |
| | 5K to 25K | |
| | Rural areas | |

TABLE F-2 DATA GROUPS WITHIN THE MODEL (CONTINUED)

| PARAMETER | GROUP NAME | TYPE DESCRIPTION |
|---|---|---|
| Population Density Groups | 1. High | More than 4,499 people per square mile |
| | 2. Medium–to–High | 3,000 to 4,499 people per square mile |
| | 3. Low–to–Medium | 1,500 to 2,999 people per square mile |
| | 4. Low | Less than 1,500 people per square mile |
| Pop/density "cells" | 1 | Population over 2M, high density |
| | 2 | Same, medium–to–high density |
| | 3 | Same, low–to–medium density |
| | 4 | Same, low density |
| | 5 | 1M to 2M, high density |
| | 6 | Same, medium–to–high density |
| | 7 | Same, low–to–medium density |
| | 8 | Same, low density |
| | 9 | 500K to 1M, high density |
| | 10 | Same, medium–to–high density |
| | 11 | Same, low–to–medium density |
| | 12 | Same, low density |
| | ... | |
| | 29 | 5K to 25K, high density |
| | 30 | Same, medium–to–high density |
| | 31 | Same, low–to–medium density |
| | 32 | Same, low density |
| | 33 | Rural, low density only |
| Years | 1974 | For prediction of future impact |
| | 1975 | |
| | 1976 | |
| | 1977 | |
| | . | |
| | . | |
| | . | |
| | 2013 | |

data (Reference F-8). Population density groups were also based upon these same Federal Highway Administration and census publications.

These two latter groups are then combined into pop/density "cells" shown next in Table F-1. Thirty-three of these pop/density "cells" result, since the rural population group is paired with only the low-density group. These pop/density "cells" contain among them the entire U.S. population and also the entire U.S. roadway mileage. They therefore provide the structure for matching each person in the United States with the roadways that produce the noise at his residence.

Lastly, Table F-1 shows that calculations are performed for all years withinb a 40-year time stream. A baseline year is selected.* For that year, all data (such as traffic counts, roadway mileage, population densities) are explicitly put into the computer program. Then for future years, these data are factored upward, if appropriate, to account for growth.

The data groups within Table F-1 interrelate within the model in complex ways as discussed in the following more detailed discussions.

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* For this analysis, much of the data was entered for 1974. These data were applied to later years after suitably adjusting for growth.

Details of Vehicles (Figures F-2 and F-3, Key (1)).

The model contains 14 vehicle types, listed in Table F-1. For each of these vehicle types, the model uses for computation a set of noise emission levels (ELs) that reflect operating modes, speed, and selected years. Noise emission levels may also be entered for the regulated vehicle of interest (or other vehicle types, if appropriate).

A vehicle's emission level is a measure of its total noise output. Technically, it is the noise level measured at a position perpendicular to the side of the vehicle and at a distance of 50 feet.

The vehicle emission level is a function of vehicle type, operating mode, and vehicle speed.

$$\text{Emission levels} = f(\text{vehicle type}_{\to 14},\ \text{operating mode}_{\to 4},\ \text{speed}_{\to 5},\ \text{year}_{\to \text{base year + 4 user-chosen years}}) \qquad \text{(F-1)}$$

Equation D-1 shows the functional relationship between emission levels and the parameters upon which emissions depend. In other words, the noise emissions vary for each of the 14 vehicle types; for each vehicle type, noise varies for each of the 4 operating modes; and for each mode, noise varies for each of the 5 grouped speeds. Since the idle mode has only one speed (zero), this functional relationship yields 16 emission levels for each vehicle type, for a total of 224 emission levels.

These 224 emission levels are used to describe the average emissions of each type of vehicle operating on roadways in specified years.

The complete set of emission levels used within this regulatory analysis appear in Table F-2 (Reference F-9). Each of the noise emission values in this table representes an energy-average level. The energy average represents a time average of the time-varying emissions for vehicles accelerating and decelerating. In addition, each energy average emission level is derived from a level-average emission level and a standard deivation, $\sigma$, of the level about that average. It is assumed that the scatter of levels among all the vehicles of each vehicle type is Gaussian, and thus the energy-average emission level is computed as (Reference F-10):

$$\text{Energy-average EL} = \text{Level-average EL} + 0.115\,\sigma^2 \qquad \text{(F-2)}$$

Again, as indicated in equation F-2, sixteen emission levels are defined for each vehicle for each of four selected years.

In each year of interest, the model adds new vehicle sales to the vehicles already on the road, and depletes the general population of vehicles by those that retire from service. Only the new vehicles added each year are built to the reduced emission standard. For example, new trucks added for the years 1975 through 1977 would have 1974-value noise emissions, while those introduced during 1978 to 1986 will have reduced noise emissions as shown by the 1978 column. Trucks added in later years would have the reduced noise emissions given in the 1986 column unless the model were operated in a mode that assumed otherwise.

TABLE F-2

BASELINE VEHICLE NOISE EMISSION DATA*
(Source: Reference F-9)

Type 1: Car/8-Cylinder/Automatic

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 0-20 MPH | 59.60 | | | | |
| 0-30 | 61.50 | | | | |
| 0-40 | 63.10 | | | | |
| 0-50 | 64.90 | | | | |
| 0-60 | 66.80 | | | | |

| Deceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 20-0 MPH | 50.50 | | | | |
| 30-0 | 56.10 | | | | |
| 40-0 | 60.10 | | | | |
| 50-0 | 63.20 | | | | |
| 60-0 | 65.80 | | | | |

| Cruise Mode | | | | | |
|---|---|---|---|---|---|
| <25 MPH | 59.80 | | | | |
| 25-34 | 62.40 | | | | |
| 35-44 | 66.40 | | | | |
| 45-54 | 69.50 | | | | |
| >55 | 72.00 | | | | |

| Idle Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| | 46.00 | | | | |

Type 2: Car/6-Cylinder/Automatic

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 0-20 MPH | 60.80 | | | | |
| 0-30 | 62.50 | | | | |
| 0-40 | 63.90 | | | | |
| 0-50 | 65.50 | | | | |
| 0-60 | 67.10 | | | | |

| Deceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 20-0 MPH | 50.50 | | | | |
| 30-0 | 56.10 | | | | |
| 40-0 | 60.10 | | | | |
| 50-0 | 63.20 | | | | |
| 60-0 | 65.80 | | | | |

| Cruise Mode | | | | | |
|---|---|---|---|---|---|
| <25 MPH | 59.80 | | | | |
| 25-34 | 62.40 | | | | |
| 35-44 | 66.40 | | | | |
| 45-54 | 69.50 | | | | |
| >550 | 72.00 | | | | |

| Idle Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| | 46.00 | | | | |

*Levels at 50 feet from vehicle

(Al[illegible]-2 cont.)

Type 3: Car/6-Cylinder/Manual

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 0-20 MPH | 60.30 | | | | |
| 0-30 | 62.50 | | | | |
| 0-40 | 64.00 | | | | |
| 0-50 | 65.60 | | | | |
| 0-60 | 67.20 | | | | |
| **Deceleration Mode** | | | | | |
| Years> | 1974 | | | | |
| 20-0 MPH | 50.50 | | | | |
| 30-0 | 56.10 | | | | |
| 40-0 | 60.10 | | | | |
| 50-0 | 63.20 | | | | |
| 60-0 | 65.80 | | | | |
| **Cruise Mode** | | | | | |
| <25 MPH | 59.80 | | | | |
| 25-34 | 62.40 | | | | |
| 35-44 | 66.40 | | | | |
| 45-54 | 69.50 | | | | |
| >55 | 72.00 | | | | |
| **Idle Mode** | | | | | |
| Years> | 1974 | | | | |
| | 46.00 | | | | |

Type 4: Car and Light Truck/4-Cylinder/Automatic

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 0-20 MPH | 62.90 | | | | |
| 0-30 | 64.30 | | | | |
| 0-40 | 65.40 | | | | |
| 0-50 | 66.60 | | | | |
| 0-60 | 68.00 | | | | |
| **Deceleration Mode** | | | | | |
| Years> | 1974 | | | | |
| 20-0 MPH | 50.50 | | | | |
| 30-0 | 56.10 | | | | |
| 40-0 | 60.10 | | | | |
| 50-0 | 63.20 | | | | |
| 60-0 | 65.80 | | | | |
| **Cruise Mode** | | | | | |
| <25 MPH | 59.80 | | | | |
| 25-34 | 62.40 | | | | |
| 35-44 | 66.40 | | | | |
| 45-54 | 69.50 | | | | |
| >550 | 72.00 | | | | |
| **Idle Mode** | | | | | |
| Years> | 1974 | | | | |
| | 46.00 | | | | |

TABLE F-2 (cont.)

Type 5: Car and Light Truck/4-Cylinder/Manual

| Acceleration Mode | |
|---|---|
| Years> | 1974 |
| 0-20 MPH | 62.60 |
| 0-30 | 64.60 |
| 0-40 | 65.90 |
| 0-50 | 67.30 |
| 0-60 | 68.70 |

| Deceleration Mode | |
|---|---|
| Years> | 1974 |
| 20-0 MPH | 51.70 |
| 30-0 | 57.30 |
| 40-0 | 61.30 |
| 50-0 | 64.40 |
| 60-0 | 67.00 |

| Cruise Mode | |
|---|---|
| Years> | 1974 |
| <25 MPH | 61.00 |
| 25-34 | 63.60 |
| 35-44 | 67.60 |
| 45-54 | 70.70 |
| >55 | 73.20 |

| Idle Mode | |
|---|---|
| Years> | 1974 |
| | 46.00 |

Type 6: Light Truck/6-Cylinder

| Acceleration Mode | |
|---|---|
| Years> | 1974 |
| 0-20 MPH | 63.30 |
| 0-30 | 65.10 |
| 0-40 | 66.50 |
| 0-50 | 68.20 |
| 0-60 | 69.90 |

| Deceleration Mode | |
|---|---|
| Years> | 1974 |
| 20-0 MPH | 53.40 |
| 30-0 | 59.00 |
| 40-0 | 63.00 |
| 50-0 | 66.10 |
| 60-0 | 68.70 |

| Cruise Mode | |
|---|---|
| Years> | 1974 |
| <25 MPH | 62.70 |
| 25-34 | 65.30 |
| 35-44 | 69.30 |
| 45-54 | 72.40 |
| >550 | 74.90 |

| Idle Mode | |
|---|---|
| Years> | 1974 |
| | 46.00 |

TABLE F-2 (cont.)

Type 7: Car and Light Truck/Diesel

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | | | | |
| 0-20 MPH | 65.30 | | | | |
| 0-30 | 66.70 | | | | |
| 0-40 | 67.50 | | | | |
| 0-50 | 68.40 | | | | |
| 0-60 | 69.40 | | | | |
| **Deceleration Mode** | | | | | |
| Years> | 1974 | | | | |
| 20-0 MPH | 52.30 | | | | |
| 30-0 | 57.90 | | | | |
| 40-0 | 61.90 | | | | |
| 50-0 | 65.00 | | | | |
| 60-0 | 67.60 | | | | |
| **Cruise Mode** | | | | | |
| Years> | 1974 | | | | |
| <25 MPH | 61.60 | | | | |
| 25-34 | 64.20 | | | | |
| 35-44 | 66.20 | | | | |
| 45-54 | 71.30 | | | | |
| >55 | 73.80 | | | | |
| **Idle Mode** | | | | | |
| Years> | 1974 | | | | |
| | 46.00 | | | | |

Type 8: Medium Trucks

| Acceleration Mode | | | | | |
|---|---|---|---|---|---|
| Years> | 1974 | 1978 | 1986 | | |
| 0-20 MPH | 75.10 | 75.10 | 74.80 | | |
| 0-30 | 75.60 | 75.60 | 75.30 | | |
| 0-40 | 76.20 | 76.20 | 75.90 | | |
| 0-50 | 76.80 | 76.80 | 76.60 | | |
| 0-60 | 77.70 | 77.70 | 77.50 | | |
| **Deceleration Mode** | | | | | |
| Years> | 1974 | 1978 | 1986 | | |
| 20-0 MPH | 65.80 | 65.80 | 65.50 | | |
| 30-0 | 70.00 | 70.00 | 69.80 | | |
| 40-0 | 73.00 | 73.00 | 72.70 | | |
| 50-0 | 75.10 | 75.10 | 74.90 | | |
| 60-0 | 76.80 | 76.80 | 76.70 | | |
| **Cruise Mode** | | | | | |
| Years> | 1974 | 1978 | 1986 | | |
| <25 MPH | 77.20 | 77.20 | 76.90 | | |
| 25-34 | 77.20 | 77.20 | 76.90 | | |
| 35-44 | 78..10 | 78.10 | 77.90 | | |
| 45-54 | 80.20 | 80.20 | 80.00 | | |
| >55 | 81.70 | 81.70 | 81.60 | | |
| **Idle Mode** | | | | | |
| Years> | 1974 | 1978 | 1986 | | |
| | 54.00 | 54.00 | 54.00 | | |

TABLE F-2 (cont.)

Type 9: Heavy Trucks

| Acceleration Mode | | | |
|---|---|---|---|
| Years> | 1974 | 1978 | 1986 |
| 0-20 MPH | 82.70 | 78.90 | 75.90 |
| 0-30 | 82.80 | 79.10 | 76.30 |
| 0-40 | 83.00 | 79.60 | 77.10 |
| 0-50 | 83.40 | 80.40 | 78.40 |
| 0-60 | 84.00 | 81.50 | 80.10 |

| Deceleration Mode | | | |
|---|---|---|---|
| Years> | 1974 | 1978 | 1986 |
| 20-0 MPH | 73.90 | 70.20 | 67.50 |
| 30-0 | 77.30 | 73.90 | 71.40 |
| 40-0 | 79.60 | 76.50 | 74.40 |
| 50-0 | 81.40 | 78.60 | 77.00 |
| 60-0 | 82.70 | 80.40 | 79.10 |

| Cruise Mode | | | |
|---|---|---|---|
| Years> | 1974 | 1978 | 1986 |
| <25 MPH | 83.60 | 79.80 | 77.00 |
| 25-34 | 83.40 | 80.00 | 77.70 |
| 35-44 | 84.20 | 81.50 | 79.90 |
| 45-54 | 85.70 | 83.70 | 82.60 |
| >55 | 86.80 | 85.60 | 85.00 |

| Idle Mode | | | |
|---|---|---|---|
| Years | 1974 | 1978 | 1986 |
| | 63.00 | 60.00 | 57.00 |

Type 10: Intercity Buses

| Acceleration Mode | |
|---|---|
| Years> | 1974 |
| 0-20 MPH | 81.60 |
| 0-30 | 82.00 |
| 0-40 | 82.30 |
| 0-50 | 82.60 |
| 0-60 | 82.80 |

| Deceleration Mode | |
|---|---|
| Years> | 1974 |
| 20-0 MPH | 68.10 |
| 30-0 | 71.40 |
| 40-0 | 73.80 |
| 50-0 | 75.60 |
| 60-0 | 77.10 |

| Cruise Mode | |
|---|---|
| Years> | 1974 |
| <25 MPH | 76.00 |
| 25-34 | 76.00 |
| 35-44 | 78.40 |
| 45-54 | 80.20 |
| >55 | 81.70 |

| Idle Mode | |
|---|---|
| Years> | 1974 |
| | 62.00 |

F-2 (cont.)

Type 11: Transit Buses

| Acceleration Mode | |
|---|---|
| Years> | 1974 |
| 0-20 MPH | 81.00 |
| 0-30 | 81.00 |
| 0-40 | 81.10 |
| 0-50 | 81.20 |
| 0-60 | 81.50 |

| Deceleration Mode | |
|---|---|
| Years> | 1974 |
| 20-0 MPH | 63.70 |
| 30-0 | 67.80 |
| 40-0 | 70.60 |
| 50-0 | 72.90 |
| 60-0 | 74.70 |

| Cruise Mode | |
|---|---|
| Years> | 1974 |
| <25 MPH | 73.00 |
| 25-34 | 73.00 |
| 35-44 | 75.80 |
| 45-54 | 78.10 |
| >55 | 79.90 |

| Idle Mode | |
|---|---|
| Years> | 1974 |
| | 58.00 |

Type 12: School Buses

| Acceleration Mode | |
|---|---|
| Years> | 1974 |
| 0-20 MPH | 77.60 |
| 0-30 | 78.10 |
| 0-40 | 78.40 |
| 0-50 | 78.90 |
| 0-60 | 79.40 |

| Deceleration Mode | |
|---|---|
| Years> | 1974 |
| 20-0 MPH | 63.70 |
| 30-0 | 67.80 |
| 40-0 | 70.60 |
| 50-0 | 72.90 |
| 60-0 | 74.70 |

| Cruise Mode | |
|---|---|
| Years> | 1974 |
| <25 MPH | 73.00 |
| 25-34 | 73.00 |
| 35-44 | 75.80 |
| 45-54 | 78.10 |
| >55 | 79.90 |

| Idle Mode | |
|---|---|
| Years> | 1974 |
| | 58.00 |

TABLE F-2 (cont.)

Type 13: Unmodified Motorcycles

| Acceleration Mode | | | | |
|---|---|---|---|---|
| Years> | 1974 | 1981 | 1983 | 1986 |
| 0-20 MPH | 73.30 | 71.50 | 68.50 | 66.50 |
| 0-30 | 74.90 | 73.10 | 70.10 | 68.10 |
| 0-40 | 75.40 | 73.60 | 70.60 | 68.60 |
| 0-50 | 75.70 | 73.90 | 70.90 | 68.90 |
| 0-60 | 75.90 | 74.10 | 71.10 | 69.10 |
| **Deceleration Mode** | | | | |
| Years> | 1974 | 1981 | 1983 | 1986 |
| 20-0 MPH | 61.50 | 59.70 | 56.70 | 54.70 |
| 30-0 | 65.90 | 64.10 | 61.10 | 59.10 |
| 40-0 | 69.00 | 67.20 | 64.20 | 62.20 |
| 50-0 | 71.40 | 69.60 | 66.60 | 64.60 |
| 60-0 | 73.40 | 71.60 | 68.60 | 66.60 |
| **Cruise Mode** | | | | |
| Years> | 1974 | 1981 | 1983 | 1986 |
| <25 MPH | 66.90 | 65.10 | 62.10 | 60.10 |
| 25-34 | 71.30 | 69.50 | 66.50 | 64.50 |
| 35-44 | 74.40 | 72.60 | 69.60 | 67.60 |
| 45-54 | 76.90 | 75.10 | 72.10 | 70.10 |
| >55 | 78.90 | 77.10 | 74.10 | 72.10 |
| **Idle Mode** | | | | |
| Years> | 1974 | 1981 | 1983 | 1986 |
| | 58.90 | 58.20 | 55.20 | 53.20 |

Type 14: Modified Motorcycles

| Acceleration Mode | | | | |
|---|---|---|---|---|
| Years> | 1974 | | | |
| 0-20 MPH | 87.50 | | | |
| 0-30 | 89.10 | | | |
| 0-40 | 89.60 | | | |
| 0-50 | 89.90 | | | |
| 0-60 | 90.10 | | | |
| **Deceleration Mode** | | | | |
| Years> | 1974 | | | |
| 20-0 MPH | 75.70 | | | |
| 30-0 | 80.10 | | | |
| 40-0 | 83.20 | | | |
| 50-0 | 85.60 | | | |
| 60-0 | 87.60 | | | |
| **Cruise Mode** | | | | |
| Years> | 1974 | | | |
| <25 MPH | 81.10 | | | |
| 25-34 | 85.50 | | | |
| 35-44 | 88.60 | | | |
| 45-54 | 91.10 | | | |
| >55 | 93.10 | | | |
| **Idle Mode** | | | | |
| Years> | 1974 | | | |
| | 72.00 | | | |

The sales rate and the vehicle depletion rate are discussed further in the following subsection.

In addition to noise emission levels, the model considers the fraction of time each vehicle spends in each of the four operating modes. These mode fractions depend also upon the roadway type, as shown in equation F-3.

$$\text{Fraction of time in mode} = f(\text{vehicle type}^{\text{only 10}}, \text{operating mode}^{4}, \text{roadway type}^{\text{only 2}}) \qquad \text{(F-3)}$$

It should be noted that the mode fraction does not vary for all 14 vehicle types, but is the same for several of them. Similarly, it does not vary for all of the roadway types, but regroups all roadways into two groups for this purpose.

The functional relationship in equation D-3 yields 80 values. These values are contained in 14 tables, three of which are included here as Table F-3. Specifically, Table F-3 documents the mode fractions for the three bus vehicle types. The remainder of the tables are contained in Reference F-1. This information contained in all 14 tables was extrapolated from References F-3 and F-4.

Details of Roadway (Figures F-2 and F-3 Key (2))

The model contains 6 roadway types, as listed in Table F-1. For each of these roadway types, the model contains six specific pieces of data:

- Fraction of mileage at each speed range
- Average daily traffic
- Traffic mix

TABLE F-3 Mode Fraction (Percent of Time) in Operating Mode: Transit

| | OPERATING MODE | | | | |
|---|---|---|---|---|---|
| Roadway Type | Acceleration M=1 | Deceleration M=2 | Cruise M=3 | Idle M=4 | Total |
| 1 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 2 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 3 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 4 | 20.00 | 20.00 | 26.00 | 34.00 | 100.00 |
| 5 | 20.00 | 20.00 | 26.00 | 34.00 | 100.00 |
| 6 | 20.00 | 20.00 | 26.00 | 34.00 | 100.00 |

TABLE F-3(cont.) Mode Fraction (Percent of Time) in Operating Mode: Intercity Buses

| | OPERATING MODE | | | | |
|---|---|---|---|---|---|
| Roadway Type | Acceleration M=1 | Deceleration M=2 | Cruise M=3 | Idle M=4 | Total |
| 1 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 2 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 3 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 4 | 13.00 | 17.00 | 56.00 | 14.00 | 100.00 |
| 5 | 13.00 | 17.00 | 56.00 | 14.00 | 100.00 |
| 6 | 13.00 | 17.00 | 56.00 | 14.00 | 100.00 |

TABLE F-3 (cont.) Mode Fraction (Percent of Time) in Operating Mode: School Buses

| | OPERATING MODE | | | | |
|---|---|---|---|---|---|
| Roadway Type | Acceleration M=1 | Deceleration M=2 | Cruise M=3 | Idle M=4 | Total |
| 1 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 2 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 3 | 5.00 | 5.00 | 85.00 | 5.00 | 100.00 |
| 4 | 9.00 | 9.00 | 21.00 | 61.00 | 100.00 |
| 5 | 9.00 | 9.00 | 21.00 | 61.00 | 100.00 |
| 6 | 9.00 | 9.00 | 21.00 | 61.00 | 100.00 |

- o Lane width
- o Number of lanes
- o Clear-zone width

In actual fact, each roadway has a large range of speeds associated with it. Although vehicle speeds vary on each roadway from moment to moment, the program considers only the average speed for any given segment of roadway. In other words, within each population area the program distributes all the mileage of a given type of roadway into the five speed groups, based upon that mileage's average speed. Resulting is the fraction of roadway mileage in each of the five speed groups for each population area.

These fractions of mileage contain only those miles that pass through occupied land areas. Other mileage is excluded before distribution into speed groups. This mileage exclusion was computed using Figure A.2.2 of Reference F-1.

Next, the program multiplies these mileage fractions by the total mileages, to obtain the number of miles of that roadway type in the given speed group on a national basis.

$$\text{Number of miles in a given speed group} = f(\text{speed group}_{5\text{–}9}, \text{roadway type}_{4\text{–}6}, \text{population}, \text{population density}) \qquad \text{(F-4)}$$

This allocation of roadway mileage by speed group is also a function of the two population groups shown in equation F-4. These population groups are discussed further below.

In all, this functional relationship yields 216 values for each speed group, for a total of 1080 values. The complete set of values is contained in a set of 20 tables (Reference F-1, Table A.3.2), two of which are included here in Table F-4.

A partial summary of these 20 tables appear in Table F-5. There the total roadway mileage through occupied land is split by population and roadway type. Information concerning speed grouping and grouping by population density is not presented in Table F-5, although included in the 20 tables.

Next, the program contains average daily traffic for each of the roadway types.

$$\text{Average daily traffic} = f\left(\text{roadway type}^{(6)},\ \text{place population}^{(9)},\ \text{year}^{(\text{base year + 8 selected years})}\right) \qquad \text{(F-5)}$$

For the baseline year, this functional relationship yields 54 values (Reference F-5). These appear in Table F-6.

Each of these traffic values is then further divided by vehicle type. The resulting traffic mix appears in Table F-7 (References F-11 to F-15).

$$\text{1974 Traffic mix} = f\left(\text{vehicle type}^{(\text{only 8})},\ \text{roadway type}^{(6)},\ \text{population}^{(\text{only 4})}\right) \qquad \text{(F-6)}$$

These data are sufficient to define vehicle mix for the baseline year 1974. To predict future-year traffic mixes, however, a breakdown of vehicles by their year of production is carried out. This breakdown resides within the computer program, and appears here as Tables F-8 and F-9 (see Figure

TABLE F-4

ROADWAY MILEAGE DATA
AVERAGE TRAVEL SPEED 20 MPH

ID = 1

HIGH POPULATION DENSITY AREAS

| | K = 1 | 2 | 3 | 4 | 5 | 6 | All K |
|---|---|---|---|---|---|---|---|
| J = 1 | 0 | 3 | 16 | 41 | 37 | 94 | 191 |
| 2 | 0 | 7 | 21 | 71 | 71 | 172 | 342 |
| 3 | 0 | 1 | 4 | 11 | 12 | 31 | 59 |
| 4 | 0 | 3 | 17 | 45 | 42 | 119 | 226 |
| 5 | 0 | 5 | 24 | 58 | 61 | 149 | 297 |
| 6 | 0 | 5 | 29 | 67 | 69 | 171 | 341 |
| 7 | 0 | 1 | 6 | 14 | 15 | 33 | 69 |
| 8 | 0 | 3 | 27 | 59 | 63 | 140 | 292 |
| 9 | 0 | 0 | 0 | 8698 | 6159 | 215859 | 230716 |
| ALL J> | 0 | 28 | 144 | 9064 | 6529 | 216768 | 232533 |

ID = 2

MEDIUM TO HIGH POPULATION DENSITY AREAS

| | K = 1 | 2 | 3 | 4 | 5 | 6 | All K |
|---|---|---|---|---|---|---|---|
| J = 1 | 6 | 78 | 438 | 1085 | 989 | 2494 | 5090 |
| 2 | 1 | 19 | 59 | 201 | 203 | 491 | 974 |
| 3 | 1 | 6 | 31 | 84 | 95 | 242 | 459 |
| 4 | 7 | 69 | 360 | 963 | 886 | 2514 | 4799 |
| 5 | 2 | 23 | 110 | 273 | 283 | 699 | 1390 |
| 6 | 1 | 18 | 99 | 229 | 233 | 579 | 1159 |
| 7 | 1 | 10 | 97 | 210 | 228 | 504 | 1050 |
| 8 | 1 | 16 | 154 | 336 | 364 | 804 | 1675 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ALL J> | 20 | 239 | 1348 | 3381 | 3281 | 8327 | 16596 |

J 1 = Population over 2 million (M)
J 2 = 1 M to 2 M
J 3 = 500K to 1 M
J 4 = 200K to 500K
J 5 = 100K to 200K
J 6 = 50K to 100K
J 7 = 25K to 50K
J 8 = 5K to 25K
J 9 = Rural

K 1 = Interstate Highways
K 2 = Freeways and Expressways
K 3 = Major Arterials
K 4 = Minor Arterials
K 5 = Collectors
K 6 = Local Roads and Streets

TABLE F-5 Distribution of Road Mileage, Average Daily Traffic (ADT) and Daily Vehicle Miles Traveled (DVMT) by Place Size (J) and Roadway Type (K)

| Place Size | | | ROADWAY TYPE | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | INTERSTATE | OTHER E'WAY & EXP'WAY | MAJOR ARTERIALS | MINOR ARTERIALS | COLLECTORS | LOCAL |
| | >2M | Miles | 1,998 | 1,749 | 9,861 | 14,103 | 12,854 | 84,247 |
| | | ADT | 74,866 | 66,470 | 18,768 | 9,315 | 3,783 | 1,129 |
| | | DVMT | 149,582,268 | 116,256,030 | 185,071,248 | 131,369,445 | 48,626,682 | 95,114,863 |
| | 1M to 2M | Miles | 1,869 | 1,527 | 5,156 | 10,219 | 10,308 | 64,678 |
| | | ADT | 60,228 | 32,548 | 17,397 | 6,898 | 3,496 | 656 |
| | | DVMT | 112,566,132 | 49,700,796 | 89,698,932 | 70,490,662 | 36,036,768 | 42,428,768 |
| | 500K to 1M | Miles | 1,477 | 739 | 4,034 | 6,320 | 7,190 | 47,466 |
| | | ADT | 46,997 | 34,036 | 16,359 | 8,045 | 3,760 | 672 |
| | | DVMT | 69,414,569 | 25,152,604 | 65,992,206 | 50,844,400 | 27,034,400 | 31,897,152 |
| | 200K to 500K | Miles | 1,743 | 1,076 | 5,566 | 8,569 | 7,897 | 58,252 |
| | | ADT | 40,367 | 28,812 | 16,029 | 8,470 | 3,812 | 839 |
| | | DVMT | 70,359,681 | 31,001,712 | 89,217,414 | 75,579,430 | 30,103,364 | 48,873,428 |
| | 100K to 200K | Miles | 854 | 803 | 3,851 | 5,502 | 5,714 | 36,697 |
| | | ADT | 32,190 | 22,984 | 14,984 | 7,301 | 3,287 | 649 |
| | | DVMT | 27,490,260 | 18,456,152 | 57,352,943 | 40,170,102 | 18,781,918 | 23,816,353 |
| | 50K to 100K | Miles | 512 | 600 | 3,335 | 4,445 | 4,534 | 29,284 |
| | | ADT | 21,913 | 19,971 | 12,376 | 6,057 | 2,917 | 645 |
| | | DVMT | 11,219,456 | 11,982,600 | 41,273,960 | 26,923,365 | 13,225,678 | 18,888,180 |
| | 25K to 50K | Miles | 397 | 447 | 4,282 | 5,377 | 5,828 | 33,464 |
| | | ADT | 23,251 | 16,875 | 11,384 | 5,430 | 2,484 | 631 |
| | | DVMT | 9,230,647 | 7,543,125 | 48,746,298 | 29,197,110 | 14,476,752 | 21,109,479 |
| | 5K to 25K | Miles | 899 | 1,099 | 9,652 | 12,124 | 13,130 | 75,431 |
| | | ADT | 18,206 | 13,244 | 8,922 | 4,255 | 1,946 | 495 |
| | | DVMT | 16,367,144 | 13,343,016 | 86,115,144 | 61,587,620 | 25,550,980 | 37,338,345 |
| | Rural | Miles | 31,744 | 85,716 | 155,547 | 435,517 | 307,917 | 1,942,733 |
| | | ADT | 13,700 | 4,623 | 2,523 | 899 | 370 | 98 |
| | | DVMT | 434,892,800 | 396,265,068 | 392,445,081 | 387,174,613 | 113,929,290 | 190,387,834 |

Note: ADT-DVMT/Miles is the derived quality.

TABLE F-6

Average Daily Traffic (ADT)
By Roadway Type (K) and Place Size (J)
Baseline Year 1974

| | K = 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| J=1 | 74866 | 66470 | 18768 | 9315 | 3783 | 1129 |
| 2 | 60228 | 32548 | 17397 | 6898 | 3496 | 656 |
| 3 | 46997 | 34036 | 16359 | 8045 | 3760 | 672 |
| 4 | 40367 | 28812 | 16029 | 8470 | 3812 | 839 |
| 5 | 32190 | 22984 | 14984 | 7301 | 3287 | 649 |
| 6 | 21913 | 19971 | 12376 | 6057 | 2917 | 645 |
| 7 | 23251 | 16876 | 11384 | 5430 | 2484 | 631 |
| 8 | 18206 | 13224 | 8922 | 4255 | 1946 | 495 |
| 9 | 13700 | 4623 | 2523 | 889 | 370 | 98 |

TABLE F-7

Percentage Vehicle Mix in Traffic Flow by Place Size and Functional Roadway Classification Baseline Conditions

URBAN PLACES SIZES: Over 2M; 1M-2M; 500K-1M

| VEHICLE TYPE | ROADWAY TYPE (INDEX K) | | | | | |
|---|---|---|---|---|---|---|
| Light Vehicles | 87.62 | 87.62 | 91.82 | 90.52 | 90.51 | 95.76 |
| Medium Trucks | 2.11 | 2.11 | 3.05 | 4.31 | 3.61 | 1.16 |
| Heavy Trucks | 9.17 | 9.17 | 4.03 | 3.11 | 3.82 | 0.99 |
| Intercity Buses | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 |
| Transit Buses | 0.08 | 0.08 | 0.08 | 0.54 | 0.54 | 0.54 |
| School Buses | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 |
| Unmodified Motorcycles | 0.88 | 0.88 | 0.88 | 1.32 | 1.32 | 1.32 |
| Modified Motorcycles | 0.12 | 0.12 | 0.12 | 0.18 | 0.18 | 0.18 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

URBAN PLACES SIZES: Over 200K-500K; 100K-200K; 50K-100K

| VEHICLE TYPE | ROADWAY TYPE (INDEX K) | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Light Vehicles | 87.64 | 87.64 | 91.84 | 90.71 | 90.70 | 95.98 |
| Medium Trucks | 2.11 | 2.11 | 3.05 | 4.31 | 3.61 | 1.16 |
| Heavy Trucks | 9.17 | 9.17 | 4.03 | 3.11 | 3.82 | 0.99 |
| Intercity Buses | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Transit Buses | 0.04 | 0.04 | 0.04 | 0.30 | 0.30 | 0.30 |
| School Buses | 0.00 | 0.00 | 0.00 | 0.08 | 0.08 | 0.08 |
| Unmodified Motorcycles | 0.88 | 0.88 | 0.88 | 1.32 | 1.32 | 1.32 |
| Modified Motorcycles | 0.12 | 0.12 | 0.12 | 0.18 | 0.18 | 0.18 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

NOTE: Some columns do not add up to exactly 100 because of rounding

K 1 = Interstate Highways
K 2 = Freeways and Expressways
K 3 = Major Arterials
K 4 = Minor Arterials
K 5 = Collectors
K 6 = Local Roads and Streets

TABLE F-7 (cont.)

Percentage Vehicle Mix in Traffic Flow
by Place Size and Functional Roadway

URBAN PLACES SIZES: 25K-50K; 5K-25K

| VEHICLE TYPE | ROADWAY TYPE (INDEX K) | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Light Vehicles | 87.67 | 87.67 | 91.67 | 90.34 | 90.33 | 95.61 |
| Medium Trucks | 2.11 | 2.11 | 3.05 | 4.31 | 3.61 | 1.16 |
| Heavy Trucks | 9.17 | 9.17 | 4.03 | 3.11 | 3.82 | 0.99 |
| Intercity Buses | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 |
| Transit Buses | 0.05 | 0.05 | 0.05 | 0.21 | 0.21 | 0.21 |
| School Buses | 0.00 | 0.00 | 0.00 | 0.52 | 0.52 | 0.52 |
| Unmodified Motorcycles | 0.88 | 0.88 | 0.88 | 1.32 | 1.32 | 1.32 |
| Modified Motorcycles | 0.12 | 0.12 | 0.12 | 0.18 | 0.18 | 0.18 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

RURAL AREAS
ROADWAY TYPE (INDEX K)

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Light Vehicles | 79.67 | 79.67 | 85.78 | 88.27 | 93.33 | 96.74 |
| Medium Trucks | 2.74 | 2.74 | 3.80 | 4.39 | 0.56 | 0.41 |
| Heavy Trucks | 16.16 | 16.16 | 8.99 | 5.14 | 3.91 | 0.65 |
| Intercity Buses | 0.24 | 0.24 | 0.24 | 0.00 | 0.00 | 0.00 |
| Transit Buses | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| School Buses | 0.19 | 0.19 | 0.19 | 0.70 | 0.70 | 0.70 |
| Unmodified Motorcycles | 0.88 | 0.88 | 0.88 | 1.32 | 1.32 | 1.32 |
| Modified Motorcycles | 0.12 | 0.12 | 0.12 | 0.18 | 0.18 | 0.18 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

NOTE: Some columns do not add up to exactly 100 because of rounding.

TABLE F-8

Baseline Year (1974) Vehicle Population
by Model Year and Vehicle Category

| Model Year | Light Vehicles | Trucks | Intercity Buses | Transit Buses | School Buses | Motorcycles |
|---|---|---|---|---|---|---|
| 1974 | 13,959,524 | 447,576 | 1,479 | 12,571 | 58,226 | 518,315 |
| 1973 | 14,599,524 | 457,770 | 2,246 | 6,706 | 47,511 | 579,971 |
| 1972 | 13,145,920 | 387,705 | 1,886 | 4,819 | 38,378 | 522,226 |
| 1971 | 11,107,210 | 281,879 | 1,084 | 3,319 | 28,263 | 443,740 |
| 1970 | 11,003,084 | 274,759 | 13,905* | 42,057* | 184,460* | 437,103 |
| 1969 | 11,161,141 | 291,911 | - | - | - | 443,380 |
| 1968 | 10,274,987 | 229,451 | - | - | - | 408,177 |
| 1967 | 8,581,706 | 211,166 | - | - | - | 340,911 |
| 1966 | 8,461,220 | 211,814 | - | - | - | 336,125 |
| 1965 | 7,397,576 | 185,276 | - | - | - | 293,871 |
| 1964 | 5,151,096 | 152,266 | - | - | - | 204,629 |
| 1963 | 3,658,626 | 121,684 | - | - | - | 145,340 |
| 1962 | 2,348,827 | 97,573 | - | - | - | 93,308 |
| 1961 | 1,167,288 | 69,094 | - | - | - | 46,317 |
| 1960 | 883,563 | 70,227 | - | - | - | 35,063 |
| 1959 | 506,559 | 59,871 | - | - | - | 20,129 |
| 1958 | 2,100,082* | 370,391* | - | - | - | 83,436* |

*Population includes all vehicles in this model year and older.

TABLE F-9

Distribution of Vehicle Population by Vehicle Type
for Model Years 1974 and Earlier

| Vehicle* | Fraction of Vehicle Category Population |
|---|---|
| Type 1 | 0.4673 |
| Type 2 | 0.1420 |
| Type 3 | 0.0167 |
| Type 4 | 0.0168 |
| Type 5 | 0.1603 |
| Type 6 | 0.1514 |
| Type 7 | 0.0005 |
| Total | 1.0000 |
| Type 8 | 0.6146 |
| Type 9 | 0.3854 |
| Total | 1.0000 |
| Type 10 | 1.0000 |
| Type 11 | 1.0000 |
| Type 12 | 1.0000 |
| Type 13 | 0.8800 |
| Type 14 | 0.1200 |
| Total | 1.0000 |

* See Table D-2

A-4.2 of Reference F-1 derived from References F-13 and F-14 Table F-8 provides vehicle information in six vehicle groups, while Table F-9 further subdivides these groups into the total of 14 as illustrated in equation F-7.

$$\text{1974 vehicle mix} = f(\text{vehicle type}_{\rightarrow 14}, \text{model year}_{\rightarrow 17}) \qquad \text{(F-7)}$$

The average daily traffic is also derived for future years. First we account for new vehicles sold each year that increase the average daily traffic.

$$\text{Vehicle sales} = f(\text{vehicle type}_{\rightarrow \text{only 4}}, \text{year}_{\rightarrow 40}) \qquad \text{(F-8)}$$

This functional relationship illustrated by equation F-8 represents growth factors relative to sales in 1974 (see Figure A-4.2 of Reference F-1 for growth factors of vehicles other than buses, derived from References F-13 and F-14. For future years, the average daily traffic is also depleted as shown by equation F-9 by those vehicles that retire from service (References F-13 and F-14.

$$\text{Percentage of vehicles retiring} = f(\text{vehicle type}_{\rightarrow \text{only 2}}, \text{vehicle age}_{\rightarrow 20}) \qquad \text{(F-9)}$$

Examples of this depletion rate are contained in Appendix G of Reference F-1. Table F-10 presents vehicle population by type for each year. This table takes into account vehicle sales and depletion rates.

In summary, average daily traffic flow plus vehicle mix starts at the 1974 values (baseline) for each roadway (equations F-5, F-6, and F-7). Daily

traffic flow grows according to new-vehicle sales (equation F-8), and is depleted by the number of vehicles retiring (equation F-9). As the traffic changes in this manner, all new-vehicle sales consist of noise-regulated vehicles -- where such vehicles have been specified (equation F-1).

For the Single Event Response part of the model, the average daily traffic flow and vehicle mix is used in the same manner as above. However, the noise impact from only one vehicle type at a time is computed.

The basic roadway configuration appears in Figure F-6. A roadway is shown to the left, with the adjacent land extending to the right.

Each roadway type consists of a definite number of travel lanes, of definite width, then a clear zone of definite width, and then occupied land.

$$\text{Lane width} = f(\text{roadway type}) \quad \text{(only 2)} \qquad \text{(F-10)}$$

$$\text{Number of travel lanes} = f(\text{roadway type}) \quad \text{(only 2)} \qquad \text{(F-11)}$$

$$\text{Clear-zone width} = f(\text{roadway type}\ (6),\ \text{population size}\ (9),\ \text{population density}\ (4)) \qquad \text{(F-12)}$$

Lane widths are 15 feet for interstate roadways and 12 feet for all other roadways. The number of travel lanes is two for all local roadways and four for all other roadways. The clear-zone widths are more complicated functions, as indicated in equation F-12. The clear-zone widths used in the model appear in Table F-11. The definition of the clear-zone distance is based upon the best information currently available (References F-5, F-7 and F-16).

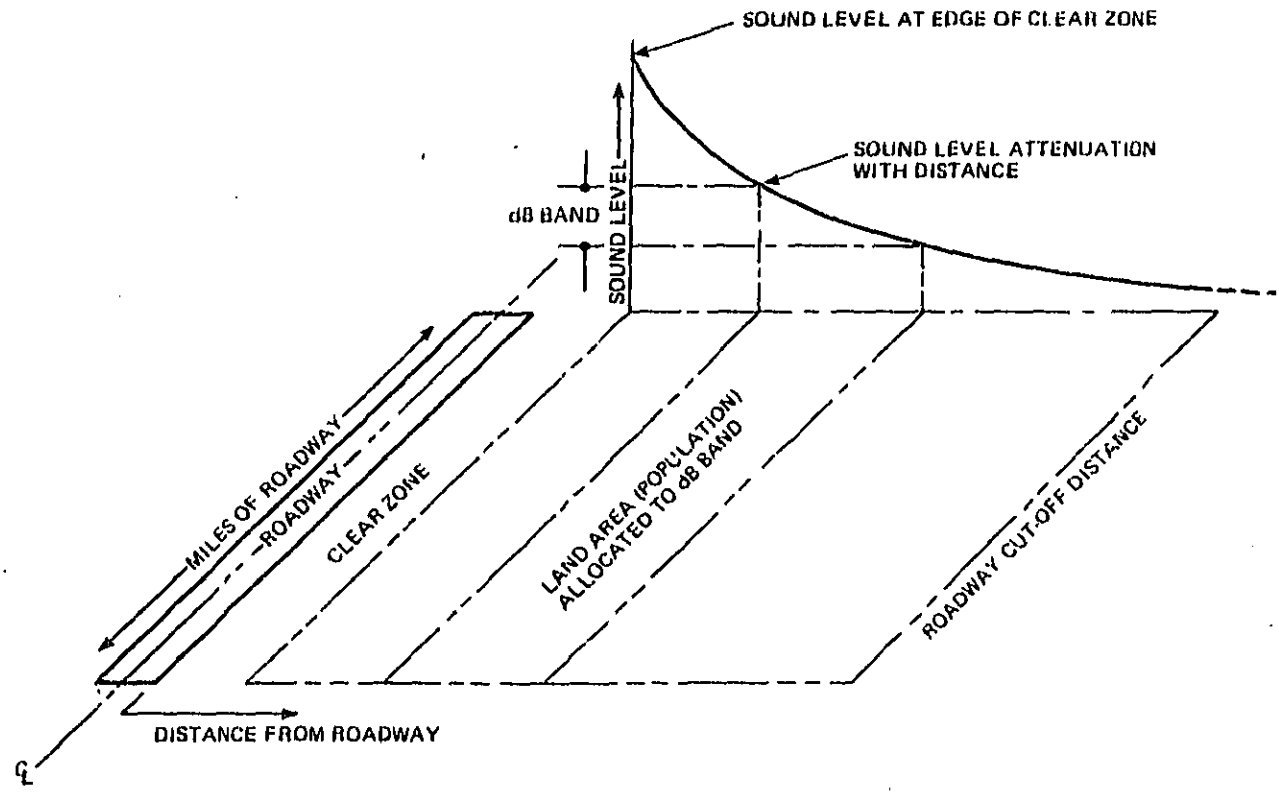
TABLE F-10

VEHICLE POPULATION BY TYPE

| TYPE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | ALL TYPES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cylinders | 8 | 6 | 6&8 | 4 | 4 | 6&8 | | | | | | | | | |
| Engine | Gas | Gas | Gas | Gas | Gas | Gas | Diesel | | | | | | | | |
| Trans-mission | Auto-matic | Auto-matic | Man-ual | Auto-matic | Man-ual | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| VEH. Type> | PC | PC | PC | PC&LT | PC&LT | LT TRK | PC&LT | MED TRK | HVY TRK | IC BUS | TR BUS | SCH BUS | UM MTCY | MD MTCY | |
| UNIT | MILLIONS | | | | | | | | | TENS OF THOUSANDS | | | MILLIONS | | |
| Year | | | | | | | | | | | | | | | |
| 1974 | 58.68 | 17.83 | 2.10 | 7.76 | 20.13 | 19.01 | 0.06 | 2.41 | 1.51 | 2.06 | 6.95 | 35.68 | 4.36 | 0.59 | 134.09 |
| 1980 | 65.13 | 21.41 | 2.69 | 11.16 | 22.74 | 26.85 | 0.11 | 2.87 | 1.80 | 1.63 | 8.98 | 49.14 | 4.44 | 0.61 | 160.41 |
| 1985 | 57.21 | 28.03 | 3.69 | 23.04 | 25.74 | 32.23 | 0.16 | 3.38 | 2.12 | 2.10 | 12.34 | 62.58 | 5.76 | 0.79 | 182.91 |
| 1990 | 45.60 | 35.84 | 4.78 | 37.58 | 29.48 | 34.84 | 0.19 | 3.78 | 2.37 | 2.43 | 14.16 | 67.43 | 7.80 | 1.06 | 204.17 |
| 1995 | 42.44 | 41.92 | 5.60 | 47.13 | 33.21 | 41.35 | 0.23 | 4.18 | 2.62 | 2.72 | 15.37 | 70.13 | 9.40 | 1.18 | 226.43 |
| 2000 | 45.73 | 46.60 | 6.22 | 52.82 | 33.21 | 41.35 | 0.23 | 4.61 | 2.89 | 3.01 | 16.42 | 72.81 | 10.53 | 1.44 | 250.10 |
| 2005 | 50.45 | 51.44 | 6.87 | 58.31 | 40.57 | 45.64 | 0.25 | 5.09 | 3.19 | 3.31 | 17.48 | 75.50 | 11.30 | 1.54 | 275.62 |
| 2010 | 55.69 | 56.78 | 7.58 | 64.37 | 44.78 | 50.37 | 0.28 | 5.62 | 3.52 | 3.60 | 18.54 | 78.19 | 11.61 | 1.58 | 303.18 |

FIGURE F-6

ROADWAY TRAFFIC NOISE EXPOSURE OF LAND AREA




NOTE: LAND AREA AND POPULATION IS UNIFORMLY DISTRIBUTED ON BOTH SIDES OF ROADWAY.

Clear-zones consist of the area between the roadway pavement and the adjacent, occupied land. These clear-zones include parking lanes, and sidewalks. In all but the rural population group, clear-zones also include front yards of residences -- but only along arterials, collectors, and local roadways. For interstates and freeways, clear-zones include the right-of-way adjacent to the roadway pavement.

Details of Propagation (Figures F-2 and F-3, Key (2))

Propagation of bus noise from the roadway into the adjacent occupied land is influenced, in part, by:

- o Distance
- o Ground effects
- o Shielding

For persons close by a roadway, the roadway appears relatively straight. The roadway also appears "infinitely long" to nearby persons. Both these approximations are made for all roadway propagation calculations in the model. Therefore, the only geometric quantity of concern is the perpendicular distance between the person and the roadway.

The model utilizes a random process to determine the perpendicular distances between all roadways and all persons. In essence, the model distributes people randomly over a well-defined land area (lying wholly outside the clear-zones for each roadway), and then the distribution of perpendicular distances is calculated. The details of this distance calculation are presented in the following subsection.

Once the distance between any person and roadway is determined, then the noise propagation can be measured in terms of this distance, the attenuation characteristics of the intervening ground (the clear-zone), and the shielding provided by intervening buildings.

TABLE F-11

CLEAR ZONE DISTANCES (IN FEET) BY ROADWAY TYPE (K), POPULATION DENSITY CATEGORY (ID), AND POPULATION PLACE SIZE (J)*

| | | Population Place Size, Index J | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| K | ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | ALL | 50. | 50. | 50. | 50. | 50. | 50. | 50. | 50. | 50. |
| 2 | ALL | 30. | 30. | 30. | 40. | 40. | 40. | 40. | 40. | 40. |
| 3 | 1 | 10. | 10. | 10. | 10. | 10. | 10. | 10. | 10. | 40. |
| | 2 | 15. | 15. | 15. | 20. | 20. | 20. | 20. | 20. | 40. |
| | 3 | 20. | 20. | 20. | 30. | 30. | 30. | 30. | 30. | 40. |
| | 4 | 30. | 30. | 30. | 40. | 40. | 40. | 40. | 40. | 40. |
| 4 | 1 | 10. | 10. | 10. | 10. | 10. | 10. | 10. | 10. | 40. |
| | 2 | 15. | 15. | 15. | 20. | 20. | 20. | 20. | 20. | 40. |
| | 3 | 20. | 20. | 20. | 30. | 30. | 30. | 30. | 30. | 40. |
| | 4 | 30. | 30. | 30. | 40. | 40. | 40. | 40. | 40. | 40. |
| 5 | 1 | 5. | 5. | 5. | 10. | 10. | 10. | 10. | 10. | 40. |
| | 2 | 10. | 10. | 10. | 20. | 20. | 20. | 20. | 20. | 40. |
| | 3 | 15. | 15. | 15. | 30. | 30. | 30. | 30. | 30. | 40. |
| | 4 | 20. | 20. | 20. | 40. | 40. | 40. | 40. | 40. | 40. |
| 6 | 1 | 5. | 5. | 5. | 10. | 10. | 10. | 10. | 10. | 40. |
| | 2 | 10. | 10. | 10. | 20. | 20. | 20. | 20. | 20. | 40. |
| | 3 | 15. | 15. | 15. | 30. | 30. | 30. | 30. | 30. | 40. |
| | 4 | 20. | 20. | 20. | 40. | 40. | 40. | 40. | 40. | 40. |

Index K denotes highway type; Index ID denotes population density category.

*See Table F-1 for roadway type, population place size and population density groups

To determine ground attenuation the model assumes a noise divergence of 3 dB per distance doubling from the roadway (line sources), and 6 dB per distance doubling for individual vehicles as they pass by. In addition, the model assumes an excess ground attenuation of 1.5 dB per distance doubling over absorptive clear-zones.

$$\text{Ground attenuation} = f(\underset{\text{only 2}}{\text{roadway type}}, \underset{\text{only 2}}{\text{population groups}}) \qquad \text{(F-13)}$$

Such excess attenuation is assumed for:

- Interstate roadways plus freeways and expressways for place population groups over 25,000 people
- Major and minor arterials plus collectors and local roadways, for place populations over 500,000 people

Average shielding due to intervening buildings is assumed to depend only the width of the clear-zone, and the population density as illustrated in equation

$$\text{Building shielding} = f(\underset{4}{\text{clear-zone width}}, \underset{3}{\text{population density}}) \qquad \text{(F-14)}$$

The building shielding and ground attenuation factors are combined with the 3 dB or 6 dB per distance doubling. The resulting propagation curves are provided in Figures F-7 and F-8. Figure F-7 applies to roadway line sources (where the source is made up of a stream of vehicles), and is used in the General Adverse Response part of the model. Figure F-8 is for individual vehicle point sources, and is used in the Single Event Response part of the model. Attenuation values extracted from these curves are used by the computer to calculate the propagation of the noise into occupied land, starting at the edge of the clear-zone. (See References F-1, F-17 and F-18 for more detailed discussions of the propagation rates used.)

The Single Event part of the model accounts for building attenuation so that indoor noise can be predicted. To estimate indoor noise levels from outside noise sources, the sound attenuation offered by building walls and windows is calculated. Although dwelling walls effectively attenuate sound, windows generally provide poorer sound insulation from exterior noise. When windows are open the difference between indoor and outdoor noise varies from 8 to 25 dB; with windows closed, the attenuation varies from 19 to 34 dB, and with double-glazed windows, noise may be reduced as much as 45 dB. Average differences between values for open window and closed window conditions are 15 dB and 25 dB respectively (Reference F-19).

The analysis assumes an attenuation value of 15 dB for the suburban single-family detached and the suburban duplex dwelling areas (assuming window open conditions), and a value of 20 dB for other dwellings to account for the attenuation of outdoor noise by the exterior shell of the house (assuming a mixture of windows open and closed). These attenuation values represent an average between summer and winter, and new construction and old construction.

$$\text{Building noise isolation} = f(\text{population}, \text{population density}) \qquad \text{(F-15)}$$

The building noise insulation values used in the computer analysis are presented in Table F-12.

Details of Receivers (Figures F-2 and F-3, Key (3))

First, each person in the United States is assigned to one of the 33 pop/density "cells" of Table F-1. These cells are defined by (1) the total population in the city/town/area where that person lives, and (2) the population density in his neighborhood within his city/town/area. These assignments to pop/density cells reside within the computer program, and appear here in Table F-13. The land areas of each of these pop/density cells also appear in

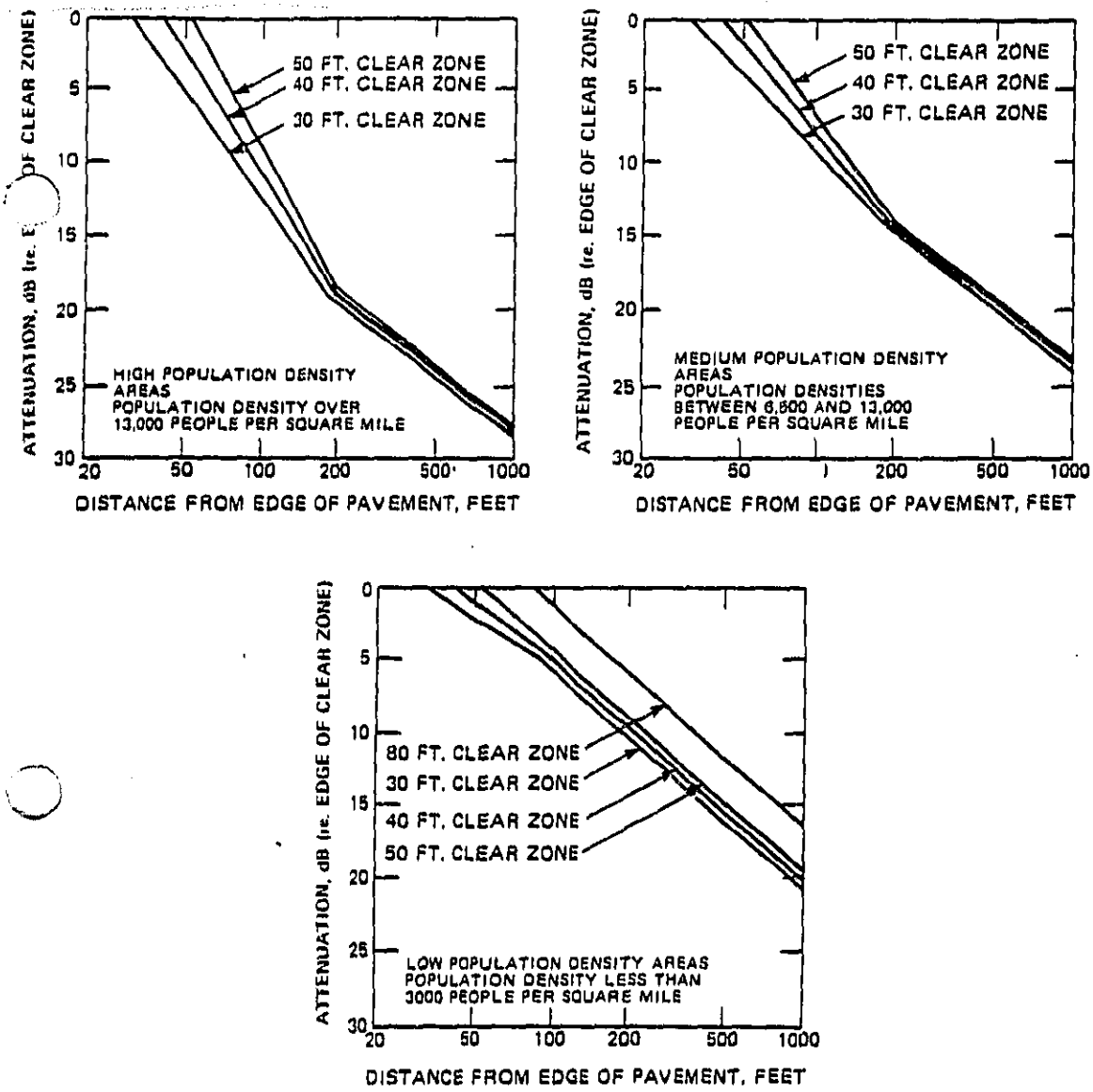



FIGURE F-7 SOUND LEVEL ATTENUATION CURVES: LINE SOURCE

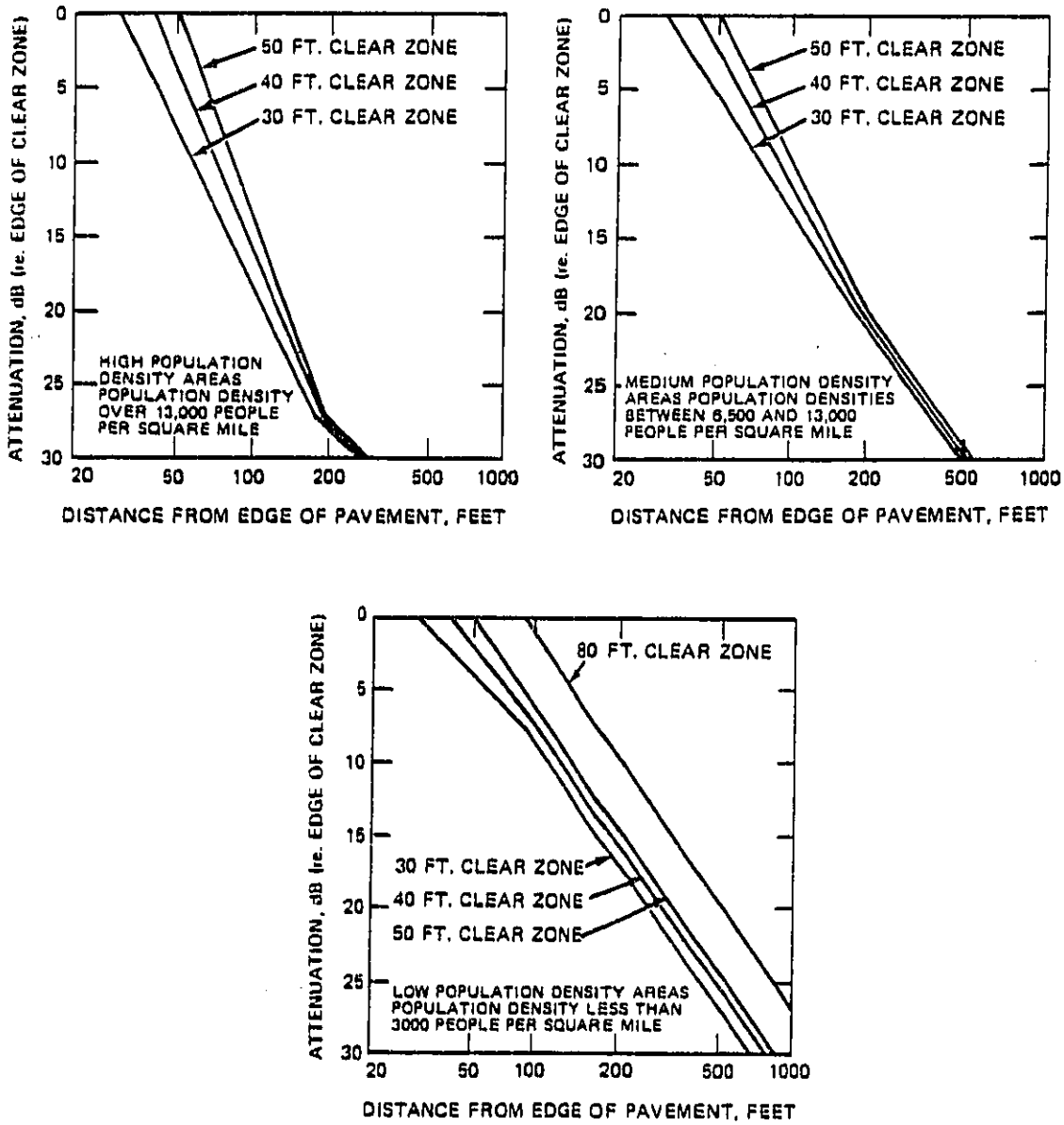



FIGURE F-8 SOUND LEVEL ATTENUATION CURVES: POINT SOURCE

TABLE F-12

Building Exterior Noise Reduction (in decibels)
by Place Size (Index J) and Population Density Area (Index ID)

| Population Density Area Index, ID | Population Place Size, Index J | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | Over 2M | 1M 2M | 500K 1M | 200K 500K | 100K 200K | 50K 100K | 25K 50K | 5K 25K | Rural Areas |
| 1 High Density | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 2 Medium to High Density | 20.0 | 20.0 | 20.0 | 15.0 | 15.0 | 15.0 | 20.0 | 20.0 | 15.0 |
| 3 Medium to Low Density | 20.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| 4 Low Density | 20.0 | 15.0 | 15.0 | 15.0 | 15.0 | 11.0 | 15.0 | 15.0 | 15.0 |

TABLE F-13

DISTRIBUTION OF POPULATION AND LAND AREA BY PLACE SIZE
(INDEX J) AND POPULATION DENSITY CATEGORY (INDEX ID)

| Population Density Area Index ID | | Parameter | 1<br>>2M | 2<br>1M<br>-2M | 3<br>500K<br>-1M | 4<br>200K<br>-500K | 5<br>100K<br>-200K | 6<br>50K<br>-100K | 7<br>25K<br>-50K | 8<br>5K<br>-25K | Urban Total | 9<br>Rural |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | Population | 5.61 | 2.10 | 0.36 | 1.61 | 1.16 | 1.07 | 0.47 | 1.85 | 14.23 | 64.18* |
| | | Area | 134.2 | 272 | 63 | 215 | 279 | 329 | 58 | 220 | 1570.2 | 3,476,938 |
| | | p* | 64,711 | 13,451 | 9,368 | 9,368 | 5,031 | 13,091 | 13,091 | 16,988 | - | 18.0 |
| | 2 | Population | 22.28 | 4.08 | 2.04 | 10.43 | 2.93 | 2.12 | 2.98 | 4.97 | 51.83 | 0.0 |
| | | Area | 3576 | 775 | 488 | 4558 | 1305 | 1115 | 8.96 | 1261 | 13970.0 | 0.0 |
| | | p* | 12,638 | 9,092 | 6,967 | 3697.0 | 3,304 | 2,863 | 8,506 | 10,681 | - | |
| | 3 | Population | 21.59 | 11.13 | 8.40 | 6.75 | 6.84 | 4.53 | 3.51 | 8.46 | 71.20 | 0.0 |
| | | Area | 8358 | 5080 | 4426 | 5790 | 5266 | 4195 | 2230 | 4527 | 39872.0 | 0.0 |
| | | p* | 6,107 | 5,014 | 3,842 | 2,264 | 2,011 | 1,612.0 | 4,698 | 6,271 | - | |
| | 4 | Population | 0.0 | 5.35 | 5.30 | 0.0 | 0.0 | 0.0 | 1.92 | 2.70 | 15.27 | 0.0 |
| | | Area | 0.0 | 4099 | 4584 | 0.0 | 0.0 | 0.0 | 2769 | 5020 | 17262.0 | 0.0 |
| | | p* | - | 2,505 | 2,336 | - | - | - | 2,147 | 1,673 | - | |
| Total Population | | | 49.48 | 22.66 | 16.09 | 18.78 | 10.93 | 7.71 | 8.88 | 17.98 | 152.52 | 64.18 |
| Total Area | | | 12064.2 | 10216.0 | 9561.0 | 10563.0 | 6850.0 | 5639.0 | 5953.0 | 11028.0 | 72674.2 | 3476938 |

Total population = 216.70 million
Total land area = 3,549,612.2 square miles
p* = Population/(Area) (Area Factor), Adjusted Population Density in People per Square Mile

the table. The model distributes the 1974 U.S. population of 216.7 million people over 3.549 million square miles.

In Table F-13, population densities have been computed by dividing the population by occupied land area. This occupied land area excludes bodies of water, airports, roadways themselves (including their clear-zones), parking areas, and open spaces. The conversion from total area to occupied area is termed the "area factor" within the model. It is the fraction of total land area that is occupied. By this distribution, the average population density is 2,099 people per square mile for urban environments and 18 people per square mile for rural environments (see Figure A.2.2 of Reference F-1).

The data in Table F-13 are based upon 1974 populations. For future years the population densities are assumed to increase as population grows.

$$\text{Population growth factors} = f(\text{population}_{\rightarrow 9}, \text{year}_{\rightarrow 9}) \qquad \text{(F-16)}$$

The functional relationship of equation D-16 yields the 81 growth factors, presented in Table F-14. Growth factors were derived from the Bureau of Census' (Series I) assumption of an immigration and fertility rate based upon historical trends.

As discussed above, each person is assigned to one of 33 population/density cells. Each cell also contains a definite mileage value for each of the six roadway types (see Tables F-4 and F-5). The total mileage within each cell is used to compute the noise level to which persons in that cell are exposed.

To compute this noise level, the distance between people and roadways must be estimated. This estimation is done statistically, since the precise distance distributions are not known.

TABLE F-14

Population Growth Factors by Place Size

| | | AREA TYPE,J | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ALL |
| PLACE SIZE, THOUSANDS | | OVER 2000 | 1000-2000 | 500-1000 | 200-500 | 100-200 | 50-100 | 25-50 | 5-25 | RURAL | |
| YEAR | VARIABLE | POP(YEAR)/POP(BASELINE) | | | | | | | | | |
| 1974 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| 1980 | | 1.08 | 1.07 | 1.07 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.12 | |
| 1985 | | 1.15 | 1.14 | 1.14 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.22 | |
| 1990 | | 1.22 | 1.22 | 1.22 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.31 | |
| 1995 | | 1.29 | 1.29 | 1.29 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.39 | |
| 2000 | | 1.36 | 1.36 | 1.36 | 1.08 | 1.08 | 1.09 | 1.09 | 1.09 | 1.48 | |
| 2005 | | 1.43 | 1.44 | 1.44 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.57 | |
| 2010 | | 1.50 | 1.51 | 1.51 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.65 | |
| 2013 | | 1.55 | 1.56 | 1.56 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.70 | |

First the cell's occupied land area is divided by the roadway mileage within that cell to determine the area allotted to each roadway mile. This area is then split in half and placed on each side of a one mile length of roadway, beyond the clear-zone. The far edge of this portion of land area is shown as the cutoff distance in figure F-6.

All persons within the cell are then randomly assigned a particular roadway mile. They are then distributed uniformly on both sides of that one mile of roadway, between the edge of the clear-zone and the cutoff distance. This assignment determines each person's "primary" roadway -- in essence, the roadway closest to that person's place of residence.

Statistically, this random distribution of all persons, over a well-defined area, determines each person's distance to his primary roadway.

Each person is also affected by noise from other roadways within his cell. These are called "secondary" roadways. To compute secondary-roadway noise exposure the distance between the receiver and these roadways is also determined statistically.

The assumption is made that each secondary-roadway distance is greater than the cutoff distance computed for the "primary" roadway. In other words, it is assumed that each person is within the cutoff distance for one and only one roadway, his "primary" roadway. All others are further away. This cutoff distance then provides a <u>minimum</u> distance for the random distribution of person/secondary-roadway combinations.

The maximum distance between persons and roadways obviously depends upon the shape of the land area that comprises that person's cell. If the cell is near-circular in shape, then the maximum distances are not extreme. On the other hand, if the shape is very long and narrow, then the maximum distances could be huge. Thus the approximate shape is assumed to be rectangular, and

is bisected by the secondary roadway of interest. The length of the rectangular area is equal to the total length of the secondary roadway in that cell. The rectangle's width is the cell's area divided by the rectangle's length, so that the total cell's area is included in the rectangle.

With this cell shape, then, all persons are distributed randomly within the rectangle, outside the cutoff distance. Statistically, this random distribution of all persons, over a well-defined area, determines each person's distance to each secondary roadway and considers the total mileage for each roadway type within the cell.

The rectangle mathematics are then repeated for all other secondary roadway types, until distances to all of them are determined in this random manner.

Out of this statistical process comes a full list of each person's distances to all roadways in his cell. His distance to his closest roadway is less than the cutoff distance, while his distances to all other roadways is larger than this cutoff distance.

Consequently, what is computed is the joint probability distribution of the set of all distances between each receiver and all roadways within his pop/density cell. For computational efficiency, the computer determines the noise level distribution instead of the distance distribution. And it determines this in 3-decibel increments, rather than in infinitesimal increments.

For the General Adverse Response part of the model, the average outdoor day-night noise level, $L_{dn}$, is the measure of noise exposure. This is calculated for each person at his place of residence. On the other hand, for the Single Event Response part of the model, several different noise level values are calculated, as presented in Figure F-3. These measures are:

Single-event equivalent noise level, $L_{eq(T)}$:

- o Indoors, day and night
- o Outdoors, day

Sound exposure level, $L_S$:

- o Indoors, day and night

The single-event equivalent noise level, $L_{eq(T)}$, is used to measure speech communication interference. The sound exposure level, $L_S$, is used to measure sleep interference. To relate these noise levels to potential impact for a typical 24 hour day a person's activities over that 24 hours must also be allocated between indoors and outdoors, and separately for day and night as illustrated in equation F-17.

$$\text{Fraction of activity times} = f(\text{location}_{\to 3},\ \text{time of day}_{\to 2},\ \text{activity}_{\to 6}) \qquad \text{(F-17)}$$

This activity allocation is addressed at Key 3 in Figure F-3 and it is detailed in Table F-15 Persons are located away from home, or at home outdoors, or at home indoors. Then separately by day and night, each person spends his time at the activities shown to the right of the Table.

Separately, then, by these activity groups, the average person's time has been fractioned as in Figure F-9 (See Appendix B of Reference F-1 for a more detailed discussion.) These activity fractions are a composite of separate fractions for distinct groups of persons within the U.S.: (1) employed men, (2) employed women, (3) housepersons, and (4) other persons (persons younger than 17, persons older than 65 and not employed, persons in institutions, and unemployed persons).

As Figure F-9 indicates, even during the daytime a small portion of the population is sleeping. This potential daytime sleep interference is accounted for in the impact estimates.

TABLE F-15

ACTIVITY GROUPS FOR THE SINGLE EVENT RESPONSE

| PERSON's LOCATION | TIME OF DAY | ACTIVITY GROUP |
|---|---|---|
| Away from home | Day and Night | Working |
| | | Travelling |
| At home, outdoors | Day | Walking |
| | | Outside-home leisure activities |
| At home, indoors | Day | Sleeping |
| | | Other indoor activities such as TV viewing, enjoying other media, other leisure or semi-leisure activities, home and family type activities, and eating |
| | Night | Sleeping |
| | | Other indoor activities such as TV viewing, enjoying other media, other leisure or semi-leisure activites, home-and-family-type activities, and eating |

NOTE: Day is the period between 7 am and 10 pm.
Night is the remainder of the 24-hours, 10 pm to 7 am .

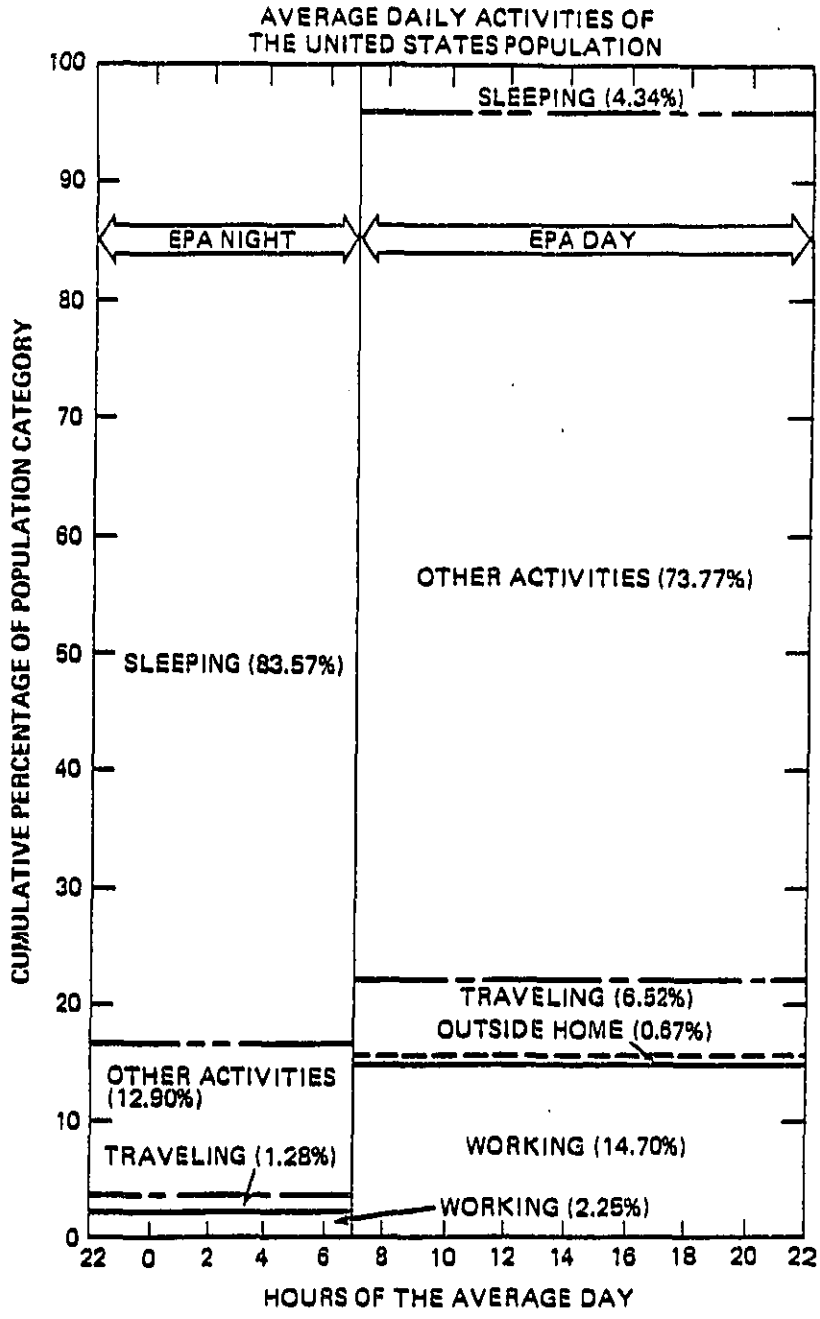



FIGURE F-9 AVERAGE ACTIVITY PATTERN FOR THE U.S. POPULATION

Some Equations of Importance

The discussion above focused upon the data that are used in the noise exposure calculations. Presented here are some equations (simplifications of those that appear in Reference F-1) of importance in this noise prediction with some further assumptions concerning their use within the model.

The General Adverse Response part of the model yields the day-night noise level, $L_{dn}$, at each person's home:

$$\text{Total} \qquad 10^{L_{dn}/10} = \sum_{\text{all roads } r} \left[10^{L_{dn}/10}\right]_r \qquad \text{(F-18)}$$

$$\text{Each road} \qquad 10^{L_{dn}/10} = \sum_{\text{all lanes } \ell} \left[10^{L_{dn}/10}\right]_\ell \, 10^{-A/10}$$

$$\text{Each lane (at clear-zone edge)} \qquad 10^{L_{dn}/10} = \left(\frac{15}{24}\right) \sum_{\text{daytime hours } d} \left[10^{L_{eq}/10}\right]_d + \left(\frac{9}{24}\right) \sum_{\text{night hours } n} \left[10^{L_{eq}/10}\right]_n$$

$$\text{Each day or night hour} \qquad 10^{L_{eq}/10} = \left(\frac{1.49}{D_c}\right)\left(\frac{D_p}{D_c}\right)^{\gamma} \sum_{\substack{\text{280 vehicle combinations} \\ t,\, m,\, s}}^{n} \left[\left(\frac{N}{S}\right) 10^{L_o/10}\right]_{tms}$$

where $L_{dn}$ = day-night noise level, in decibels

$L_{eq}$ = hourly equivalent noise level, in decibels

A = building attenuation + distance attenuation, from edge of clear zone to receiver, in decibels - line source

$D_p$ = distance from travel-lane centerline to edge of pavement, ft

$D_c$ = distance from travel-lane centerline to edge of clear zone, ft

t = index over 14 vehicle types

m = index over 4 operational modes

s = index over 5 vehicle speed ranges

(for 14x4x5=280 vehicle combinations)

combination

$S$ = speed for each combination, miles per hour

$L_o$ = energy-average emission level (at 50 ft) for each combination, in decibels

$\gamma$ = ground attenuation constant for clear zone
= 0 for hard ground
= 0.5 for absorptive ground

The Single Event Response part of the model yields two measures of the noise at each person's home. The first of these is the sound exposure level, $L_s$:

Single-event

$$10^{L_s/10} = \left[\frac{4260}{D_c}\right]\left[\frac{D_p}{D_c}\right]^{\gamma}\left[\frac{1}{S}\right] 10^{L_o/10}\, 10^{-A/10} \qquad \text{(F-19)}$$

where $L_s$ = sound exposure level, in decibels

$A$ = same as for F-18 (also line source)

$D_p$ = same as for F-18

$D_c$ = same as for F-18

$S$ = speed for this vehicle, miles per hour

= same as for F-18

The second measure of single-event noise is the single-event equivalent sound level $L_{eq(T)}$:

Single-event

$$10^{L_{eq}(T)/10} = \left[\frac{S}{4.1\,D}\right] 10^{L_s/10} \qquad \text{(F-20)}$$

where $L_{eq(T)}$ = single-event equivalent sound level over duration T, in decibels

$T$ = duration of event, between 10 dB-down points

$D$ = total distance from travel line to receiver, ft

$S$ = speed for a vehicle, miles per hour

$L_S$ = sound exposure level, in decibels

The input data to these equations are detailed in the sections above. In addition, the following assumptions are inherent in the structure of these equations themselves:

- Each person sees each roadway as indefinitely long and straight.
- The distance between vehicles is the same for acceleration, deceleration and cruise operational modes.
- A single average speed for each roadway segment is sufficient to predict that roadway's noise levels.
- 87 percent of the total traffic passes during the daytime (7 am through 10 pm), and the remaining 13 percent passes during night -- for the General Adverse Response only.
- Traffic is distributed equally among all traffic lanes.
- Roadway median widths are minimal, compared to the total width of the roadway.
- The single-event noise is computed within the 10 dB down points, during the passby of each vehicle.
- Single events are counted in the analysis only if the maximum noise level during the vehicle's passby exceeds the background noise. To avoid underestimating intrusion, this background noise is assumed to be very low: 55 dB (A-weighted) outdoors and 45 dB (A-weighted) indoors. Essentially, these background levels are very long range goals in urban areas, and are far below the levels that now exist. However, they do reflect the desires of states and municipalities for a quieter environment, and they assume that ambient levels will, in

the future, be lowered by coordinated federal, state and local efforts. To a first approximation, this background noise is that due to noise sources other than transportation sources -- for example, building ventilation noise, both indoors and outdoors.

Details of Noise-level Sorting (Figures F-4 and F-5, Key (4))

As a result of the noise level predictions, all persons in the United States are paired with their respective noise levels. These person/noise pairs are then sorted by noise level. The sorting is done concurrently with the prediction procedure.

Details of Conversion from Noise Level to Impact (Figures F-4 and F-5, Key (5))

Exposure to a particular noise level does not necessarily mean that person is fully impacted by that noise (although may be partially impacted). Therefore, the number of persons exposed at each noise level is multiplied by certain "impact fractions" or weightings. These fractions are close to zero for low noise levels, and then increase with noise level, until they reach unity.

For particular effects of noise on people, the weightings differ. The fractions result from a large number of attitudinal surveys and laboratory studies of the effects of noise on people.

For the General Adverse Response portion of the model, the fractional weighting is derived from equation F-2 which is an approximation to a quadratic equation that is the best fit to a large number of attitudinal survey results. The weighting values along with noise level and population information are used in equation F-3 by the model to compute Level Weighted Population within each noise level band.

For the Single Event Response portion of the model, the current estimates of weighting values are presented in Figures F-10 and F-11 (for speech interference) and Figure F-12 (for sleep interference). These weightings are also used in equation F-3 along with noise level and population information.

For speech interference, the noise descriptor is the single-event equivalent sound level, $L_{eq(T)}$. For sleep interference, it is the sound exposure level, $L_S$.

Details of Total Nationwide Impact (Figures F-4 and F-5, Key (6))

After impact is estimated for each noise level separately, then the total nationwide impact is added over all noise levels. This process is overviewed in Figures F-4 and F-5 and is detailed here.

The General Adverse Response depends upon a full year's worth of noise at the person's home. It is assessed from the prediction of yearly-average $L_{dn}$ at the residences of all persons in the U.S.

The Single Event Response depends upon an average day's worth of noise, and the number of intrusive single events that potentially occur during the day or night. It also depends upon the activities of people during the day and night, indoors and outdoors. (See Table F-15).

The estimations within the model do not account for persons when they are away from their homes (first group in Table F-15). Omitted are 20.53 percent of the population during the daytime (7 am through 10 pm) while these people are traveling or working away from home. Similarly omitted are 3.06 percent of the population during the nighttime (See Appendix B of Reference F-1).

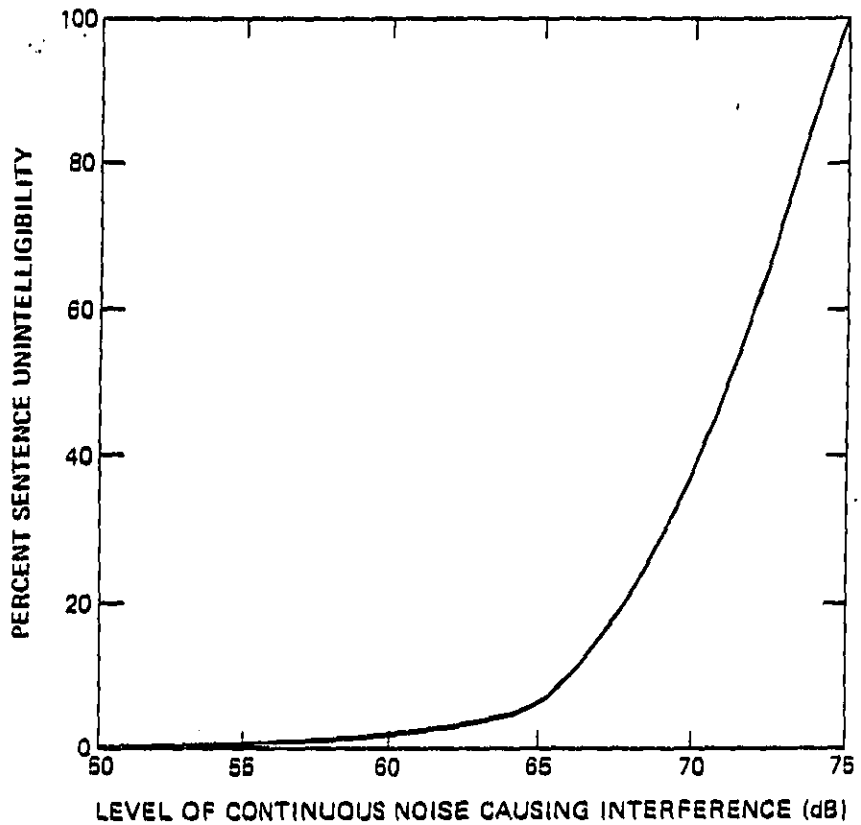



FIGURE F-10 WEIGHTING FUNCTION FOR INDOOR SPEECH INTERFERENCE (RELAXED CONVERSATION AT GREATER THAN 1 METER SEPARATION, 45 dB BACKGROUND IN THE ABSENCE OF INTERFERING NOISE)

FROM REFERENCE F-20

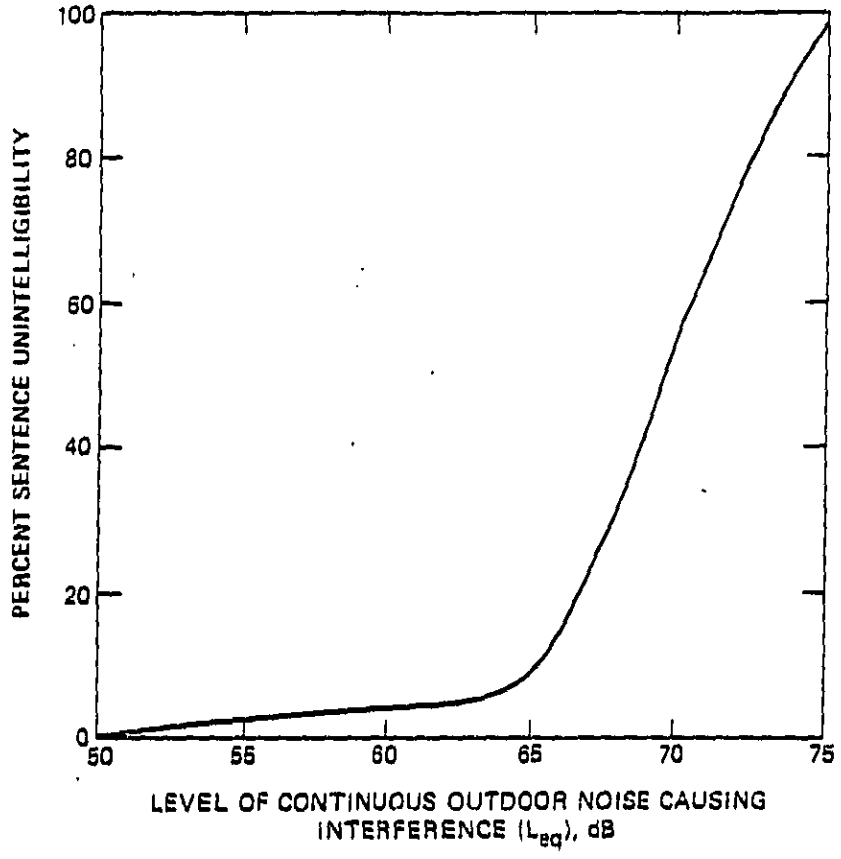
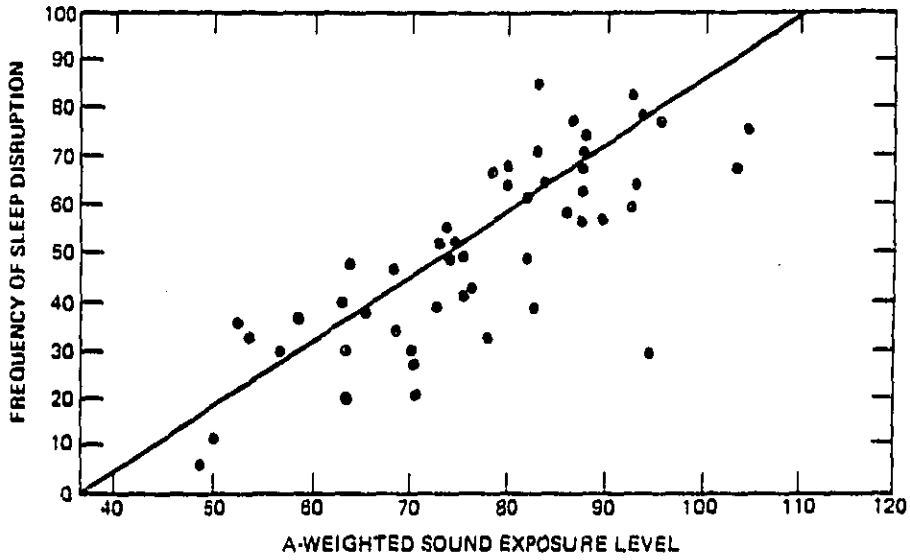
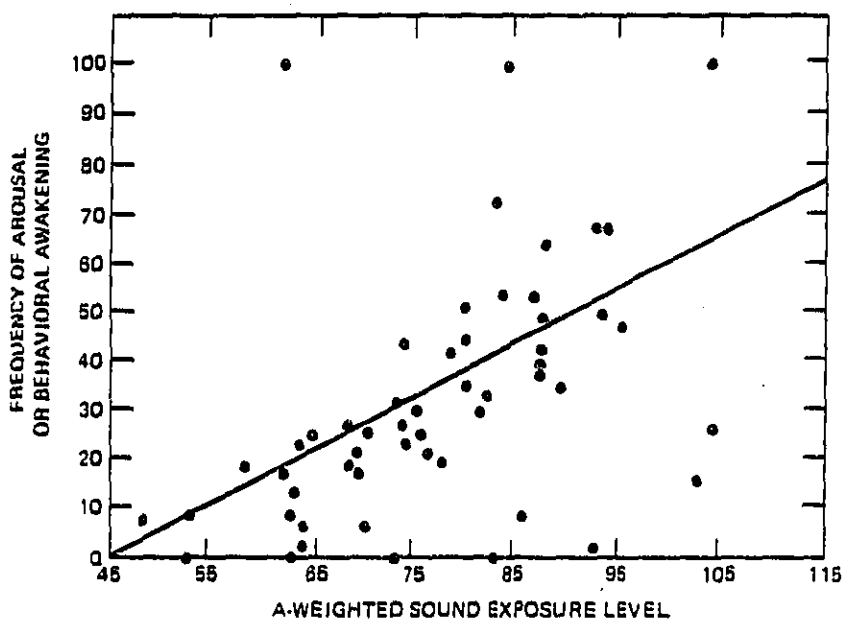



FIGURE F-11 WEIGHTING FUNCTION FOR OUTDOOR SPEECH INTERFERENCE (NORMAL VOICE AT 2 METERS)

FROM REFERENCE F-20




PROBABILITY OF A NOISE INDUCED SLEEP STAGE CHANGE




PROBABILITY OF A NOISE INDUCED AWAKENING

**FIGURE F-12 WEIGHTING FUNCTIONS FOR NOISE INDUCED SLEEP DISRUPTION AND SLEEP AWAKENING**

ADAPTED FROM REFERENCE F-21 and F-22

As shown in Table F-16 the model estimates speech interference while the average person is outdoors, or is indoors but not sleeping. It estimates the two types of sleep interference while the average person is indoors sleeping.

One activity group in Table F-15 is unique -- the group for people outdoors walking. For these "pedestrians," speech interference is not evaluated at their residences, but rather is evaluated at the edge of the clear-zone for each pedestrian's primary roadway. In essence, this represents speech interference while that person is walking along streets in his neighborhood. Speech interference is also estimated outdoors during a person's outside leisure activities around his home.

TABLE F-16

LOCATIONS OF ACTIVITIES

| | |
|---|---|
| **Sleep Interference** | |
| Disruption | People Indoors at home day/night |
| Awakening | People Indoors at home day/night |
| **Speech Interference** | |
| Indoors | People indoors at home not sleeping |
| Outdoors | People outdoors at home |
| Pedestrians | Walking outdoors at the edge of a clear zone |

## REFERENCES


F-1. Rudder, F.F., L. Ronk, and B.A. Hutcheson, "National Roadway Traffic Noise Exposure Model," report prepared for the U.S. Environmental Protection Agency by Science Applications, Inc., 1979.

F-2. Ma, Y.Y., and F.F. Rudder, "Statistical Analysis of FHWA Traffic Noise Data," U.S. Department of Transportation, Federal Highway Administration, Report FHW-RD-78-64, July 1978.

F-3. Gray, R.F.: "A Survey of Light Vehicle Operations," Engineering Publication 6313, General Motors Proving Ground, Milford, Michigan, July 1975.

F-4. Sakagami, J.: "Consideration of Noise Emission of Road Vehicles on Urban Streets in Japan," proceedings Inter-Noise 75, Tokyo University Sendai 980, 1975, pp. 21-28.

F-5. "National Functional System Mileage and Travel Summary," U.S. Department of Transportation, Federal Highway Administration, Office of Planning, June 1977.

F-6. "National Highway Inventory and Performance Study Manual, 1976," U.S. Department of Transportation, Federal Highway Administration, July 1975.

F-7. "The Status of the Nation's Highways: Conditions and Performance," report of the Secretary of Transportation to the United States Congress, 95th Congress, 1st Session, (45-29) U.S. Government Printing Office, September 1977.

F-8. "1970 Census of Population, Number of Inhabitants, United States Summary," U.S. Department of Commerce, Bureau of Census, December 1971.

F-9. Plotkin, Kenneth J., "Average Noise Levels for Highway Vehicles," Wyle Research Technical Note 79-2, September 1979.

F-10. Johnson, D.R., "A Note on the Relationship Between Noise Exposure and Noise Probability Distribution," National Physical Laboratory, NPL Aero Report Ac 40, May 1969.

F-11. "An Asessment of the Technology for Bus Noise Abatement," Booz/Allen Applied Research, draft final report submitted to U.S. Environmental Protection Agency, Office of Noise Abatement and Control, EPA Contract No. 68-01-3509, June 22, 1976.

F-12. U.S. Environmental Protection Agency, "Proposed Motorcycle Noise Emission Regulations, EPA Report 550/9-77-203, November, 1977.

F-13. "1975 Automobile Facts & Figures," Motor Vehicle Manufacturers Association, Detroit, Michigan 48202.

F-14. "American Trucking Trends 1975," American Trucking Association, Inc., Washington, D.C. 20036, 1976.

F-15 Kent, P. and M. Branes: "1975 National Truck Characteristic Report," U.S. Department of Transportation, Federal Highway Administration, April 1978.

F-16 Galloway, W.J., K. Eldred, and M.A. Simpson, "Population Distribution of the United States as a Function of Outdoor Noise level," U.S. Environmental Protection Agency Report No. 550/9-74-009A, June 1974.

F-17. Plotkin, K.J., "Average Noise Levels for Highway Vehicles," Wyle Research Technical Note 79-2, prepared for U.S. Environmental Protection Agency, Office of Noise Abatement and Control, September 1979.

F-18 Wyvill, C. (Ed.), "Discussion of Sound Propagation," Technical Meeting, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, held at Crystal City, 14 October 1977.

F-19 Sutherland, L.C., "Indoor Noise Environments Due to Outdoor Noise Sources," Noise Control Engineering, 11(3), 124-137, 1978.

F-20 U.S. EPA, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." EPA Report 550/9-74-004, March, 1974.

F-21 Lukas, J., "Measures of Noise Level: Their Relative Accuracy in Predicting Objective and Subjective Responses to Noise During Sleep," U.S. Environmental Protection Agency, EPA-600/1-77-010, February 1977.

F-22 Lukas, J., "Noise and Sleep: A Literature Review and a Proposed Criteria for Assessing Effect," The Journal of the Acoustical Society of America, Vol. 58 (6), pp. 1232-1242, 1975.