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WCR 77-9

ASSESSMENT OF GROUND SURFACE CORRECTIONS FOR MOTOR VEHICLE NOISE MEASUREMENTS

For

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Noise Abatement and Control
Washington, D.C. 20460

By

Donald B. Pies

WYLE RESEARCH
El Segundo, California 90245

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REPORT

FORWARD

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1.0 INTRODUCTORY SUMMARY

1.1 Purpose

In 1974, the U.S. Environmental Protection Agency (EPA) published a regulation limiting the noise levels produced by trucks operated by motor carriers engaged in interstate commerce. A measurement methodology was included in the background considerations for this regulation that allowed measurements of truck noise levels to be made over hard (i.e., concrete, asphalt, packed dirt or gravel) or soft (i.e., grass or similar absorbent material) surfaces, with an adjustment factor of 2 dB to be added to the latter to account for the effect of ground attenuation. The Bureau of Motor Carrier Safety (BMCS) has the task of enforcing this regulation, and has published an enforcement procedure that includes the 2 dB adjustment factor (see Appendix A).

The provision of the adjustment factor is predicated on simple geometry of ground coverage and does not necessarily apply under other more complex conditions. Also, it appears that a systematic study has not been made of all available data in order to justify the numerical value of the correction factor. The purpose of this program is to study existing data and present recommendations as to the validity of the 2 dB adjustment factor.

1.2 Approach

A number of past studies on truck noise have concentrated on: procedures to collect passby noise data; schemes for data analysis; effects on the noise due to changes in vehicle operation; and, the ambient environment. Potential data discrepancies between these studies have existed because additional noise-influencing factors were not properly considered. It was felt, therefore, that it would not be valid to combine all available data in one overall analysis to determine the surface correction factor, but rather to analyze each set of data separately for only those studies which included both hard and soft sites. This approach unfortunately eliminated the use of several sources of data which only dealt with hard or soft surface conditions. Additionally, sources of data were not used where documentation was sketchy or where too few data measurements existed.

WHAT KINDS OF FACTORS?

In accordance with the criteria set forth to locate useful data, only three studies were found. The most productive source was an extremely well-documented investigation recently performed by the U.S. Department of Transportation, Transportation Systems Center.[1] The other two studies were conducted by Wyle Laboratories – the first for EPA and the second study based on unpublished data.[2,3] Conclusions drawn from each of the three studies are summarized in the following section.

1.3 Overall Conclusions

The available data tend to indicate that for truck noise, 2 dB is a valid surface correction between hard and soft conditions. Recommended values of the surface correction, $\Delta_{H/S}$, classified as "valid without additional verification" and "valid only after additional verification" are given below.

Valid without additional verification:

$\Delta_{H/S}$	Operational Mode of Truck
2 dB	• Low Speed Acceleration, <56 km/h (<35 mph)

Valid only after additional verification:

$\Delta_{H/S}$	Operational Mode of Truck
2 dB	• High-speed Coastby, >56 km/h (>35 mph) • Stationary Runup
3 dB	• High-speed Passby at governed engine speed, >56km/h (>35 mph) • High-speed Passby at typical highway power setting, >56km/h (>35 mph)

Two site-selection recommendations are also presented:

1. Recommendations for Sites with Topographic Deviations –

   Based on conclusions drawn from the Wyle analysis of the DOT Report, Section 325.5.(c).(5). of the BMCS enforcement regulation should not only require that the site be "relatively flat" but that the ground elevation between the microphone position and roadway deviate no more than ±0.3 meters (1 ft.) relative to the roadway*.

2. Recommendations for the Definition of Hard and Soft Sites –

   Based on the Wyle analysis of the DOT Report, Sections 325.5.(c).(1) and (2) of the BMCS enforcement regulation should be revised to read:

   (1) Hard test site means any test site having the ground surface covered with concrete, asphalt, packed dirt, gravel, or similar reflective material for no less than two-thirds the distance between the microphone target point and the microphone location point.

   (2) Soft test site means any test site having the ground surface covered with grass, other ground cover, or similar absorptive material for no less than two-thirds the distance between the microphone target point and the microphone location point.

Other aspects of this study worthy of note are summarized below:

- A thorough analysis of the DOT data revealed an approximate 1 dB reduction in the noise level for each 0.6 meter (2 ft.) decrease in the ground elevation at a 15 meter (50 ft.) microphone location relative to the road.[1]

- No obvious trend was found to indicate that the surface correction factor was truck dependent.[1]

* While a correction procedure to allow for greater deviations in ground elevation might be developed, it is not recommended.

- Tire noise levels seemed to be influenced more by topographic deviations than other sources of truck noise.[1]

- An 11°C (20°F) increase in the ambient temperature will cause an approximate 1 dB decrease in the measured noise for automobiles at 15 meters (50 ft).[4,5]

- For any condition which might effect the noise (surface, weather, etc.), correction factors determined for a passby test are not necessarily valid for a stationary test for automobiles.[5]

- The relative influence of variations in the various types of hard surfaces (asphalt, concrete, etc.) upon the noise are negligible with the exception of tire dominant sources.[5]

Additional work is needed in the following areas:

- Further verification is required to confirm to redefine the values of $\Delta_{H/S}$ recommended in this section under the category of "Valid only after additional verification."

- A comprehensive study should be conducted to investigate, in more detail, the effect of topographic deviations at the microphone location.

- Experimental verification of the proper correction factor for surfaces such as packed dirt or gravel with light grass covering are lacking and should be obtained. Presently, it is recommended that measurement sites with surfaces of this type should be avoided.

2.0 REVIEW OF THE DEPARTMENT OF TRANSPORTATION DATA

WHAT WAS THE PURPOSE OF THE DOT STUDY?

2.1 Introduction

The data in this report were the product of a comprehensive effort, by the U.S. Department of Transportation, Transportation Systems Center (DOT/TSC) under sponsorship of the DOT Office of Noise Abatement. The measurements were made in and around Fort Wayne, Indiana during the period July 10 to July 20, 1974.

Multi-microphone measurements were made at nine highway sites and one standard measuring site to record the passby noise emissions from three specific multi-axle trucks and one from transient fleet trucking (those trucks which happen to pass through the measurement site under normal operation). The three trucks – each of which had a different noise characteristic – were operated under three types of tightly controlled passbys to simulate typical truck operations on the highway. This gave a combination of nine categories of truck-type classifications and operational modes. Measurements performed for transient fleet trucking were made to record typical noise levels of the passbys encountered at the nine highway sites.

The three truck types used in the controlled passby test were:

- Vehicle IH 843 – Engine and exhaust dominant, lug-type rear tires.
- Vehicle IH 866 – Fan dominant, lug-type rear tires.
- Vehicle IH 394 – Exhaust dominant, quiet rib-type rear tires.

Each of these trucks made several passbys for the three operational modes listed below.

- Acceleration – Each vehicle passby conformed to SAE-J366b. Truck speeds were typically 32 to 48 km/h (20 to 30 mph) at the microphone position. Extreme care was used to accelerate consistently for each test.
- Power-by – Each vehicle passby was made at approximately 88 km/h (55 mph) and at the maximum rated engine speed.

- Coastby – Each vehicle approached the measurement position at such a speed so as to coast-by at approximately 88 km/h (55 mph) after the engine power was cut at a point 76 meters (250 ft) upstream of the microphone centerline. The lug-type rear tires were expected to dominate the noise emission.

Transient fleet trucks considered for measurement were limited to those passbys with a 61 meter (200 ft) minimum distance between vehicles. Speeds typically recorded were within the range of 72 to 97 km/h (45 to 60 mph) for the more than 300 truck passbys.

Numerous microphone ground locations and vertical heights were used at each site but only positions which conformed with the BMCS regulation standards were analyzed here. Therefore, only the 15 meter (50 ft) microphone-to-roadway center spacing and the 1.2 meter (4 ft) microphone height were considered. Data measured at the remaining microphones are covered by the extensive documentation of the complete report.[1]

Hard and soft sites are defined in the BMCS Motor Carrier Noise Emission Standards as follows:

- "Hard test site means any test site having ground surface covered with concrete, asphalt, packed dirt, gravel, or similar reflective material for more than one-half the distance between the microphone target point and the microphone location point."
- "Soft test site means any test site having the ground surface covered with grass, other ground cover, or similar absorptive material for one-half or more of the distance between the microphone target point and the microphone location point."

These definitions do not differentiate between a site that is slightly dominant in one type of surface condition and one that is entirely composed of the same surface material. In other words, the BMCS standards do not distinguish between a site consisting of 100 percent hard surface and a site consisting of 51 percent hard and 49 percent soft surface. Among the 10 sites analyzed in the DOT study, the proportion of hard to soft surface covering varied from entirely hard to 32 percent hard and 68 percent soft. Combinations of surface proportions for these sites are illustrated in Figure 2-1. A site that is predominantly soft will typically have no more than 68 percent soft surface coverage due to the hard breakdown lane and one-half the active lane encompassing a total of approximately 4.9 meters (16 ft). Additional data were collected at Sites 5, 6, and 7 for truck acceleration tests with the vehicle in Lane 2. In effect, this added 3.7 meters (12 ft) of hard surface to the site (the microphone was moved inward 3.7 meters to compensate for the lane shift) and changed the Site 5 classification from soft to hard. Therefore, Site 5, Lane 2 data was grouped with Sites 1, 3, 6 and 7.

2.2 Conclusions Regarding the DOT Data

A comprehensive analysis of the data in the DOT report was conducted, and the details are presented in Appendix B. Conclusions drawn from this analysis are given in the following section.

2.2.1 Summary of Recommended Values of the Hard/Soft Correction Factor, $\Delta_{H/S}$

Based on analysis of the data in the DOT study, recommended values of $\Delta_{H/S}$ are:

$\Delta_{H/S}$	Operational Mode of Truck
2 dB	• Acceleration from low speed • High speed coastby
3 dB	• High speed passby at governed engine speed • High speed passby at typical highway power setting

The nominal 2 dB value of $\Delta_{H/S}$ for acceleration and for high speed coastby operations was generally within half a decibel of $\Delta_{H/S}$ calculated for each of the controlled passby tests. Standard deviations within each of these tests were very much less than $\Delta_{H/S}$, thus implying that the mean values of $\Delta_{H/S}$ were very reliable. Other studies, concentrating on transient fleet noise levels, have also shown that 2 dB is a reasonable correction for a

WHAT OTHER STUDIES?

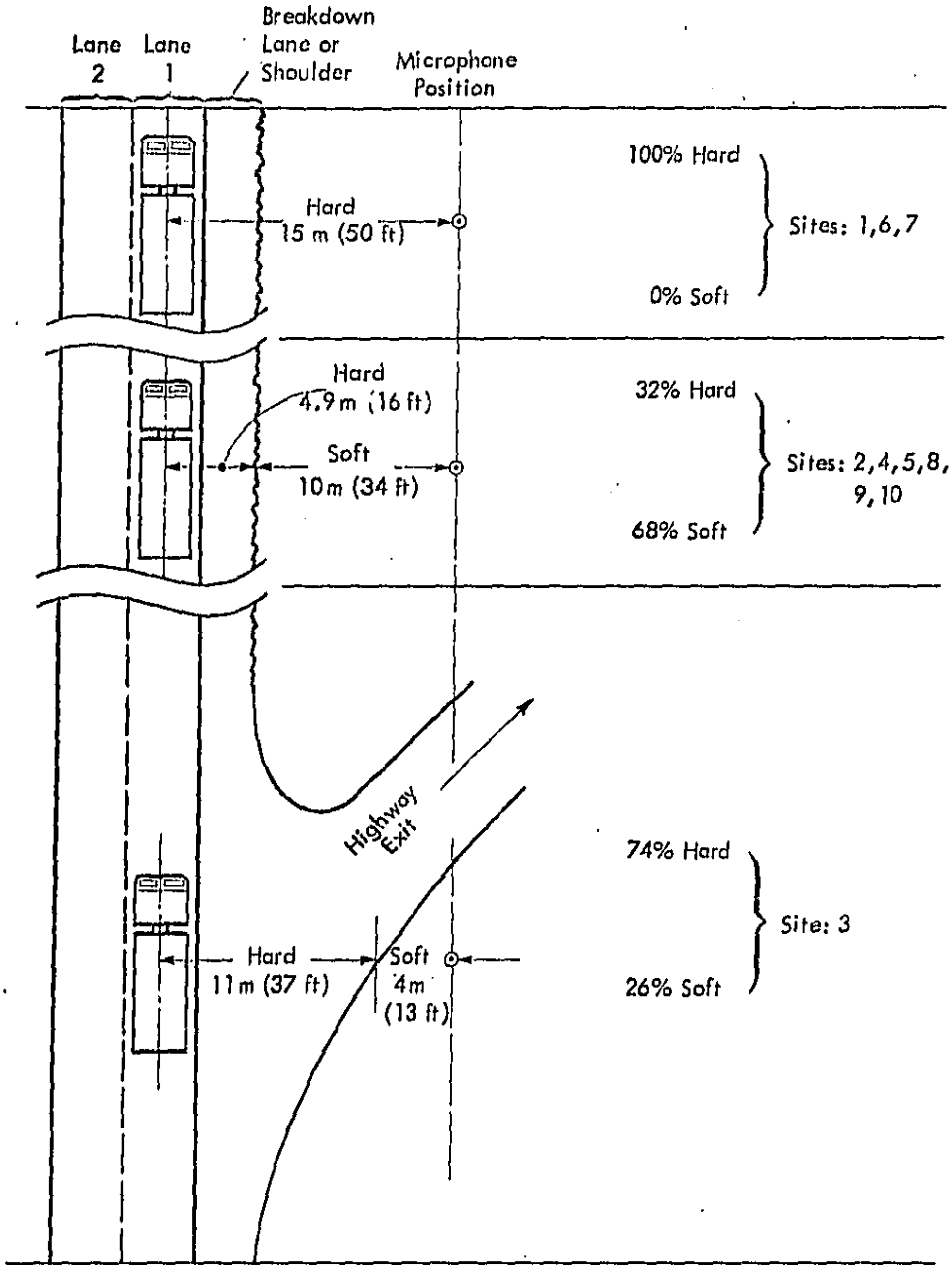

Figure 2-1. Combinations of Hard and Soft Sites Encountered in the DOT Study

WHAT TWO TESTS?

truck accelerating from a low speed.[2,3] The agreement between $\Delta_{H/S}$ for controlled and transient fleet acceleration passbys indicates the two are compatible tests to determine effects of the surface conditions. No other studies were found which investigated ground surface corrections for high speed coastby tests and, therefore, conclusions regarding the validity of $\Delta_{H/S}$ for this mode of operation were based exclusively on the controlled passby test data in the DOT report.

The 3 dB correction assigned to the high speed passbys at governed engine speed and typical highway power settings showed fairly tight grouping of $\Delta_{H/S}$ values for two of the three trucks in the controlled passby test and for the transient fleet passbys. No reason was given why the third truck — IH-394 — gave a distinctly different value of $\Delta_{H/S}$ than the other cases. For each of the three trucks in the power-by test, the standard deviations of the hard and soft average noise levels were again much smaller values than the $\Delta_{H/S}$. On the other hand, the transient fleet passby test yielded standard deviations of approximately 3 dB. Such a standard deviation was equivalent to typical values in other studies which observed transient fleet passby noise and therefore, the DOT data could be considered a close representation of the entire national fleet.[2,3] The general agreement between $\Delta_{H/S}$ for controlled and transient passby tests again indicates that each are valid procedures to calculate the surface correction factor. The choice of the value of 3 dB as a correction factor for the high speed passby test was made with reservation since no other investigation had chosen such a value for this condition.

2.2.2 Other Influences On the Noise

2.2.2.1 Sites With Uneven Ground Surface

The apparent influence of uneven ground surface upon the noise measured at 15 meters (50 ft) in the DOT study clearly indicates that sites should be as level as possible. Correction factors developed in Appendix B suggest a 1 dB reduction for each 0.6 meter- (2 ft) decrease in the ground elevation (at a 15 meter microphone location) relative to the road. Extrapolation of the data in Figure B-1 was not performed in this analysis because it was not considered to be a valid process for general situations. In addition, for road-to-microphone distances other than 15 meters (50 ft), noise level variations due to topographic deviations will have a relationship other than that shown in Figure B-1. In other words, Figure B-1 is valid only for the stated road-to-microphone distance.

WHAT ARE WE GOING TO DO IF WE SUPPORT THE POSITION THAT MEASUREMENTS MAY BE MADE AT 30 FT?

The application of correction factors to compensate for both uneven ground surfaces as well as the composition of the surface itself (i.e., hard or soft) is not deemed to be a technique sufficiently accurate for regulation enforcement. Introduction of more than one correction factor can inject an unacceptable composite error into the final result. Errors of this type can thus be avoided by stipulating that the maximum allowable difference in ground elevation at the roadway and microphone sites be 0.3 meters (1 ft). Possible error resulting from uneven ground surfaces will thus be eliminated.

HOW WILL THIS AFFECT THE # OF ACCEPTABLE ENFORCEMENT SITES? WHY 1 FT?

No obvious trend in the calculated values of $\Delta_{H/S}$ was found that indicated the type of truck had any influence on the surface correction factor. This conclusion was formulated by observing that there was no consistent trend in surface correction factor between each of the three trucks and three operational modes (nine combinations).

2.2.2.2 Effects of Deviations in Ground Elevation On Tire Noise

A comparison of data from the coastby test and the other two types of controlled passby test was made and a trend was observed which indicated that tire noise is influenced more drastically by topographic deviations than other sources of truck noise. The method used to detect this trend required a comparison of the slope of each of the 18 linear regression curves used for evaluating topographic deviations which are tabulated in Tables B-1, B-2, and B-3 of Appendix B. Generally, these curves indicated a larger slope for ground elevation differences for trucks with lug-type rear tires when performing the coastby test than for all other test combinations. Even the quiet rib-type tires used in the coastby test did not appear to have as great a slope in the linear regression curves for ground elevation differences as the lug-type tires. This trend was not well quantified because the sample size was too small to substantiate a well-defined correction factor.

2.2.2.3 Effects of Slight Variations in the Surface Type

The DOT data indicate that changing the area of the site from 32 percent hard surface to 56 percent hard surface can easily increase the maximum passby noise level by one decibel. This trend was observed from a limited amount of data for the acceleration test at Site 5 (see Table B-1 in Appendix B). At this site, measurements were taken in the first and second lanes such that the second lane data effectively contained 3.7 meters more (12 ft) of hard surface between the microphone and roadway. The microphone was moved to maintain the standard 15 meter (50 ft) separation distance. These findings indicate that noise levels recorded at sites which have slightly over one-half the microphone-to-roadway distance consisting of a soft surface might be influenced by the near majority of the hard surface, and thus be unfairly required to meet the more stringent soft surface criteria.

In summary, the DOT data suggest that a preferred site classification scheme would be the following:

1. A soft site must consist of at least two-thirds of the microphone-to-roadway distance having ground surface covered with grass, other ground cover, or similar absorptive material (see Figure 2-2a).
2. A hard site must consist of at least two-thirds of the microphone-to-roadway distance having ground surface covered with concrete, asphalt, packed dirt, gravel, or similar reflective material (see Figure 2-2b).
3. Sites which do not qualify under either of these definitions should be eliminated to reduce ambiguous application of surface correction factors.

2.2.3 Discussion of the DOT Analysis of the Data

The bulk of the DOT report consists of a comprehensive documentary presentation which covered all phases of the data collection and analysis. DOT's analysis differed from the analysis presented here in two ways. First, the DOT interpolation scheme for correcting the noise levels measured at the 1.2, 2.4, and 3.7 meter (4, 8, and 12 ft) microphone heights to an equivalent 1.2 meter (4 ft) elevation above the road was based on limited data. Significant differences exist between the correction factors computed by DOT and those presented in this analysis. Second, DOT averaged together the noise levels

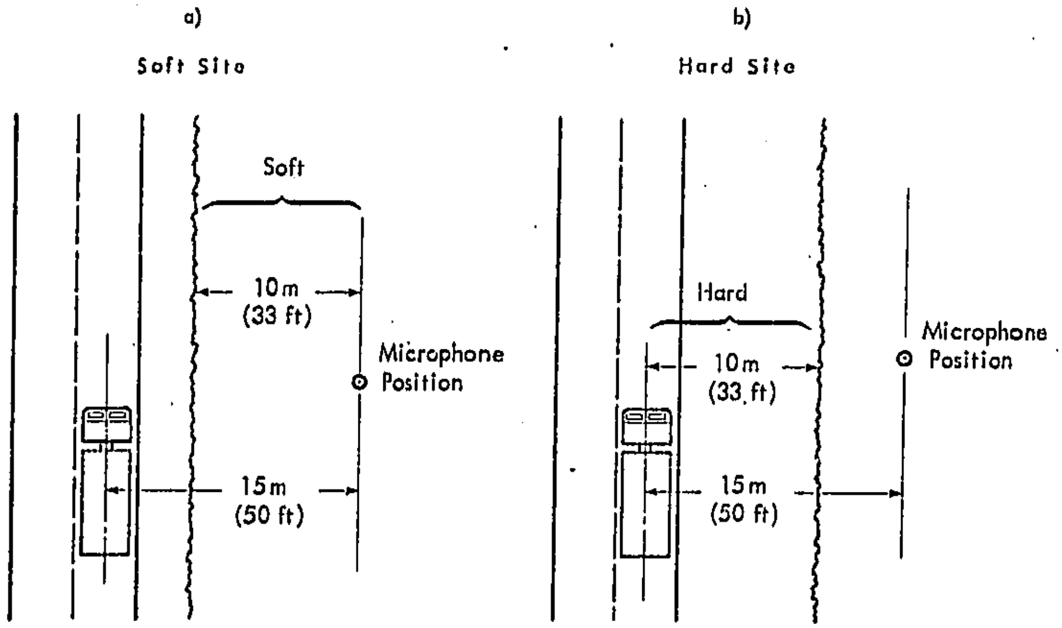

Figure 2-2. Recommended Minimum Distance Allowable For Soft and Hard Site Classifications.

of the three trucks in the controlled passby test to determine a representative noise level for the hard surfaces and one for the soft surfaces, and then determined surface differences. It was felt that noise levels from the different trucks should not be combined unless a large number of trucks were used to assure a fleet-representative distribution of data. This analysis treated the truck noise levels for the controlled passby calculations of $\Delta_{H/S}$ separately for each of the three operational modes. These calculations of $\Delta_{H/S}$ eliminated the absolute noise levels of the three trucks which then made composite averages valid for each of the three operational modes.

DOT only summarized $\Delta_{H/S}$ at 15 meters (50 ft) for the power-by case. Two classifications of soft surfaces were given, one for "predominantly soft" and the other for "soft." Similar definitions were assigned to hard surfaces. Values of $\Delta_{H/S}$ were defined as:

Hard	Sites 1, 7, and 6	0 dB
Predominantly Hard	Site 3	0 dB
Predominantly Soft	Sites 4, 10, and 2	2.0 dB
Soft	Sites 5 and 8	2.5 dB

DOT's values of $\Delta_{H/S}$ differ by 0.5 to 1.0 dB from the values of $\Delta_{H/S}$ found in the present investigation. It is also noted that DOT eliminated Site 9 because that site required a positive elevation correction which could not be determined by using the DOT topographic correction method.

3.0 REVIEW OF THE WYLE 1974 DATA

3.1 Introduction

Truck noise data were collected in 1974 by Wyle Laboratories and consisted of noise measurements for numerous trucks over both hard and soft surfaces along the same stretch of road.[3] Additional aspects of this data are listed below:

- All measurements were performed for truck acceleration from an initial low speed – <56 km/h (<35 mph).
- Truck driver instructions were to pass the measurement stations at the governed engine speed; truck speeds were never greater than 48 km/h (30 mph).
- Vehicles used in the test consisted of transient fleet trucks.
- Each truck passed the hard and soft sites in succession.
- Microphones were 15 meters (50 ft) from the center of the passby lane; 1.2 meters (4 ft) above the ground; and 46 meters (150 ft) separated the hard and soft sites.
- The absolute noise level at each site and the difference between noise levels for the two sites were recorded for each truck passby.
- Three days were required to record three sets of data with 100 to 150 truck samples per day.
- The hard surface consisted of an asphalt ground cover.
- The soft surface consisted of dry ground with light grass cover.
- Although these tests were performed in California, it was obvious that some trucks were far from compliance with the state noise regulation.
- Typical temperatures ranged from 18°C to 32°C (65°F to 90°F) and wind speeds were low and considered to be of no consequence.

- Most of the trucks were of the cab-over-engine style.
- For the hard site, the ground elevation at the microphone was 5.1 cm (2 in.) below the roadway.
- For the soft site, the ground elevation at the microphone was 30.5 cm (12 in.) below the roadway.

3.2 Presentation and Discussion of the Data

Noise level histograms of the hard and soft data for the three days are given in Figure 3-1, 3-2, and 3-3. Generally the shape of the histograms indicated similar trends of the data distributions. Three levels were recorded for each truck passby:

1. Absolute value of the maximum passby noise level at the hard site,
2. Noise level at the soft site,
3. The difference between hard and soft noise levels for each individual truck.

?

Arithmetic averages and standard deviations for the three levels of the three days are given in Table 3-1.

Table 3-1

Summary of the Wyle-1974 Data

Δ_{H/S_1} = the average of the "n" individual differences in the noise between hard and soft sites.

Δ_{H/S_2} = the difference between the average noise level at the hard and soft sites.

n = the number of passbys.

Date	Hard Site		Soft Site		Δ_{H/S_1} dB	STD DEV dB	Δ_{H/S_2} dB	n
	Average Noise Level dBA	Standard Deviation dB	Average Noise Level dBA	Standard Deviation dB				
10/ 8/74	85.1	3.6	83.3	3.3	1.8	2.0	1.8	97
10/ 9/74	86.1	3.1	84.4	3.1	1.75	2.1	1.72	150
10/10/74	86.1	3.3	84.2	3.4	1.87	1.9	1.91	159

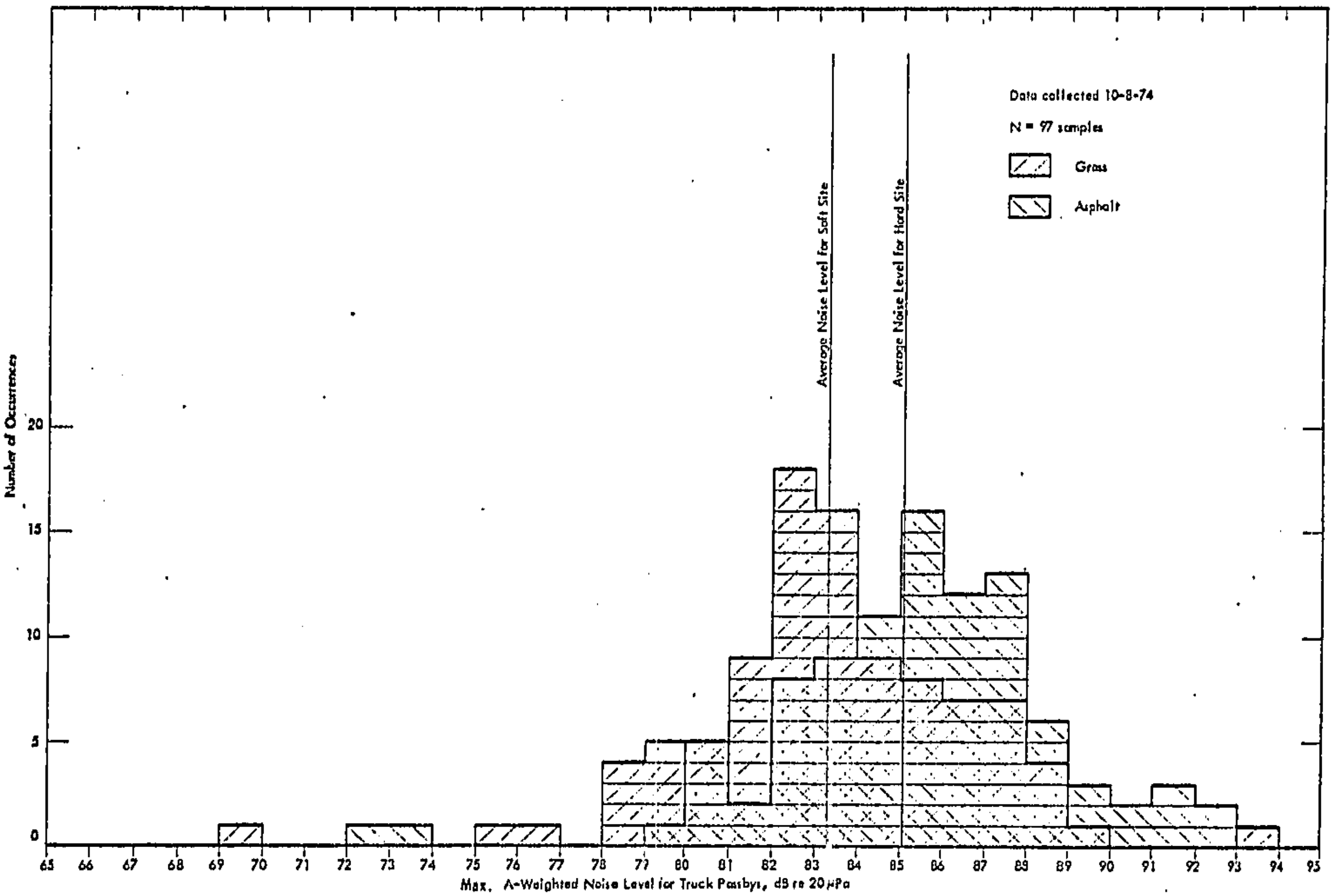

Figure 3-1. Distribution of Noise Levels Recorded October 8, 1974.

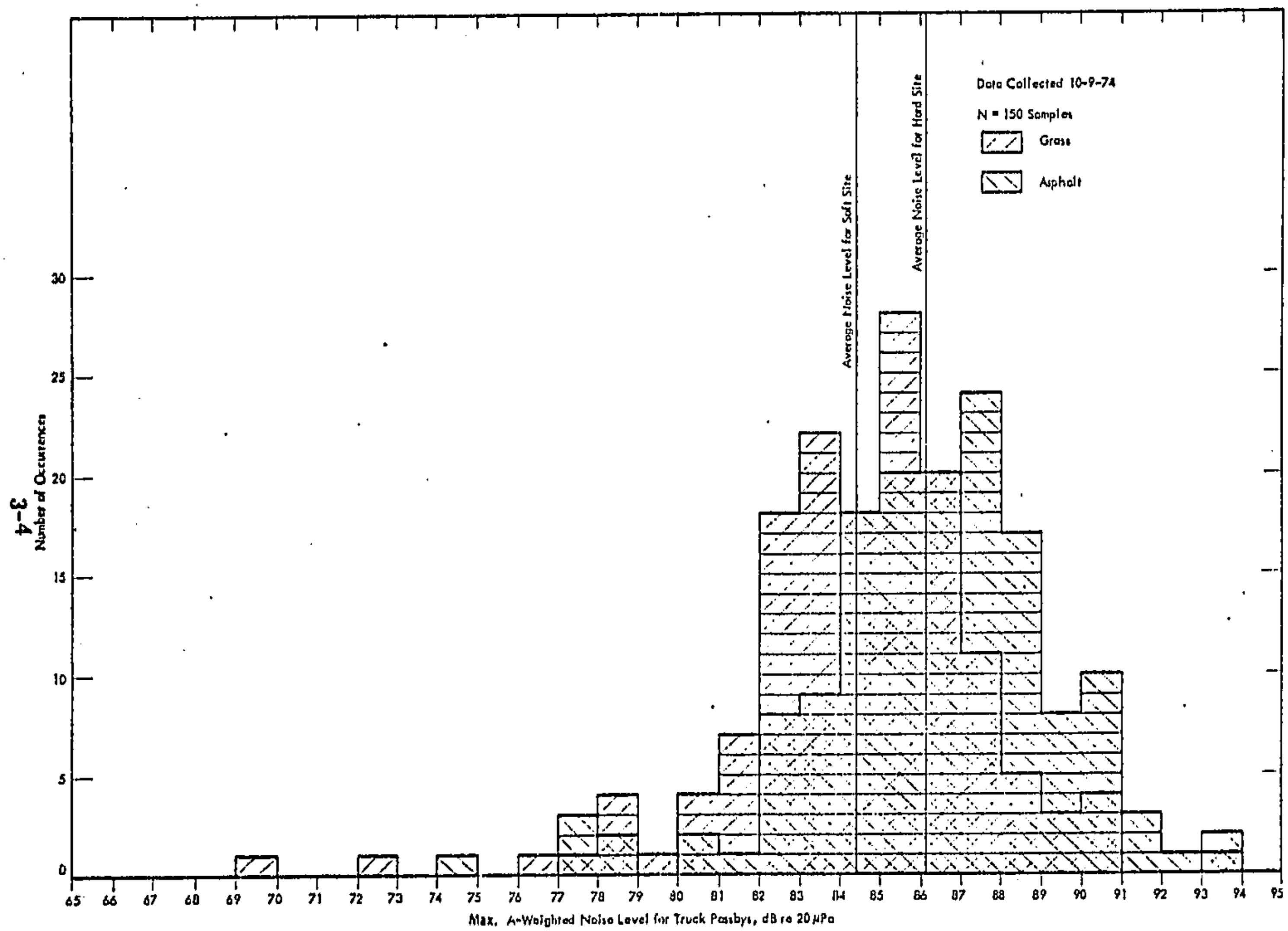

Figure 3-2. Distribution of Noise Levels Recorded October 9, 1974.

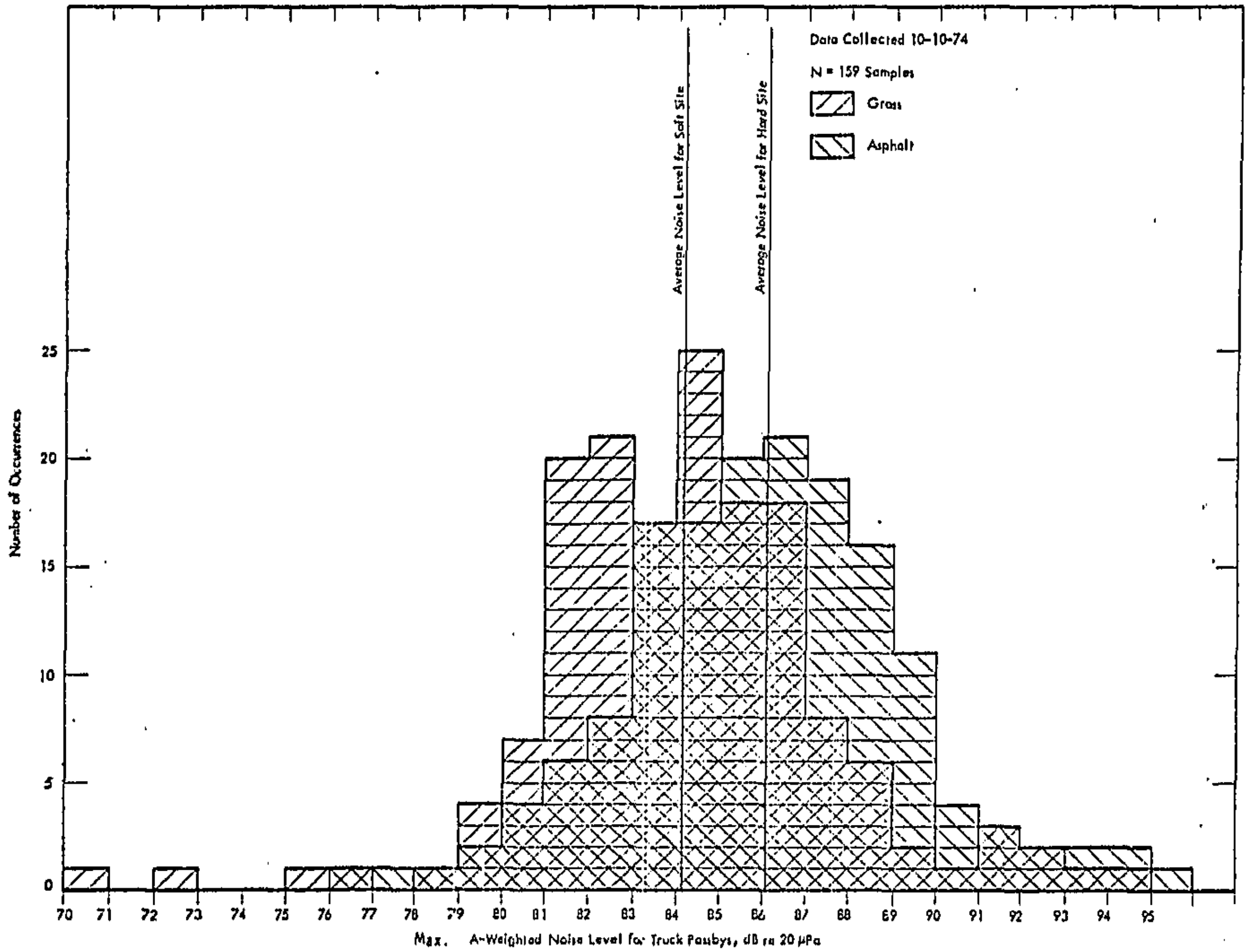

Figure 3-3. Distribution of Noise Levels Recorded October 10, 1974.

The arithmetic average values of the maximum noise levels of the truck passbys showed close agreement between the second and third days and a 1 dB deviation from the first day. Standard deviations were typically 3.0 to 3.5 dB for all cases, which was consistent with other studies that measured large numbers of trucks.[1,2] The spread of the data was attributed to driver-to-driver differences, truck-to-truck noise production differences, and an approximate 14°C (25°F) temperature variation over each day the data were collected. The driver-to-driver differences were apparent because some drivers had obviously interpreted the drive-by instructions differently than others. None of the data was subjectively eliminated because this would place a bias on the data base and typical deviations from actual field enforcement situations would not be represented. The large data sample for each day was taken to assure that the calculated average noise levels were representative of the true average levels for the California truck fleet.

It is interesting to compare values of Δ_{H/S_1} (the average of the individual differences in the noise levels between hard and soft sites) and Δ_{H/S_2} (the difference between the average noise levels at the hard and soft sites). For identical sample populations, these two values are mathematically equivalent. However, variations in the measurement conditions over the period of the tests produce intrinsic differences in these values. These variations consist of inherent small measurement errors as well as slight fluctuations in ambient weather conditions over a period of time. Δ_{H/S_1} is, therefore, a preferred value since each truck passby is measured at approximately the same time, thus eliminating any errors due to changes in ambient conditions. It is worthwhile to note, however, that the results for Δ_{H/S_1} and Δ_{H/S_2} are, for all practical purposes, equivalent. The above error factors are quite small and may, in fact, be neglected.

In practice, Δ_{H/S_1} is quite difficult to measure and, indeed, most studies look only at Δ_{H/S_2} which is fairly easy to measure and is practically equivalent to Δ_{H/S_1}. This equivalence validates the use of Δ_{H/S_2} in previous studies.[3]

Although there existed large variations in individual Δ_{H/S_1} values, the overall results were considered to be quite good since a large sample size was used and there was close agreement among the three days of data-taking.

3.3 Conclusions Regarding the Wyle-1974 Data

Based on the Wyle-1974 data, the recommended value of $\Delta_{H/S}$ for truck acceleration from a low speed was 1.8 dB. This value was chosen with some reservation for the general case for two reasons. First, the ground elevation at the microphone was 30.5 cm (12 in.) below the roadway at the soft site and only 5.1 cm (2 in.) at the hard site. Application of the correction factors developed through analysis of the DOT data indicated a 0.5 dB correction should be applied to the soft site, which would accordingly change $\Delta_{H/S}$ to equal 1.3 dB.[1] The second reason for reservation in selection of the value of $\Delta_{H/S}$ was due to the fact that the soft site was composed of dry ground with light grass covering and thus was an example of a condition somewhere between hard and soft. These results can be construed to imply an intermediate correction between hard and soft sites. This would be consistent with the recommended $\Delta_{H/S}$ value of 2.0 dB at sites having the recommended definition of "hard" or "soft."

4.0 REVIEW OF THE WYLE/EPA REPORT

4.1 Introduction

A study was conducted for the EPA in 1973 to establish a background data base of truck noise levels in different parts of the country under different operating conditions. In all, 7,449 trucks were monitored at 25 locations in speed zones of less than or greater than 56 km/h (35 mph). All data were collected at 15 meters (50 ft) from the center of the lane and 1.2 meters (4 ft) above the ground. No record of topographic deviations or weather variations at the various sites was kept.

4.2 Presentation and Discussion of the Data

The only data applicable for calculating the surface correction factor were for trucks accelerating in speed zones less than 56 km/h (35 mph). The cumulative distribution, plotted in Figure 4-1 on probability graph paper, depicts the data for both hard and soft surfaces and indicates a standard deviation of about 4 dB assuming a normal distribution. Comparison of these two distribution curves clearly reveals the existence of an approximate 2 dB difference between maximum passby levels for hard and soft sites. This difference was only determined for trucks accelerating at low speed. As in the Wyle-1974 data, no correction is given for typical high-speed truck passbys.

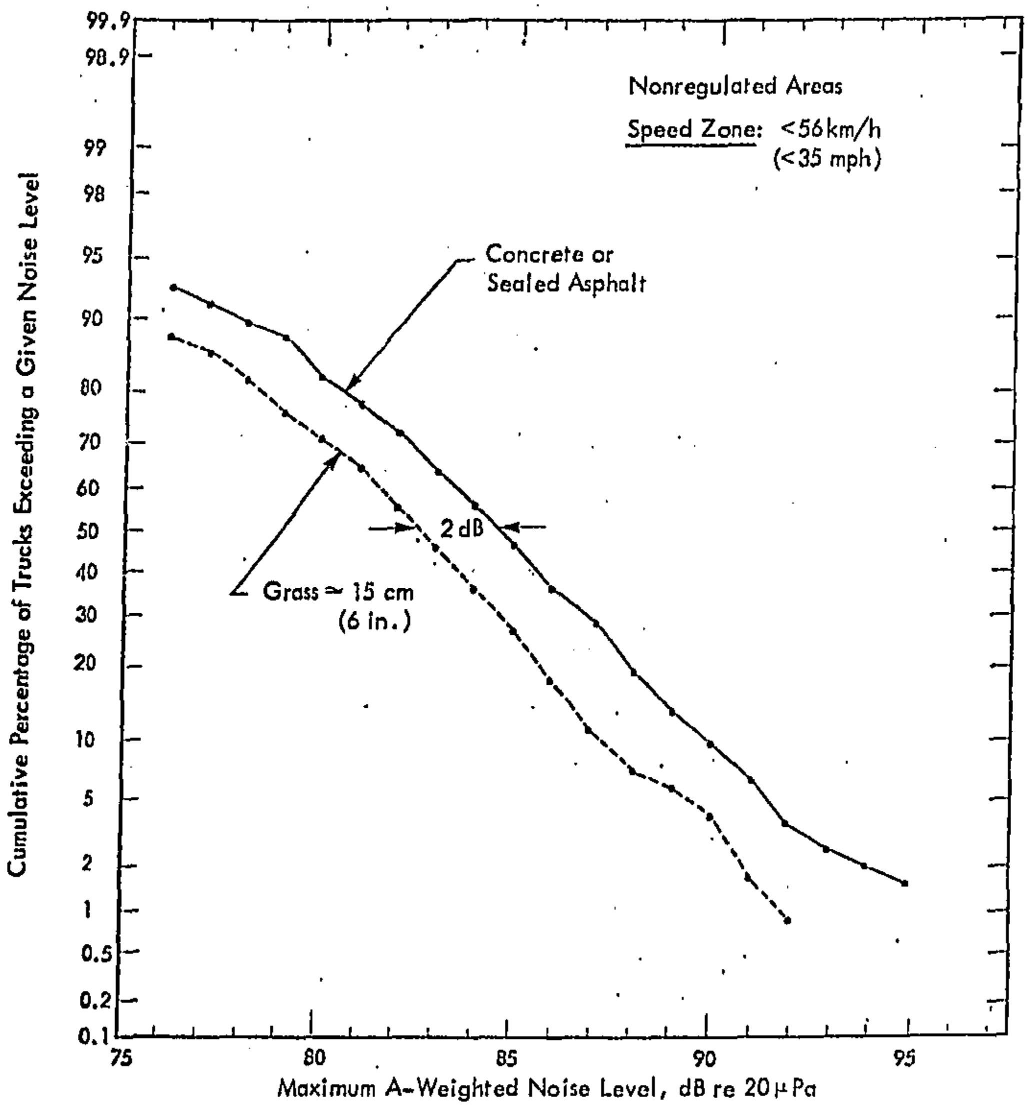

Figure 4-1. Overall Noise Level Distribution for Trucks Accelerating in Speed Zones <56 km/h (<35 mph) with Ground Surface as Parameter.

REFERENCES

1. Rickely, E.J. and Quinn, R.W., "Noise Measurement Data for Highway Site Qualification," U.S. Department of Transportation, Transportation Systems Center, final report draft. 1976.

2. Sharp, B.H., "A Study of Truck Noise Levels and the Effect of Regulations," Wyle Laboratories Report WR 74-8, prepared for U.S. Environmental Protection Agency. December 1974.

3. Thompson, J.W., Unpublished truck noise data, Wyle Laboratories. October, 1974.

4. Hillquist, R.K., and Bettis, R.A., Measurement of Automobile Passby Noise, SAE Paper 720275, SAE Transactions 81 (1972).

5. Piercy, J.E., Embleton, T.F.W., and Olson, N., "Mechanisms Causing Variability in the Noise Testing of Light Motor Vehicles," Division of Physics, National Research Council, Ottawa, Ontario. March, 1976.

APPENDIX A

DEPARTMENT OF TRANSPORTATION, BUREAU OF MOTOR CARRIER SAFETY REGULATIONS FOR ENFORCEMENT OF MOTOR CARRIER NOISE EMISSION STANDARDS

DEPARTMENT OF TRANSPORTATION BUREAU OF MOTOR CARRIER SAFETY REGULATIONS FOR ENFORCEMENT OF MOTOR CARRIER NOISE EMISSION STANDARDS

(Title 49, Code of Federal Regulations Chapter II, Part 325, 40 FR 42437, September 12, 1975, Effective October 15, 1975, Amended 41 FR 10227, March 10, 1976, 41 FR 28267, July 9, 1976)

AUTHORITY: sec. 18, 86 Stat. 1234, 1249-1250, 42 U.S.C. 4917.

Subpart A—General Provisions

§ 325.1 Scope of the rules in this part.

(a) The rules in this Part prescribe procedures for inspection, surveillance, and measurement of motor vehicles and motor vehicle equipment operated by motor carriers to determine whether those vehicles and that equipment conform to the Interstate Motor Carrier Noise Emission Standards of the Environmental Protection Agency, 40 CFR Part 202.

(b) Except as provided in paragraph (c) of this section, the rules in this Part apply to motor carriers engaged in interstate commerce. The rules apply at any time or under any condition of highway grade, load, acceleration or deceleration.

(c) The rules in this Part do not apply to—

(1) A motor vehicle that has a Gross Vehicle Weight Rating (GVWR) of 10,000 pounds (4,536 kg.) or less;

(2) A combination of motor vehicles that has a Gross Combination Weight Rating (GCWR) of 10,000 pounds (4,536 kg.) or less;

(3) The sound generated by a warning device, such as a horn or siren, installed in a motor vehicle, unless such device is intentionally sounded in order to preclude an otherwise valid noise emission measurement;

(4) An emergency motor vehicle, such as a fire engine, an ambulance, a police van, or a rescue van, when it is responding to an emergency call;

(5) A snow plow in operation; or

(6) The sound generated by auxiliary equipment which is normally operated only when the motor vehicle on which it is installed is stopped or is operating at a speed of 5 miles per hour (8 kph) or less, unless such device is intentionally operated at speeds greater than 5 mph (8 kph) in order to preclude an otherwise valid noise measurement. Examples of that type of auxiliary equipment include, but are not limited to, cranes, asphalt, spreaders, ditch diggers, liquid or slurry pumps, auxiliary air compressors, welders, and trash compactors.

§ 325.3 Effective date.

The rules in this part are effective on October 15, 1975.

§ 325.5 Definitions.

(a) Statutory definitions. All terms defined in the Noise Control Act of 1972 (Pub. L. 92-574, 86 Stat. 1234) are used as they are defined in that Act.

(b) Definitions in standards. All terms defined in § 202.10 of the Interstate Motor Carrier Noise Emission Standards, 40 CFR 202.10, are used as they are defined in that section.

(c) Additional definitions.

(1) "Hard test site" means any test site having the ground surface covered with concrete, asphalt, packed dirt, gravel, or similar reflective material for more than ½ the distance between the microphone target point and the microphone location point.

(2) "Soft test site" means any test site having the ground surface covered with grass, other ground cover, or similar absorptive material for ½ or more of the distance between the microphone target point and the microphone location point.

(3) "Ground cover" means any of various low, dense-growing plants, such as ivy, myrtle, low weeds, or brush.

(4) "Traffic railing" means any longitudinal highway traffic barrier system installed along the side or median of a highway. For the purpose of this part, a traffic railing must have at least 35 percent of its vertical height, from the ground surface to the top of the railing, open to free space in order to qualify as an acceptable object within a noise measurement test site. Further, for the purposes of this part, posts or other discrete supports shall be ignored when ascertaining open free space.

(5) "Relatively flat" when used to describe a noise measurement site means a site which does not contain significant concave curvatures or slope reversals that may result in the focusing of sound waves toward the microphone location point.

§ 325.7 Allowable noise levels.

Motor vehicle noise emissions, when measured according to the rules of this part, shall not exceed the values specified in Table 1.

TABLE 1.—*Maximum Permissible Sound Level Readings* [decibel(A)][1,2]

If the distance between the microphone location point and the microphone target point is—	Highway operations test				Stationary tests	
	Soft site		Hard site		Soft site	Hard site
	35 mi/h or less	Above 35 mi/h	35 mi/h or less	Above 35 mi/h		
35 ft (10.7 m) or more but less than 39 ft (11.9 m)	89	93	91	95	89	91
39 ft (11.9 m) or more but less than 43 ft (13.1 m)	88	92	90	94	88	90
43 ft (13.1 m) or more but less than 48 ft (14.6 m)	87	91	89	93	87	89
48 ft (14.6 m) or more but less than 58 ft (17.1 m)	86	90	88	92	86	88
58 ft (17.1 m) or more but less than 70 ft (21.3 m)	85	89	87	91	85	87
70 ft (21.3 m) or more but less than 83 ft (25.3 m)	84	88	86	90	84	86

[1] The speeds shown refer to measurements taken at sites having speed limits as indicated. These speed limits do not necessarily have to be posted.
[2] This table is based on motor carrier noise emission requirements specified in 40 CFR 202.20 and 40 CFR 202.21.

§ 325.9 Measurement tolerances.

(a) Measurement tolerances will be allowed to take into account the effects of the following factors:

(1) The consensus standard practice of reporting field sound level measurements to the nearest whole decibel.

(2) Variations resulting from commercial instrument tolerances.

(3) Variations resulting from the topography of the noise measurement site.

(4) Variations resulting from atmospheric conditions such as wind, ambient temperature, and atmospheric pressure.

(5) Variations resulting from reflected sound from small objects allowed within the test site.

(6) The interpretation of the effects of the above cited factors by enforcement personnel.

(b) Measurement tolerances shall not exceed 2 decibels for a given measurement.

Subpart B—Administrative Provisions

§ 325.11 Issuance, amendment, and revocation of the rules in this part.

The procedures specified in Part 389 of this Chapter for the issuance, amendment, or revocation of the Federal Motor Carrier Safety Regulations apply to rulemaking proceedings for the issuance, amendment, or revocation of the rules in this part.

§ 325.13 Inspection and examination of motor vehicles.

(a) Any special agent of the Federal Highway Administration (designated in Appendix B to Subchapter B of this Chapter) is authorized to inspect, examine, and test a motor vehicle operated by a motor carrier in accordance with the procedures specified in this Part for the purpose of ascertaining whether the motor vehicle and equipment installed on the motor vehicle conforms to the Interstate Motor Carrier Noise Emission Standards of the Environmental Protection Agency, 40 CFR Part 202.

(b) A motor carrier, its officers, drivers, agents, and employees must, at any time, submit a motor vehicle used in its operations for inspection, examination, and testing for the purpose of ascertaining whether the motor vehicle and equipment installed on it conforms to the Interstate Motor Carrier Noise Emission Standards of the Environmental Protection Agency, 40 CFR Part 202.

(c) *Prescribed Inspection Report.* Form MCS-63, Driver-Equipment Compliance Check shall be used to record findings from motor vehicles selected for noise emission inspection by authorized employees.

(d) *Motor Carrier's Disposition of Form MCS 63.* (1) The driver of any motor vehicle receiving a Form MCS 63 shall deliver such MCS 63 to the motor carrier operating the vehicle upon his arrival at the next terminal or facility of the motor carrier, if such arrival occurs within twenty-four (24) hours. If the driver does not arrive at a terminal or facility of the motor carrier operating the vehicle within twenty-four (24) hours he shall immediately mail the Form MCS 63 to the motor carrier. For operating convenience, motor carriers may designate any shop, terminal, facility, or person to which it may instruct its drivers to deliver or forward Form MCS 63. It shall be the sole responsibility of the motor carrier that Form MCS 63 is returned to the Federal Highway Administration, in accordance with the terms prescribed thereon and in subparagraphs (2) and (3) of this paragraph. A driver, if himself a motor carrier, shall return Form MCS 63 to the Federal Highway Administration, in accordance with the terms prescribed thereon and in subparagraphs (2) and (3) of this paragraph.

(2) Motor carriers shall carefully examine Forms MCS 63. Appropriate corrective action shall be taken on vehicles found to be not in compliance with the requirements of this Part.

(3) Motor carriers shall complete the "Motor Carrier Certification of Action Taken" on Form MCS-63 in accordance with the terms prescribed thereon. Motor carriers shall return Forms MCS-63 to the Director, Regional Motor Carrier Safety Office of the Bureau of Motor Carrier Safety, Federal Highway Administration, at the address indicated upon Form MCS-63 within fifteen (15) days following the date of the vehicle inspection.

[325.13(c), (d), added at 41 FR 10226, March 10, 1976]

Subpart C—Instrumentation

§ 325.21 Scope of the rules in this subpart.

The rules in this subpart specify criteria for sound level measurement systems which are used to make the sound level measurements specified in Subpart D and Subpart E of this part.

§ 325.23 Type of measurement systems which may be used.

The sound level measurement system must meet or exceed the requirements of American National Standard Specification for Sound Level Meters (ANSI S1.4-1971), approved April 27, 1971, issued by the American National Standards Institute,[1] throughout the applicable frequency range for either:

(a) A Type 1 sound level meter;

(b) A Type 2 sound level meter; or

(c) A Type S sound level meter which has—

(1) A-weighting frequency response;

(2) Fast dynamic characteristics of its indicating instrument; and

(3) A relative response level tolerance consistent with those of either a Type 1 or Type 2 sound level meter, as specified in Section 3.3 of ANSI S1.4-1971.

§ 325.25 Calibration of measurement systems.

(a)(1) The sound level measurement system must be calibrated and appropriately adjusted at one or more frequencies in the range from 250 to 1,000 Hz at the beginning of each series of measurements and at intervals of 5-15 minutes thereafter, until it has been determined that the sound level measurement system has not significantly drifted from its calibrated level. Once this fact has been established, calibrations may be made at intervals once every hour. A significant drift shall be considered to have occurred if a 0.3 dB or more excursion is noted from the system's predetermined reference calibration level. In the case of systems using displays with whole decibel increments, the operator may visually judge when the 0.3 dB drift has been met or exceeded.

[325.25(a)(1) amended at 41 FR 10227, March 10, 1976]

(2) The sound level measurement system must be checked periodically by its manufacturer, a representative of its manufacturer, or a person of equivalent special competence to verify that its accuracy meets the manufacturer's design criteria.

(b) An acoustical calibrator of the microphone coupler type designed for the sound level measurement system in use shall be used to calibrate the sound level measurement system in accordance with paragraph (a) of this section. The calibration must meet or exceed the accuracy requirements specified in § 5.4.1 of the American National Standard Institute Standard *Methods for Measurements of Sound Pressure Levels,* (ANSI S1.13-1971) for field method measurements.

[325.25(b) amended at 41 FR 10227, March 10, 1976]

§ 325.27 Windscreens.

A properly installed windscreen, of the type recommended by the manufacturer of the Sound Level Measurement System, shall be used during the time that noise emission measurements are being taken.

Subpart D—Measurement of Noise Emissions Highway Operations

§ 325.31 Scope of the rules in this subpart.

The rules in this subpart specify conditions and procedures for measurement of the sound level generated by a motor vehicle engaged in a highway operation for the purpose of ascertaining whether the motor vehicle conforms to the Standards for Highway Operations set forth in 40 CFR 202.20.

§ 325.33 Site characteristics; highway operations.

(a) Measurement shall be made at a test site which is adjacent to, and includes a portion of, a traveled lane of a *public highway.* A *microphone target point* shall be established on the centerline of the traveled lane of the highway, and a microphone location point shall be established on the ground surface not less than 35 feet (10.7 m) or more than 83 feet (25.3 m) from the microphone target point and on a line that is perpendicular to the centerline of the traveled lane of the highway and that passes through the microphone target point. In the case of a standard test site, the microphone location point is 50 feet (15.2 m) from the microphone target point. Within the test site is a triangular measurement area. A plan view diagram of a standard test site, having an open site within a 50-foot (15.2 m) radius of both the microphone target point and the microphone location point, is shown in Figure 1. Measurements may be made at a test site having smaller or greater di-

[1] Copies of the specification may be secured from the American National Standards Institute, 1430 Broadway, New York, New York, 10018.

mensions in accordance with the rules in Subpart F of this Part.

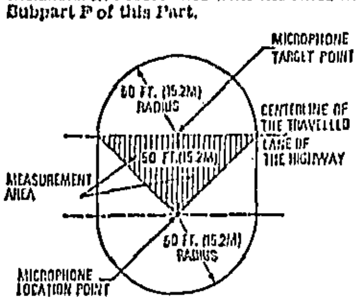

Figure 1
STANDARD TEST SITE; HIGHWAY OPERATIONS

(b) The test site must be an open site, essentially free of large sound-reflecting objects. However, the following objects may be within the test site, including the triangular measurement area:

(1) Small cylindrical objects such as fire hydrants or telephone or utility poles.

(2) Rural mailboxes.

(3) Traffic railings of any type of construction except solid concrete barriers (see § 325.5(c)(4)).

(4) One or more curbs having a vertical height of 1 foot (.3 m) or less.

(c) The following objects may be within the test site if they are outside of the triangular measurement area of the site:

(1) Any vertical surface (such as billboard), regardless of size, having a lower edge more than 15 feet (4.6 m) higher than the surface of the traveled lane of the highway.

(2) Any uniformly smooth sloping surface slanting away from the highway (such as a rise in grade alongside the highway) with a slope that is less than 45 degrees above the horizontal.

(3) Any surface slanting away from the highway that is 45 degrees or more and not more than 90 degrees above the horizontal, if all points on the surface are more than 15 feet (4.6 m) above the surface of the traveled lane of the highway.

(d) The surface of the ground within the measurement area must be relatively flat (see § 325.5(c)(5)). The site shall be a "soft" test site. However, if the site is determined to be "hard," the correction factor specified in § 325.75(a) of this part shall be applied to the measurement.

(e) The traveled lane of the highway within the test site must be dry, paved with relatively smooth concrete or asphalt, and substantially free of—

(1) Holes or other defects which would cause a motor vehicle to emit irregular tire, body, or chassis impact noise; and

(2) Loose material, such as gravel or sand.

(f) The traveled lane of the highway on which the microphone target point is situated must not pass through a tunnel or underpass located within 200 feet (61 m) of that point.

§ 325.35 Ambient conditions; highway operations.

(a) (1) *Sound.* The ambient A-weighted sound level at the microphone location point shall be measured, in the absence of motor vehicle noise emanating from within the clear zone, with fast meter response using a sound level measurement system that conforms to the rules of § 325.23 of this Part.

(2) The measured ambient level must be 10 dB(A) or more below that level specified in § 325.7, Table 1, which corresponds to the maximum permissible sound level reading which is applicable at the test site at the time of testing.

[325.35(a)(2) amended at 41 FR 28267, July 9, 1976]

(b) *Wind.* The wind velocity at the test shall be measured at the beginning of each series of noise measurements and at intervals of 5-15 minutes thereafter until it has been established that the wind velocity is essentially constant. Once this fact has been established, wind velocity measurements may be made at intervals of once every hour. Noise measurements may only be made if the measured wind velocity is 12 mph (19.3 kph) or less. Gust wind measurements of up to 20 mph (33.2 kph) are allowed.

(c) *Precipitation.* Measurements are prohibited under any condition of precipitation, however, measurements may be made with snow on the ground. The ground surface within the measurement area must be free of standing water.

§ 325.37 Location and operation of sound level measurement system; highway operations.

(a) The microphone of a sound level measurement system that conforms to the rules in § 325.23 of this Part shall be located at a height of not less than 2 feet (.6 m) nor more than 6 feet (1.8 M) above the plane of the roadway surface and not less than 3½ feet (1.1 m) above the surface on which the microphone stands. The preferred microphone height on flat terrain is 4 feet (1.2 m).

[325.37(a) amended at 41 FR 10227, March 10, 1976]

(b)(1) When the sound level measurement system is hand-held or is otherwise monitored by a person located near its microphone, the holder must orient himself relative to the highway in a manner consistent with the recommendation of the manufacturer of the sound level measurement system.

(2) In no case shall the holder or observer be closer than 2 feet (.6 m) from the system's microphone, nor shall he locate himself between the microphone and the vehicle being measured.

(c) The microphone of the sound level measurement system shall be oriented toward the traveled lane of the highway at the microphone target point at an angle that is consistent with the recommendation of the system's manufacturer. If the manufacturer of the system does not recommend an angle of orientation for its microphone, the microphone shall be oriented toward the highway at an angle of not less than 70 degrees and not more than perpendicular to the horizontal plane of the traveled lane of the highway at the microphone target point.

(d) The sound level measurement system shall be set to the A-weighting network and "fast" meter response mode.

§ 325.39 Measurement procedure; highway operations.

(a) In accordance with the rules in this subpart, a measurement shall be made of the sound level generated by a motor vehicle operating through the measurement area on the traveled lane of the highway within the test site, regardless of the highway grade, load, acceleration or deceleration.

(b) The sound level generated by the motor vehicle is the highest reading observed on the sound level measurement system as the vehicle passes through the measurement area, corrected, when appropriate, in accordance with the rules in Subpart F of this Part. (Table 1 in § 325.9 lists the range of maximum permissible sound level readings for various test conditions.) The sound level of the vehicle being measured must be observed to rise at least 6 dB(A) before the maximum sound level occurs and to fall at least 6 dB(A) after the maximum sound level occurs in order to be considered a valid sound level reading.

Subpart E—Measurement of Noise Emissions Stationary Test

§ 325.51 Scope of the rules in this subpart.

(a) The rules in this subpart specify conditions and procedures for measuring the sound level generated by a vehicle when the vehicle's engine is rapidly accelerated from idle to governed speed at wide open throttle with the vehicle stationary, its transmission in neutral, and its clutch engaged, for the purpose of ascertaining whether the motor vehicle conforms to the Standard for Operation Under Stationary Test, 40 CFR 202.21.

(b) The rules in this subpart apply only to a motor vehicle that is equipped with an engine speed governor.

(c) Tests conducted in accordance with the rules of this subpart may be made on either side of the vehicle.

§ 325.53 Site characteristics; stationary test.

(a) (1) The motor vehicle to be tested shall be parked on the test site. A microphone target point shall be established on the ground surface of the site on the centerline of the lane in which the motor vehicle is parked at a point that is within 3 feet (.9 m) of the longitudinal position of the vehicle's exhaust system outlet(s). A microphone location point shall be established on the ground surface not less than 35 feet (10.7 m) and not more than 83 feet (25.3 m) from the microphone target point. Within the test site is a triangular measurement area. A plan view diagram of a standard test site, having an open site within a 50-foot (15.2 m) radius of both the microphone target point and the microphone location point, is shown in Figure 2.

[325.53(a)(1) amended at 41 FR 10227, March 10, 1976]

(2) Measurements may be made at a test site having smaller or greater di-

nensions in accordance with the rules in Subpart F of this Part.

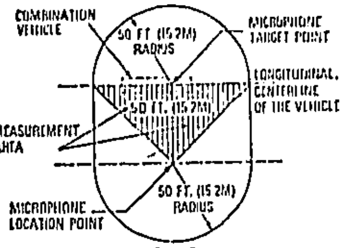

Figure 2
STANDARD TEST SITE;
STATIONARY TEST

(b) The test site must be an open site, essentially free of large sound-reflecting objects. However, the following objects may be within the test site, including the triangular measurement area:

(1) Small cylindrical objects such as fire hydrants or telephone or utility poles.

(2) Rural mailboxes.

(3) Traffic railings of any type of construction except solid concrete barriers (see § 325.5(c)(4)).

(4) One or more curbs having a height of 1 foot (.3 m) or less.

(c) The following objects may be within the test site if they are outside of the triangular measurement area of the site:

(1) Any vertical surface, regardless of size (such as a billboard), having a lower edge more than 15 feet (4.6 m) above the ground.

(2) Any uniformly smooth surface slanting away from the vehicle with a slope that is less than 45 degrees above the horizontal.

(3) Any surface slanting away from the vehicle that is 45 degrees or more and not more than 90 degrees above the horizontal, if all points on the surface are more than 15 feet (4.6 m) above the surface of the ground in the test site.

(d) The surface of the ground within the measurement area must be relatively flat. (See § 325.5(c)(5)). The site shall be a "hard" site. However, if the site is determined to be "soft," the correction factor specified in § 325.75(b) of this Part shall be applied to the measurement.

§ 325.55 Ambient conditions; stationary test.

(a)(1) *Sound.* The ambient A-weighted sound level at the microphone location point shall be measured, in the absence of motor vehicle noise emanating from within the clear zone, with fast meter response using a sound level measurement system that conforms to the rules of § 325.23 of this part.

(2) The measured ambient level must be 10 dB(A) or more below that level specified in § 325.7, Table 1, which corresponds to the maximum permissible sound level reading which is applicable at the test site at the time of testing.

[325.55 amended at 41 FR 10227, March 10, 1976, and 41 FR 28267, July 9, 1976]

(b) *Wind.* The wind velocity at the test site shall be measured at the beginning of each series of noise measurements and at intervals of 5–15 minutes thereafter until it has been established that the wind velocity is essentially constant. Once this fact has been established, wind velocity measurements may be made at intervals of once every hour. Noise measurements may only be made if the measured wind velocity is 12 mph (19.3 kph) or less. Gust wind measurements of up to 20 mph (33.2 kph) are allowed.

(c) *Precipitation.* Measurements are prohibited under any conditions of precipitation, however, measurements may be made with snow on the ground. The ground within the measurement area must be free of standing water.

§ 325.57 Location and operation of sound level measurement system; stationary test.

(a) The microphone of a sound level measurement system that conforms to the rules in § 325.23 of this Part shall be located at a height of not less than 2 feet (.6 m) nor more than 6 feet (1.8 m) above the plane of the roadway surface and not less than 3½ feet (1.1 m) above the surface on which the microphone stands. The preferred microphone height on flat terrain is 4 feet (1.2 m).

[325.57(a) amended at 41 FR 10227, March 10, 1976]

(b) When the sound level measurement system is hand-held or otherwise monitored by a person located near its microphone, the holder must orient himself relative to the highway in a manner consistent with the recommendation of the manufacturer of the sound level measurement system. In no case shall the holder or observer be closer than 2 feet (.6 m) from the system's microphone, nor shall he locate himself between the microphone and the vehicle being measured.

(c) The microphone of the sound level measurement system shall be oriented toward the vehicle at an angle that is consistent with the recommendation of the system's manufacturer. If the manufacturer of the system does not recommend an angle of orientation for its microphone, the microphone shall be oriented at an angle of not less than 70 degrees and not more than perpendicular to the horizontal plane of the test site at the microphone target point.

(d) The sound level measurement system shall be set to the A-weighting network and "fast" meter response mode.

§ 325.59 Measurement procedure; stationary test.

In accordance with the rules in this subpart, a measurement shall be made of the sound level generated by a stationary motor vehicle as follows:

(a) Park the motor vehicle on the test site as specified in § 325.53 of this subpart. If the motor vehicle is a combination (articulated) vehicle, park the combination so that the longitudinal centerlines of the towing vehicle and the towed vehicle or vehicles are in substantial alignment.

(b) Turn off all auxiliary equipment which is installed on the motor vehicle and which is designed to operate under normal conditions only when the vehicle is operating at a speed of 5 mph (8 kph) or less. Examples of such equipment include cranes, asphalt spreaders, liquid or slurry pumps, auxiliary air compressors, welders, and trash compactors.

(c) If the motor vehicle's engine radiator fan drive is equipped with a clutch or similar device that automatically either reduces the rotational speed of the fan or completely disengages the fan from its power source in response to reduced engine cooling loads, park the vehicle before testing with its engine running at high idle or any other speed the operator may choose, for sufficient time but not more than 10 minutes, to permit the engine radiator fan to automatically disengage when the vehicle's noise emissions are measured under stationary test.

(d) With the motor vehicle's transmission in neutral and its clutch engaged, rapidly accelerate the vehicle's engine from idle to its maximum governed speed with wide open throttle. Return the engine's speed to idle.

(e) Observe the maximum reading on the sound level measurement system during the time the procedures specified in paragraph (d) of this section are followed. Record that reading, if the reading has not been influenced by extraneous noise sources such as motor vehicles operating on adjacent roadways.

(f) Repeat the procedures specified in paragraphs (d) and (e) of this section until the first two maximum sound level readings that are within 2dB(A) of each other are recorded. Numerically average these two maximum sound level readings. When appropriate, correct the average figure in accordance with the rules in Subpart F of this part.

(g) The average figure, corrected as appropriate, contained in accordance with paragraph (f) of this section, is the sound level generated by the motor vehicle for the purpose of determining whether it conforms to the Standard for Operation Under Stationary Test, 40 CFR 202.21. (Table 1 in § 325.9 lists the range of maximum permissible sound level readings for various test conditions.)

Subpart F—Correction Factors

§ 325.71 Scope of the rules in this subpart.

(a) The rules in this subpart specify correction factors which are added to, or subtracted from, the reading of the sound level generated by a motor vehicle, as displayed on a sound level measurement system, during the measurement of the motor vehicle's sound level emissions at a test site which is not a standard site.

(b) The purpose of adding or subtracting a correction factor is to equate the sound level reading actually generated by the motor vehicle to the sound level reading it would have generated if the measurement had been made at a standard test site.

§ 325.73 Microphone distance correction factors.

If the distance between the microphone location point and the microphone target point is other than 50 feet (15.2 m), the maximum observed sound level reading generated by the motor vehicle in accordance with § 325.39 of this part or the numerical average of the recorded maximum observed sound level readings generated by the motor vehicle in accordance with § 325.59 of this part shall be corrected as specified in the following table:

TABLE 2—DISTANCE CORRECTION FACTORS

If the distance between the microphone location point and the microphone target point is:	The value (dB(A)) to be applied to the observed sound level reading is—
35 feet (10.7 m) or more but less than 39 feet (11.9 m)	−3
39 feet (11.9 m) or more but less than 43 feet (13.1 m)	−2
43 feet (13.1 m) or more but less than 48 feet (14.6 m)	−1
48 feet (14.6 m) or more but less than 58 feet (17.7 m)	0
58 feet (17.7 m) or more but less than 70 feet (21.3 m)	+1
70 feet (21.3 m) or more but less than 83 feet (25.3 m)	+2

§ 325.75 Ground surface correction factors.[2]

(a) *Highway operations.* When measurements are made in accordance with the rules in Subpart D of this part upon a test site which is "hard," a correction factor of 2 dB(A) shall be subtracted from the maximum observed sound level reading generated by the motor vehicle to determine whether the motor vehicle conforms to the Standards for Highway Operations, 40 CFR 202.20.

(b) *Stationary Test.* When measurements are made in accordance with the rules in Subpart E of this part upon a test site which is "soft," a correction factor of 2 dB(A) shall be added to the numerical average of the recorded maximum observed sound level readings generated by the motor vehicle to determine whether the motor vehicle conforms to the Standard for Operation Under Stationary Test, 40 CFR 202.21.

§ 325.77 Computation of open site requirements—nonstandard sites.

(a) If the distance between the microphone location point and the microphone target point is other than 50 feet (15.2 m), the test site must be an open site within a radius from both points which is equal to the distance between the microphone location point and the microphone target point.

[2] Table 1, in § 325.9 is a tabulation of the maximum allowable sound level readings taking into account both the distance correction factors contained in § 325.73 and the ground surface correction factors contained in § 325.75.

(b) Plan view diagrams of nonstandard test sites are shown in Figures 3 and 4. Figure 3 illustrates a test site which is larger than a standard test site and is based upon a 60-foot (18.3 m) distance between the microphone location point and the microphone target point. (See § 325.79(b)(1) for an example of the application of the correction factor to a sound level reading obtained at such a site.) Figure 4 illustrates a test site which is smaller than a standard test site and is based upon a 35-foot (10.7 m) distance between the microphone location point and the microphone target point. (See § 325.79(b)(2) for an example of the application of the correction factor to a sound level reading obtained at such a site.)

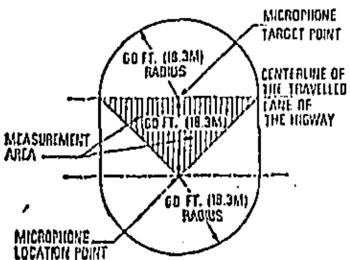

Figure 3
NON-STANDARD TEST SITE;
(60 FT (18.3M) DISTANCE BETWEEN MICROPHONE LOCATION AND TARGET POINTS)

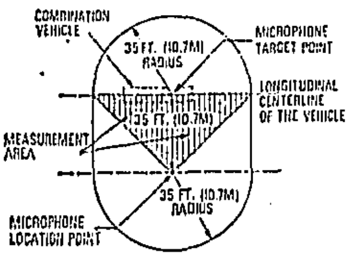

Figure 4
NON-STANDARD TEST SITE;
(35 FT.(10.7M) DISTANCE BETWEEN MICROPHONE LOCATION AND TARGET POINTS)

§ 325.79 Application of correction factors.

(a) If two correction factors apply to a measurement they are applied cumulatively.

(b) The following examples illustrate the application of correction factors to sound level measurement readings:

(1) *Example 1—Highway operations.* Assume that a motor vehicle generates a maximum observed sound level reading of 86 dB(A) during a measurement in accordance with the rules in Subpart D of this Part. Assume also that the distance between the microphone location point and the microphone target point is 60 feet (18.3 m) and that the measurement area of the test site is acoustically "hard." The corrected sound level generated by the motor vehicle would be 85 dB(A), calculated as follows:

86 dB(A)	Uncorrected reading
+1 dB(A)	Distance correction factor
−2 dB(A)	Ground surface correction factor
85 dB(A)	Corrected reading

(2) *Example 2—Stationary test.* Assume that a motor vehicle generates maximum sound level readings which average 88 dB(A) during a measurement in accordance with the rules in Subpart E of this Part. Assume also that the distance between the microphone location point and the microphone target point is 35 feet (10.7 m), and that the measurement area of the test site is acoustically "soft." The corrected sound level generated by the motor vehicle would be 87 dB(A), calculated as follows:

88 dB(A)	Uncorrected average of readings
−3 dB(A)	Distance correction factor
+2 dB(A)	Ground surface correction factor
87 dB(A)	Corrected reading

Subpart G—Exhaust Systems and Tires

§ 325.91 Exhaust systems.

A motor vehicle does not conform to the visual exhaust system inspection requirements, 40 CFR 202.22, of the Interstate Motor Carrier Noise Emission Standards, if inspection of the exhaust system of the motor vehicle discloses that the system—

(a) Has a defect which adversely affects sound reduction, such as exhaust gas leaks or alteration or deterioration of muffler elements, (small traces of soot on flexible exhaust pipe sections shall not constitute a violation of this subpart);

(b) Is not equipped with either a muffler or other noise dissipative device, such as a turbocharger (supercharger driven by exhaust gases); or

(c) Is equipped with a cut-out, by-pass, or similar device, unless such device is designed as an exhaust gas driven cargo unloading system.

§ 325.93 Tires.

(a) Except as provided in paragraph (b) of this section, a motor vehicle does not conform to the visual tire inspection requirements, 40 CFR 202.23, of the Interstate Motor Carrier Noise Emissions Standards, if inspection of any tire on which the vehicle is operating discloses that the tire has a tread pattern composed primarily of 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.

(b) Paragraph (a) of this section does not apply to a motor vehicle operated on a tire having a tread pattern of the type specified in that paragraph, if the motor carrier who operates the motor vehicle demonstrates to the satisfaction of the Director of the Bureau of Motor Carrier Safety or his designee that either—

(1) The tire did not have that type of tread pattern when it was originally manufactured or newly remanufactured; or

(2) The motor vehicle generates a maximum sound level reading of 90 dB(A) or less when measured at a standard test site for highway operations at a distance of 50 feet (15.3 m) and under the following conditions:

(i) The measurement must be made at a time and place and under conditions specified by the Director or his designee.

(ii) The motor vehicle must be operated on the same tires that were installed on it when the inspection specified in paragraph (a) of this section occurred.

(iii) The motor vehicle must be operated on a highway having a posted speed limit of more than 35 mph (56.3 kph).

(iv) The sound level measurement must be made while the motor vehicle is operating at the posted speed limit.

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APPENDIX B

Analysis of the DOT Data

B.1 DATA NORMALIZATION FOR TOPOGRAPHIC DEVIATIONS

This appendix documents the procedure used to determine the hard-soft correction factor, $\Delta_{H/S}$, using the truck noise level passby data from Reference 1. These data were collected at various sites featuring different topographic elevation characteristics. As a consequence, the data was normalized to reflect a standard microphone height above the roadway prior to the $\Delta_{H/S}$ analysis.

B.1.1 Identification of Data Trends

Individual passby noise levels were first arithmetically averaged at each site for the nine combinations of truck type and operational mode. These levels were further divided into hard and soft site classifications which gave a total of 18 combinations of data groupings for the controlled passby test. The influence of topographic deviations upon the measured noise levels was initially identified by observing trends of noise level plotted against ground elevation at the 15 meter (50 ft) microphone relative to the road. A definite trend was apparent in that noise was attenuated as the ground sloped downward and away from the roadway and that noise levels increased for the one site with a positive elevation change. Observation of the transient fleet passby data indicated topographic effects that were consistent with the controlled passbys.

No further generalizations were extended to acoustical effects from topographic deviations at microphone locations less than or greater than 15 meters (50 ft). Such a generalization can only come after careful analysis of each microphone to source orientation. Similarly, moving the microphone up and down at one distance cannot be expected to influence the noise in the same manner as changing the ground elevation. Although no definite reasons were given for these variations in the noise levels from topographic deviations, it was felt that as the ground sloped downward away from the road, the shoulder effectively increased source shielding, and the grazing angle of the vehicle with the ground surface decreased. The increase in measured noise level for the case of the ground sloping up was attributed to the reversal of these effects plus more complex phenomena which could not be specifically identified.

B.1.2 Procedure to Normalize Data.

The data analysis performed by DOT was based on the assumption that noise level variations were the same when the microphone was moved up or down as when the ground elevation was increased or decreased. DOT made corrections to the actual measured levels in proportion to the acoustical variation recorded in the vertical array of microphones that were positioned equivalent to 1.2 meters (4 ft) above the roadway. Whereas the DOT procedure may possibly yield corrected levels close to the exact values, a different approach was utilized for this report.

The procedure taken to normalize all data followed the steps listed below:

1. Calculate the 18 sets of linear regression coefficients for noise level versus relative ground elevation using the controlled passby data in Tables B-1, B-2, and B-3. These 18 cases were broken down by truck type, operation mode, and site classification.

2. Calculate the two sets of linear regression coefficients for noise level versus ground elevation using the transient fleet passby data in Table B-4.

3. Normalize the 20 linear regression curves from steps 1 and 2 above by shifting each set of data the amount required to make the zero elevation intercepts coincide. Note that both hard and soft curves are normalized together.

4. The noise level deviations relative to the zero elevation intercepts are used to establish one generalized linear regression-fit curve. The coefficients and standard error for this curve, which were calculated using all the data for the 20 previous curves, shifted the appropriate amount.

Table B-1

Summary of Average Noise Level for Each Truck at Each Site for the Acceleration Test Mode

Linear Regression Curve Coefficients Are Given by A and B for Each Truck and Surface Condition

$$\text{Where Noise Level} = A + B \begin{bmatrix} \text{Elevation of Ground at Microphone} \\ \text{Relative to the Road, Feet} \end{bmatrix}, \text{dBA}$$

	Hard Sites				Soft Sites			
Truck	Site Number	Noise Level, dBA	A_H	B_H	Site Number	Noise Level, dBA	A_S	B_S
IH 843	1	86.3			2	83.9		
	3	86.3			4	84.0		
	6	86.2	86.6	0.66	5 (Lane 1)	82.5	84.0	0.36
	7	85.7			8	81.8		
	5 (Lane 2)	83.3			9	85.0		
					10	82.9		
IH 866	1	84.9			2	82.3		
	3	84.9			4	82.8		
	5 (Lane 2)	82.9	85.1	0.44	5 (Lane 1)	82.4	83.1	0.27
	6	84.7			8	80.8		
	7	84.6			9	83.5		
					10	83.3		
IH 394	1	88.8			2	86.9		
	3	87.5			4	86.3		
	5 (Lane 2)	87.5	89.1	0.53	5 (Lane 1)	86.1	86.9	0.0012
	6	No Data			8	88.0		
	7	89.0			9	87.8		
					10	86.2		

Table B-2

Summary of Average Noise Level for Each Truck at Each Site
for the High Speed Power-By Test Mode.
Linear Regression Curve Coefficients are given by A and B
for Each Truck and Surface Condition

$$\text{Where Noise level} = A + B \left[\begin{array}{c}\text{Elevation of Ground at Microphone}\\ \text{Relative to the Road, Feet}\end{array}\right], \text{dBA}$$

Truck	Hard Sites				Soft Sites			
	Site Number	Noise Level, dBA	A_H	B_H	Site Number	Noise Level, dBA	A_S	B_S
IH 843	3	92.4	91.3	-.43	2	89.9	90.6	0.58
	6	91.9			4	90.5		
	7	91.6			5	87.3		
					8	87.5		
					9	92.6		
					10	89.2		
IH 866	3	90.3	91.5	0.44	2	88.0	88.9	0.45
	6	91.1			4	88.7		
	7	90.9			5	87.6		
					8	85.6		
					9	90.1		
					10	88.2		
IH 394	3	89.3	90.9	0.63	2	84.6	86.4	0.27
	6	No Data			4	85.7		
	7	90.3			5	87.4		
					8	83.7		
					9	87.1		
					10	86.8		

Table B-3

Summary of Average Noise Level for Each Truck at Each Site for the High Speed Coast-By Test Mode

Linear Regression Curve Coefficients Are Given by A and B for Each Truck and Surface Condition

$$\text{Where Noise Level} = A + B \left[\begin{array}{c} \text{Elevation of Ground at Microphone} \\ \text{Relative to the Road, Feet} \end{array} \right], \text{dBA}$$

Truck	Hard Sites				Soft Sites			
	Site Number	Noise Level, dBA	A_H	B_H	Site Number	Noise Level, dBA	A_S	B_S
IH 843	3	88.3	91.1	1.08	2	87.6	89.1	0.75
	6	89.7			4	88.6		
	7	90.2			5	86.0		
					8	84.5		
					9	91.5		
					10	87.4		
IH 866	3	87.6	90.4	1.09	2	86.6	87.4	0.57
	6	89.3			4	86.7		
	7	89.3			5	84.5		
					8	84.1		
					9	89.4		
					10	86.5		
IH 394	3	82.5	82.8	0.13	2	80.1	81.5	0.38
	6	No Data			4	80.8		
	7	82.7			5	79.7		
					8	80.0		
					9	83.5		
					10	80.3		

Table B-4

Summary of the Average Noise Level For Each Site For the Transient Fleet Passby Test
Linear Regression Curve Coefficients are given by A and B For Each Truck and Surface Condition

$$\text{Where Noise Level} = A + B \left[\begin{array}{c}\text{Elevation of Ground at Microphone}\\ \text{Relative to the Road, Feet}\end{array}\right],\ \text{dBA}$$

HARD SITES				SOFT SITES			
Site Number	Noise Level, dBA	A_H	B_H	Site Number	Noise Level, dBA	A_S	B_S
3	87.0	89.6	1.01	2	85.9	86.1	0.55
6	88.3			4	86.8		
7	88.8			5	84.3		
				8	80.9		
				9	86.2		
				10	86.3		

The results of this normalization scheme are given below, with numbers corresponding to the four steps in the procedural analysis:

1. Linear regression coefficients for the 18 sets of controlled passby data are given in Tables B-1, B-2, and B-3.

2. Linear regression coefficients for the two sets of transient fleet passby data are given in Table B-4.

3. Data were shifted over a range of 10.6 dB to normalize topographic deviations. The 10.6 dB spread was due to changes in the noise from truck type, operational mode, and site classification.

4. All normalized data are plotted in Figure B-1. Values of the important parameters are:

$$\begin{aligned} C &= -0.082 \text{ dB} \\ D &= 0.418 \text{ dB/ft Elevation} \\ \text{Standard Error} &= \pm 0.96 \text{ dB} \\ \text{Number of Data Points} &= 93 \end{aligned}$$

where:

$$\text{Noise Level Correction} = C + D \begin{bmatrix} \text{Elevation of Ground} \\ \text{Relative to the Road, Feet} \end{bmatrix}, \text{ dBA}$$

This noise level correction should be subtracted from the measured noise at 15 meters (50 ft) from the center of the vehicle lane, using a microphone 1.2 meters (4 ft) above the ground.

It was considered that this single generalized curve was an adequate representation of an average topographic correction to the data. This reasoning was supported by the fact that the standard error did not exceed 1 dB. It is worthwhile to note that trucks whose noise levels were dominated by the tire component were more drastically affected by a sloping terrain than trucks for which the tire noise component was a secondary factor. This trend was not quantified because the sample size was too small to substantiate a well-defined correction factor.

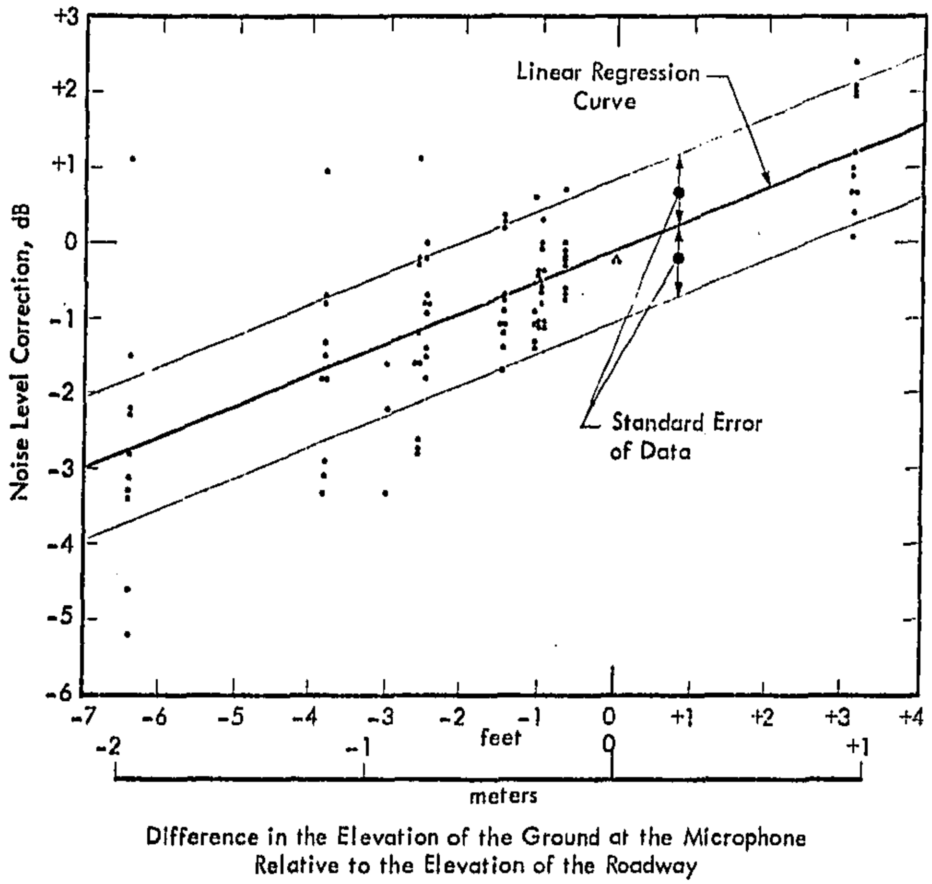

Figure B-1. Noise Level Correction for Topographic Deviations at the Position of the 15 meter (50 ft) Microphone.

B.2 SURFACE CORRECTION

B.2.1 Data Calculations

The DOT data were analyzed to determine the most appropriate value of the surface correction, $\Delta_{H/S}$. The following procedure was used to group the data into hard and soft categories from which conclusions were drawn.

1. All noise levels were normalized for a zero difference in the relative elevation between the roadway and microphone ground location. Correction values given in Figure B-1 were rounded to the nearest half decibel and are listed in Table B-5 for the 10 sites.

2. For each combination of truck type, truck operation mode, and site classification, the average of the noise levels and the standard deviation was calculated. Those 18 calculations only pertained to the controlled passby test.

3. For corresponding combinations of the data parameters in step 2 above, the difference in the noise level between hard and soft surfaces was determined. These nine values of $\Delta_{H/S}$ are tabulated in Table B-6.

4. For each operational mode, the values of $\Delta_{H/S}$ previously calculated in step 3 for the three truck types (weighted for the number of samples per truck type) were averaged. This gave a value of $\Delta_{H/S}$ for acceleration, power-by, and coast-by operations as indicated in Table B-6.

5. For each of the site classifications of the transient fleet passby test, the average of the noise levels and the standard deviation was computed.

6. The hard-soft correction factor, $\Delta_{H/S}$, for the transient fleet was determined by using the levels averaged in step 5. A summary of the transient fleet data is given in Table B-7.

Table B-5

Topographical Correction Used to Normalize Elevation Differences Between the Roadway and the Microphone Ground Position

Site Number	Ground Elevation at 15 Meters (50 ft) Relative to the Road, meters (ft)	Topographical Correction,* dB
1	0.0 (+0.0)	+ 0
2	-0.8 (-2.5)	-1.0
3	-0.8 (-2.6)	-1.0
4	-0.2 (-0.7)	+ 0
5 (Lane 1)	-1.2 (-3.8)	-1.5
5 (Lane 2)	-1.0 (-3.2)	-1.5
6	-0.3 (-1.1)	-0.5
7	-0.3 (-1.0)	-0.5
8	-2.0 (-6.4)	-2.5
9	+0.9 (+3.1)	+1.5
10	-0.5 (-1.5)	-0.5

*Rounded to nearest 0.5 dB.

Table B-6

Summary of Calculated Values of $\Delta_{H/S}$ for Each Truck Type and Operational Mode Encountered in the Controlled Passby Test

(Standard deviation for each surface condition is referred to by σ and the number of vehicle pass-bys by n. All noise levels used to calculate the mean noise levels here have received corrections for topographic deviations.)

			IH 843	IH 866	IH 394
Acceleration Test Mode	Hard Sites	Noise Level, dBA	86.4	85.1	89.0
		σ/n	0.74/19	0.45/21	0.78/15
	Soft Sites	Noise Level, dBA	84.0	83.1	87.6
		σ/n	0.61/18	0.71/15	1.53/18
Mean $\Delta_{H/S}$ = 2.0 dB (weighted for n)		$\Delta_{H/S}$	2.4	2.0	1.4
High Speed Power-By Test Mode	Hard Sites	Noise Level, dBA	92.6	91.4	90.6
		σ/n	0.75/9	0.48/9	0.77/5
	Soft Sites	Noise Level, dBA	90.1	88.7	86.3
		σ/n	0.9/17	0.33/17	1.45/16
Mean $\Delta_{H/S}$ = 3.1 dB (weighted for n)		$\Delta_{H/S}$	2.5	2.7	4.3
High Speed Coast-By Test Mode	Hard Sites	Noise Level, dBA	90.1	89.4	83.4
		σ/n	0.68/12	0.93/9	0.47/6
	Soft Sites	Noise Level, dBA	88.5	86.9	81.4
		σ/n	1.18/15	0.73/17	0.72/17
Mean $\Delta_{H/S}$ = 2.0 dB (weighted for n)		$\Delta_{H/S}$	1.6	2.5	2.0

Table B-7

Summary of the Calculated Value of $\Delta_{H/S}$ for the Transient Fleet Passby Test

(Standard deviations are referred to by σ and the number of passbys by n)

Site Number	Surface Condition	n	Average Noise Level Without Topography Correction, dBA	Relative Elevation, meters (ft)	Topo Correction dB	Corrected Average Noise Level, dBA	σ dB
3	Hard	29	87.0	-0.8 (-2.6)	-1.0	88.0	2.6
6		36	88.3	-0.3 (-1.1)	-0.5	88.8	3.1
7		42	88.8	-0.3 (-1.0)	-0.5	89.3	2.9
2	Soft	11	85.9	-0.8 (-2.5)	-1.0	86.9	3.0
4		37	86.8	-0.2 (-0.7)	0	86.8	3.0
5		44	84.3	-1.2 (-3.8)	-1.5	85.8	2.8
8		34	80.9	-2.0 (-6.4)	-2.5	83.4	4.0
9		49	86.2	+0.9 (+3.1)	+1.5	84.7	3.0
10		51	86.3	-0.5 (-1.5)	-0.5	86.8	2.7

Composite Values:

Hard — Overall Average Noise Level = 88.8 dBA; σ = 2.9 dB; n = 107

Soft — Overall Average Noise Level = 85.6 dBA; σ = 3.1 dB; n = 226

$\Delta_{H/S}$ = 3.2 dB