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EPA 550/9-81-402

CODE OF CURRENT PRACTICES FOR ENFORCEMENT OF MODEL NOISE CONTROL ORDINANCE

September 1981

U.S. ENVIRONMENTAL PROTECTION AGENCY
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16. ABSTRACT

This report provides communities interested in adopting a noise control ordinance with measurement procedures for effective enforcement. The first segment discusses the theory of sound, terminology, and computation methods. Vibration measurement and criteria are also presented.

The second segment of this report presents the current measurement procedures. Noise and vibration measurement procedures are presented for stationary noise sources. These include statistical sampling and steady sound techniques, both weighted and octave band. Both roadway (passby) and stationary sound level measurement methods are provided for automobiles, trucks, and motorcycles. Sound measurement procedures are also included for buses, construction equipment, model vehicles, recreation vehicles, and refuse collection vehicles.

Sketches of the measurement sites and forms for reporting measured data are provided for each measurement procedure.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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FIRST SEGMENT

THEORY

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1.0 INTRODUCTION

1.1 BACKGROUND

This Code of Current Measurement Practices for Enforcement of Noise Ordinances is a compilation of the most practical and effective procedures being used by State and local governments in their noise control enforcement efforts. Over 30 State and local officials reviewed these procedures for technical feasibility, practicality, and ease of enforcement. However, some of the procedures in the areas of construction, recreational vehicle, powered model vehicles and motorboat noise measurements have not been fully tested nor evaluated by State and local noise programs. These specific procedures have either been used in engineering design by applicable industries and technical societies or are included due to their potential value. As such, the appropriateness of all of these specific procedures for use in State and local enforcement needs to be confirmed and substantiated through field testing studies. EPA intends to initiate a field program in the near future to test the reliability and validity of all of these procedures, obtain data on sound levels emitted by sources, and determine the costs of administering each procedure.

This document contains all of the procedures necessary to cover the provisions in most State and local ordinances. Each procedure represents the state-of-the-art in local noise enforcement. It is the intention of EPA to publish this document in order that State and local officials can use these procedures as a valuable reference in developing their own measurement codes. After EPA concludes its planned testing program, a revised and final Code of Recommended Practices for Enforcement of Local Noise Ordinances will be published.

To help communities wishing to adopt comprehensive ordinances, the U.S. Environmental Protection Agency has introduced the "Model Community Noise Control Ordinance."[(1)] The "Model Noise Ordinance" is intended to be used as a guide and basic tool for large and small communities in their efforts to properly control and restrict noise. The Model Noise Ordinance is structured to best meet the local needs and conditions of the community.

But, no matter how well or concisely any ordinance or regulation is written, it can only be as effective as its enforcement policy. And, an enforcement policy rests on the measurement procedures used to determine compliance with the ordinance, especially when the ordinance stipulates the noise levels which are not to be exceeded.

This Code, distributed by the U.S. Environmental Protection Agency, is intended as a guideline for uniform measurement procedures for use with either the EPA Model Community Noise Control Ordinance or with an ordinance of the community's choosing. The procedures presented herein should not be confused with procedures adopted by EPA for regulatory purposes and point of sale certification procedures.

1.2 PURPOSE AND SCOPE

The purpose of this document is to provide communities interested in adopting a noise control ordinance with a compilation of the most effective, feasible and inexpensive local noise control measurement procedures for effective enforcement. This Code of Current Practices establishes tentative guidelines for the measurement and reporting of sound levels emitted by mobile and stationary noise sources.

This Code deals principally with the measurement of noise transmitted through air to a receiver. Noise measurement methods are provided for noise sources listed below:

- Automobiles
- Buses
- Construction Equipment
- Motorboats
- Motorcycles
- Powered Model Vehicles
- Recreation Vehicles
- Refuse Collection Vehicles
- Trucks
- Stationary Facilities, i.e., Industrial Plants Air Conditioners, and Construction Sites

In addition, since the Model Noise Ordinance contains, in Article X, provisions for restricting the development of certain land use types (i.e., residential structures) due to excessive ambient noise, procedures are provided for measuring the outdoor day/night sound level, L_{dn}.

Vibration measurement procedures as well as criteria are also provided.

1.3 ORGANIZATION

This Code of Current Practices is divided into two principal parts. Sections 2.0 through 4.0 discuss the theory of sound and vibration and describe the instruments which are used to make the measurements presented in this Code.

Section 4.0 discusses vibration and instrumentation and also includes vibration criteria recommended by the Committee on Hearing, Bioacoustics and Biomechanics of the National Research Council. Vibration procedures and criteria are recommended in this document, although the Model Ordinance did not directly address this most important area.

The second part, composed of Sections 5.0-15.0, contains the sound measurement methods which may be used to enforce a State or local noise ordinance. These sound measurement methods are grouped as follows:

a. Stationary noise sources
b. Sound quality for land use assessment
c. Mobile noise sources

A thorough survey of the literature was performed to identify existing measurement techniques. State and local enforcement agencies; domestic and foreign standards organizations, such as SAE, ISO, ASA; and industrial associations and federal agencies with noise control jurisdictions were contacted and asked to provide the measurement techniques used or recommended. They were also asked to suggest measurement procedure formats. Matrices for comparing each of the major aspects of the techniques were prepared for each source category. The techniques were evaluated using these matrices in terms of their accuracy, ease of implementation, cost effectiveness and applicability to a community's needs. The best features of each were abstracted and/or modified as appropriate, to provide a single procedure for each source category.

The completed noise measurement procedures were sent to enforcement officials, industry groups and acoustical experts for comments. The comments were evaluated and, where appropriate, were incorporated into the final document. The final Code reflects the needs and desires of the enforcement people who will eventually use it.

The document was prepared so that each measurement procedure could be used independently. Each measurement procedure contains all the necessary information for its implementation. A common format (with slight deviations) is used throughout. This format contains:

- Purpose
- Equipment
- Measurement Location
- Personnel
- Test Site
- Test Procedure

Methods to measure stationary noise source sound levels are presented in <u>Section 5.0</u>. The Model Community Noise Control Ordinance contains articles limiting the noise emitted from construction sites [Article VI, Section 6.2.6(b)] and from a stationary source [Article VIII, Section 8.1 and Section 8.2]. These recommended ordinance requirements can be enforced by four types of test procedures which:

a. measure the equivalent A-weighted sound level, L_{eq},* and the statistical sound levels, L_x,

b. measure the maximum A-weighted sound level, L_{max},

*See Section 2.2 for terminology.

c. measure the octave band sound pressure level spectrum, and

d. measure the impulse sound level.

A vibration measurement procedure is also discussed in Section 5.0. Operating or permitting the operation of any device that creates vibration above perception threshold levels is a prohibited act discussed in Article VI, Section 6.2.12 of the Model Community Noise Control Ordinance. The measurement procedure is presented in Section 5.0. Perception threshold criteria are discussed in Section 4.0, since communities may want to stipulate specific requirements in their legislation.

The ambient sound level, or sound quality, is an important factor to consider in selecting land for the development and building of habitable and institutional structures and recreational areas. Land-use restrictions are presented in Article X of the Model Community Noise Control Ordinance.

A method of community noise sampling requiring only a sound level meter is presented in Section 6.0. The measurement method allows a community to assess the ambient sound climate with a minimum investment in sound measurement equipment. The sampling technique provides cumulative distribution levels as well as the equivalent sound level, L_{eq}.

For those communities interested in noise measurement procedures to survey the noise environment throughout an entire community, a Community Noise Assessment Manual: Acoustical Survey, is available from the National Technical Information Service.

The second group of sound measurement procedures deals with mobile on and off road vehicles. The measurement procedures for Automobiles, Section 7.0, Buses, Section 8.0, Motorcycles, Section 11.0, and Trucks, Section 15.0, are similar. Two measurement procedures are provided. One measures vehicle noise while the vehicles are operated on local streets, roads, or highways. This measurement method provides vehicle sound levels for enforcement of Article IX, Section 9.1 which specifies the maximum sound levels which a motor vehicle can emit while operating on a public right-of-way.

A second type of noise measurement procedure is also provided for stationary operation and testing of the vehicle's noise emission levels. It requires the motor vehicle to be operated while stationary at a qualified test site. This latter method is simple to accomplish and provides sound level data which are repeatable and legally defensible. The stationary test procedure is similar to one of the U.S. Department of Transportation interstate motor carrier noise measurement procedures. It is slightly modified for automobiles, buses, and motorcycles. A community can choose the methodology which is most appropriate, considering the available resources, manpower, and ordinance requirements. Both sets of procedures can be used if a community desires a vehicle in use test and a separate procedure for certification during inspections.

A noise measurement procedure for construction equipment noise is presented in Section 9.0. Measurement of the noise emitted from individual units of construction equipment is difficult to accomplish at an operating construction site. A noise measurement procedure is described requiring that the measurement be made at seven meters from the device. If high ambient noise conditions exist, measurements are made at closer distances or an adjustment is applied for the contribution of sources other than the unit under test.

This method is based on recommended practices by the Society of Automotive Engineers[2,3] and Compressed Air and Gas Institute[4] consensus standards. The federal Environmental Protection Agency has also developed measurement methods used for product verification and enforcement of new equipment (point of sale) noise standards.[5,6] Both the technical society and Environmental Protection Agency methods require test sites which exhibit numerous acoustical environmental constraints. For example, the surface between noise source and microphone must be sealed asphalt with no large reflecting surfaces within 30 meters of the microphone or the equipment being measured.

Many construction sites do not meet this constraint and do not qualify as valid noise emission measurement sites. The measurement method presented in this Code is a pragmatic, cost-effective means for community noise enforcement and not necessarily a procedure which provides the required constraints needed for <u>new</u> product noise level verification and enforcement.

A motorboat noise measurement procedure is presented in <u>Section 10.0</u>. It is based on the SAE noise measurement method for motorboats. Numerous tests, conducted by and reported by the motorboat industry indicate the effectiveness of the test procedure. Operating motorboats in excess of regulated noise levels is discussed in Article VI, Section 6.2.15 of the Model Community Noise Control Ordinance.

A method of measuring the noise emissions of powered model vehicles is presented in Section 12.0. The Model Community Noise Control Ordinance suggests that maximum sound levels emitted by powered model vehicles (such as model airplanes) "...shall be measured at a distance of ____ feet (meters) from any point on the path of the vehicle." This type of measurement may be quite difficult to achieve. Instead, an alternative measurement method is presented. Most models are very small noise sources and can be measured in a stationary mode at 1 meter from the test model. The measurement procedure allows the test to be performed at or near recreational areas where the models will be used with minimum noise interference from other nearby noise sources. The data obtained from this test method can be used to extrapolate the noise from the model (in flight, for example) to noise sensitive land use or the recreational area boundary.

Section 13.0 provides a sound emissions measurement procedure for recreational motorized vehicles. Recreational motorized vehicles operating off public rights-of-way (such as motorbikes) use small, air cooled two- or four-stroke engines. Because of space, weight, and power limitations, the mufflers employed on these vehicles are often very rudimentary. The principal noise offender on these vehicles is typically the exhaust. These vehicles are addressed by Article IX, Section 9.2 of the Model Community Noise Control Ordinance. Mobile or acceleration tests are too complex and require too extensive a test area. Snowmobiles are also included in this category (Recreation Vehicles). The snowmobile industry and SAE have developed a consensus standard which requires a large test site covered by either packed snow or turf (primarily grass up to a maximum of 7.5 cm [3 in.] in height).[7] A procedure requiring sound measurements at 0.5 meter (20 in.) from the stationary vehicle's exhaust is presented in Section 13.0.

Section 14.0 presents a methodology for measuring noise emissions of refuse collection vehicles. Refuse collection vehicles are heavy trucks with a trash compacting mechanism mounted to the frame. Excessively high noise from compactors is considered a prohibited act in the Model Community Noise Control Ordinance, Article IX, Section 9.1.3. The noise from the compactor is measured in a manner similar to EPA's recently proposed noise emission standard for truck mounted solid waste compactors.[8] The sound measurement procedure presented requires sound measurements to be made at four locations at right angles to each other around the vehicle, while the vehicle is stationary during a normal compaction cycle. In this way, all the significant noise producing components of the vehicle are considered. Since it would be difficult to standardize the amount of refuse to use during the test, the sound measurements are made with the compactor empty.

ACOUSTICAL THEORY & TERMINOLOGY

2

1.4 REFERENCES

(1) "Model Community Noise Control Ordinance," U.S. Environmental Protection Agency, Washington, DC 20460, Report EPA 550/9-76-003, September 1975.

(2) "Exterior Sound Level Measurement for Mobile Construction Equipment," Society of Automotive Engineers, Recommended Practice J88a, 1975.

(3) "Operator Sound Level Measurement Procedure for Powered Mobile Construction Equipment - Work Cycle Test," SAE Draft Recommended Practice XJXXX, 1975.

(4) "CAGI-PNEUROP Test Code for the Measurement of Sound from Pneumatic Equipment," Compressed Air and Gas Institute, 1969.

(5) "Background Document for Portable Air Compressors," U.S. Environmental Protection Agency, Washington, DC 20460, EPA 550/9-76-004, December 1975.

(6) "Background Document for Medium and Heavy Truck Noise Emission Regulations," U.S. Environmental Protection Agency, EPA 550/9-76-008, December 1975.

(7) "Operational Sound Level Measurement Procedure for Snow Vehicles," Society of Automotive Engineers Procedure J1161, November 1976.

(8) "Information in Support of the Proposed Regulation for Truck Mounted Solid Waste Compactors," U.S. Environmental Protection Agency, EPA 550/9-77-204, 1977.

2.0 ACOUSTICAL THEORY AND TERMINOLOGY

2.1 INTRODUCTION

The purpose of this section is to acquaint the user of this Code of Current Practices with the theory and terminology used in the development of the noise measurement methods discussed later in this report. The information presented in this section is intended for indoctrination and reference. The user of this Code who desires additional details and theoretical depth should refer to text books and reports presented in a partial bibliography found at the conclusion of this section.

2.2 TERMINOLOGY

Most of the technical terms, used throughout the "Model Ordinance" and the Code of Current Practices, are presented below. Expanded and additional definitions may be found in the text books and reports listed in the bibliography at the end of this section.

Acceleration is the time rate of change of velocity. It is a vibration quantity as used in this Code. Units of acceleration are meters per second per second (abbreviated m/sec^2) or multiples of gravity acceleration, "g". By international agreement, the value of 9.806 m/sec^2 (32.17 ft/sec^2) has been chosen as the standard acceleration due to gravity.

Ambient Sound is the all-encompassing sound associated with a given environment, usually a composite of sounds from many sources near and far.

Average Sound Level is the same as equivalent sound level.

A-weighted Sound Level is the sound level measured after the ambient sound is filtered by the A-weighting network (see Section 2.3.2).

Background Ambient Sound is the all-encompassing sound associated with a given environment excluding the source being studied (i.e., automobiles, air conditioners, industrial plants and others).

Day-Night Sound Level, L_{dn}, is the 24-hour equivalent sound level, in decibels, dB, obtained after addition of 10 decibels to nighttime (10:00 P.M. to 7:00 A.M.) sound levels.

Decibel, dB, is a unit of sound level (and other levels as well). It is based on ten times the logarithm (base 10) of the ratio of two quantities, one of which may be a reference quantity.

Equivalent Sound Level, L_{eq}, is the A-weighted sound level containing the same sound energy as the time-varying sound. Technically, the equivalent sound level in decibels (dB) is the level of the A-weighted mean square sound pressure during the stated time period referenced to the square of the standard reference sound pressure of 20 microPascals.

Impulsive Sound is a brief increase in sound level (generally more than 10 decibels) above the background ambient sound level. The duration of a single impulse is usually less than one second. Familiar impulsive sounds are dynamite blasts, gun firing, and pile driving.

Noise Level is the same as sound level for sound in air. Some people use "noise" only for undesirable or unwanted sound. A sound level meter, however, does not measure people's desires; therefore, to prevent misunderstandings, it is suggested that the quantity measured by a sound level meter be called sound level rather than noise level.

Percentile Sound Level, L_X, is the sound level exceeded X-percent of the time during the period of observation. For example, L_{10} is the A-weighted sound level exceeded ten percent of the time during the period of observation.

Pure Tone is a sound distinctly heard as a single pitch (frequency) or series of single pitches. Examples are screech, whine, whistle, etc.

Sound Level, L_A, is the weighted sound pressure level obtained by the use of standard filters (electrical circuits). The most commonly used filter is the A-weighting network (see Section 2.3.2).

Sound Pressure is the instantaneous pressure above or below a static pressure (barometric pressure) due to the sound wave. The root mean square (rms) sound pressure is the square root of the average of the square of the instantaneous sound pressures.

Sound Pressure Level is defined as 20 times the logarithm (base 10) of the ratio of the root mean square sound pressure to a reference standard sound pressure of 20 microPascals. It can be noted as

$$L_p = 20 \operatorname{Log}_{10} \frac{P_{rms}}{P_o}$$

where P_o is the standard reference sound pressure - 20 microPascals.

Steady Sound is a sound whose level remains essentially constant (variations equal to or less than 6 dB) during the period of observation.

Vibration is an oscillatory motion described by either displacement, velocity, or acceleration with respect to a given reference.

Wavelength, λ, is the distance between two successive wavefronts in a periodic wave.

2.3 FUNDAMENTAL ASPECTS OF SOUND MEASUREMENTS

2.3.1 The Nature of Sound

Sound, in its simplest terms, is a form of aerodynamic vibration which transmits energy from one point in space to another. It is a pressure fluctuation to which the ear responds. Sound waves behave like the ripples in a pond produced by throwing a stone into the water. Like the ripples, sound waves move away from the source at a constant speed. The mode of propagation is momentum exchange with no net transfer of matter away from the source.

The speed of sound in air varies slightly with temperature and humidity, but for most purposes may be regarded as having a constant value of 340 m/sec (1120 ft/sec).

A physical description of sound or noise, whether from a single source or from sources in combination, requires a knowledge of certain fundamental parameters. The five basic parameters to be considered in the description of sound include:

- Magnitude
- Frequency Distribution
- Directional Distribution
- Temporal Distribution*
- Operating Conditions

Of these five basic parameters, the two, which are used most often to define sound, are its frequency content (pitch) which is expressed in Hertz (one Hertz is equal to one cycle/second) and its amplitude. Since sound is a pressure phenomenon, the amplitude of a sound should be expressed in units of pressure but is commonly expressed in decibels.

To develop a clearer idea of the magnitude of common sound signals, Figure 2.1 is presented. Note that the range of sound pressure perceived by man is quite large, on the order of 1:1,000,000.

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*For time-varying sound

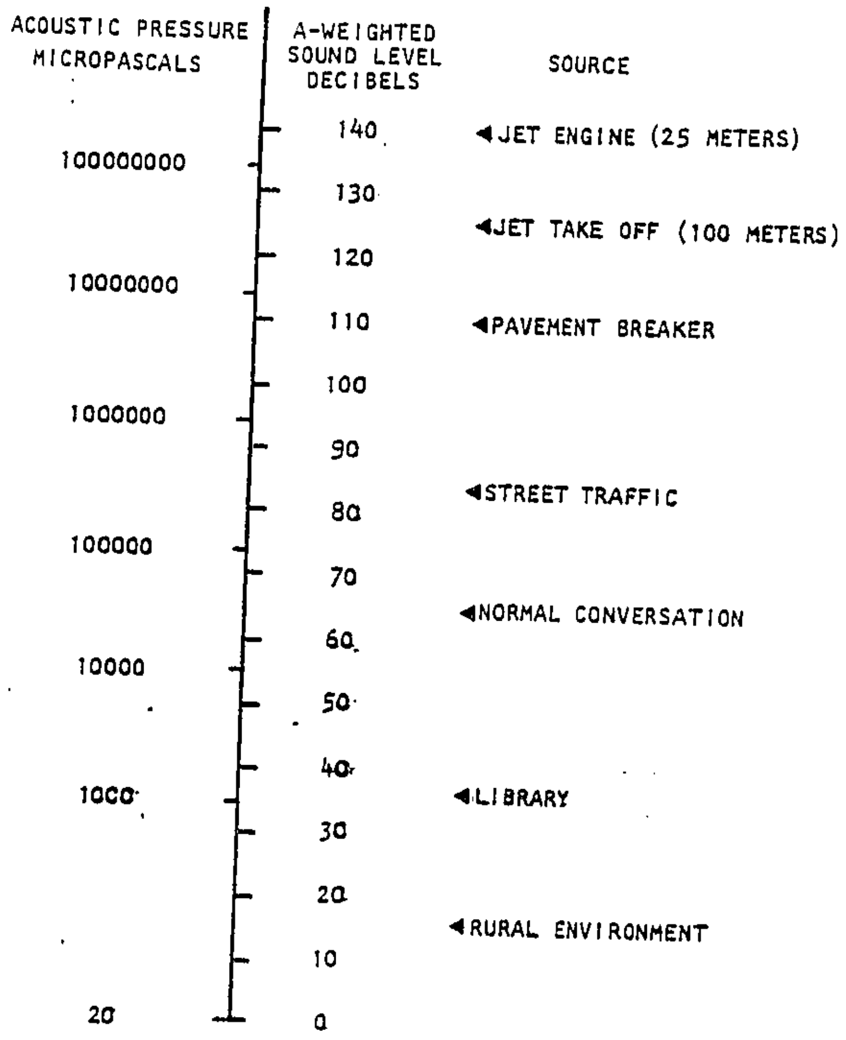


Figure 2.1 Magnitude of Some Typical Sounds

Due to the large range of sound pressures encountered (see Figure 2.1), it is more convenient to express the sound pressures on a logarithmic scale. This compression in scale to smaller numerical values is easier to use. The sound pressure level is defined as:

$$L_p = 10 \operatorname{Log}_{10} \frac{p^2}{(p_o{}^2)} \text{ dB} = 20 \operatorname{Log} \left(\frac{p}{p_o}\right) \text{ dB}$$

where p is the square root of the mean of the square (rms) of the instantaneous sound pressures, and p_o is a reference pressure.

The internationally agreed upon standard reference pressure is 20 micropascals which corresponds approximately to the faintest sound that an average young adult can hear in a quiet surrounding. The important point to remember is that the decibel is non-dimensional and is a ratio of two pressures. The sound pressure level L_p in decibels relates to magnitude only because of the reference pressure.

Sound energy can be analyzed (using electronic instruments) in bands of frequency. The preferred bands[1] for acoustic measurements cover the audible range (nominally 20-20,000 Hz) and consist of 10 frequency ranges. The frequency range of each band increases as the frequency increases. The upper frequency of each band is <u>twice</u> the lower frequency. For example, the 1000 Hz octave band extends from 707 Hz to 1414 Hz. The preferred octave band center frequencies are 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, and 16000 Hz. Note the doubling here as well.

For more detailed analysis of a sound's frequency content, still narrower bands, such as 1/3 or 1/10 octave bands, are used.

2.3.2 A-Weighted Sound Level

The apparent loudness that we attribute to a sound varies not only with the sound pressure but also with the frequency of the sound. This is further complicated by the fact that the frequency dependence is also a function of sound pressure. Since loudness is a function of level and frequency, three standard criteria were developed many years ago to attempt to convert a sound level meter to a loudness meter (somewhat unsuccessfully). These three criteria are shown in Figure 2.2. Sound levels are measured by sound level meters using electrical components called networks. Most common of these is the A-weighted network which attempts to reflect the human ear's decreased sensitivity to low frequencies at normal sound levels. A sound measured with a device using such a network provides a reading referred to as an A-weighted sound level.

To determine the A-weighted sound level given the octave band spectrum of sound, factors are subtracted from the sound pressure level values in each octave band, and the octave band sound pressure levels then added on an energy basis. These corrections, obtained from the A-weighted response curve shown in Figure 2.2., are tabulated below:

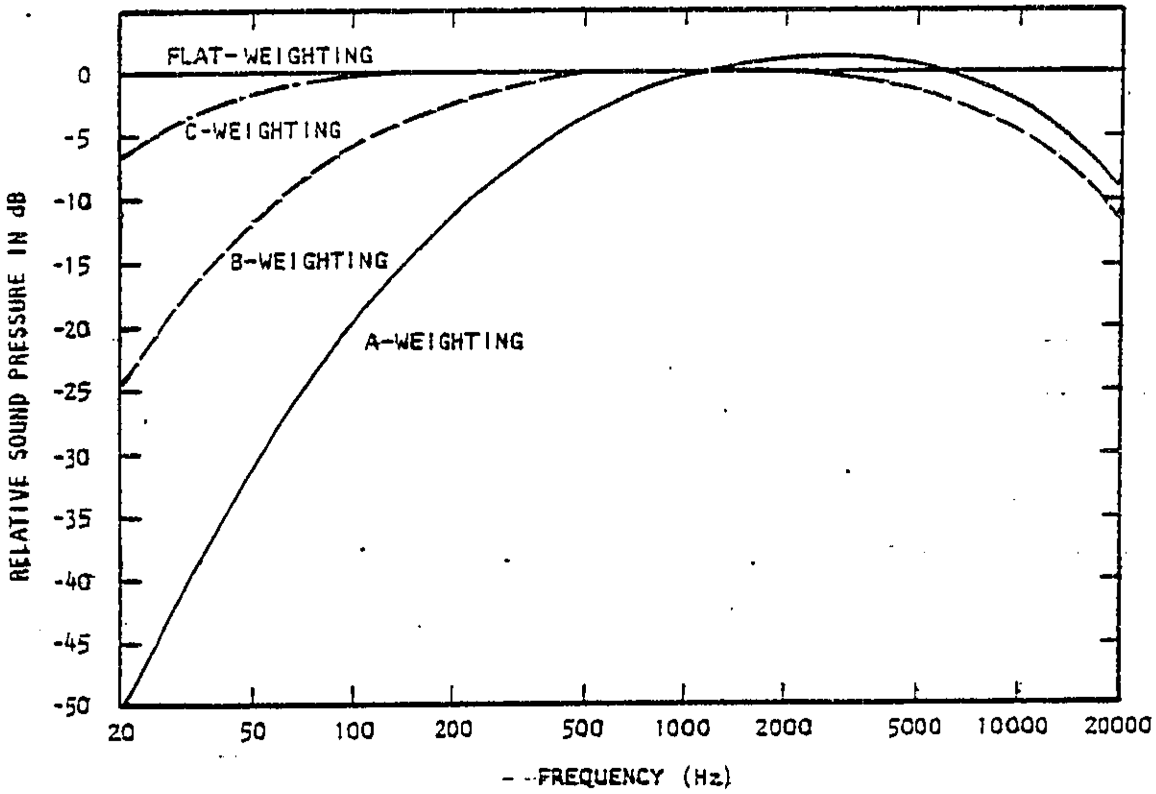


Figure 2.2 Weighting Characteristics

Octave Band Center Frequency Hz	A-Weighted Corrections dB
31.5	-39.4
63	-26.2
125	-16.1
250	-8.6
500	-3.2
1000	0
2000	+1.2
4000	+1.0
8000	-1.1

2.3.3 Combining Sound Levels

Very often there are two independent sound sources radiating concurrently. To determine the combined effect of the two sources, their contribution is added on an energy basis (sound pressure levels are not added directly but instead are converted to mean square pressure terms, which are added and then reconverted to decibels). One method of combining sound levels is the use of the graph in Figure 2.3. By knowing the two levels and therefore the difference between the two, the increment to be added to the higher level is determined. This yields the resultant sound level. This increment is read directly from the graph.

The graph presented in Figure 2.3 is based on the following relationship:

$$L_{pt} = 10 \text{ Log } [10^{L_{p1}/10} + 10^{L_{p2}/10}] \text{ dB}$$

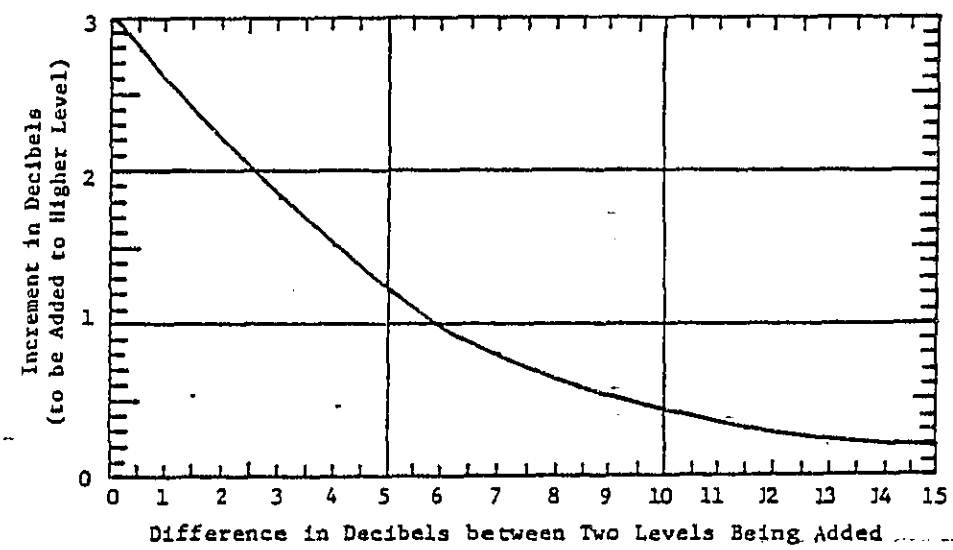


Figure 2.3 - Chart for Combining Decibels

The total sound level L_{pt} can easily be determined using a pocket calculator containing powers of ten, 10^x, and logarithm functions.

2.3.4 Equivalent Sound Level, L_{eq}

Environmental noise is not steady but fluctuates considerably in level with time. To fully characterize the exposure of an individual to time-varying sound levels, a history or cumulative distribution of the sound levels would be necessary. This requires a large number of samples. To simplify matters, noise from both individual events and quasi-steady state sources are averaged. This time weighted average is known as the equivalent sound level (L_{eq}). The equivalent sound level is equivalent to (or equal to) the steady noise level which in a stated period of time would contain the same acoustic energy as the time-varying sound. The mathematical definition of L_{eq} for an interval T is:

$$L_{eq} = 10 \text{ Log } \left(\frac{1}{T}\int_0^T \frac{p^2(t)}{p_o^{\,2}}\, dt\right) \text{ dB}$$

where p(t) is the time-varying rms sound pressure and p_o is the reference pressure.

An approximation to this integral is:

$$L_{eq} = 10 \text{ Log}_{10} \left(\frac{1}{T}\sum_{i=1}^{n} t_i \, 10^{L_i/10}\right)$$

where L_i is the sound level for time interval i
t_i is length of time interval i
and T is the period of interest.

2.3.5 Day-Night Sound Level, L_{dn}

The development of equivalent sound level was followed by the development of the day-night sound level. This is the average A-weighted sound level during a 24-hour time period with a 10-decibel weighting (penalty) applied to the nighttime sound levels (10 P.M. to 7 A.M.). This may be expressed mathematically as:

$$L_{dn} = 10 \text{ Log } \frac{1}{24} \left([15(10^{L_d/10}) + 9(10^{(L_n+10)/10})] \right)$$

where $L_d = L_{eq}$ for the daytime (0700-2200 hours)
and $L_n = L_{eq}$ for the nighttime (2200-0700 hours)

This computation is easily accomplished using a pocket calculator. The following example illustrates the method used to compute L_{dn}:

Example: The day and night sound levels are 58 dB and 52 dB, respectively.

$$10^{58/10} = 630957$$

This value must be multiplied by 15.

$$15 \times 630957 = 9464360$$

Ten decibels are added to the night sound level. The result is divided by 10 and raised to the power of ten.

$$10^{(52+10)/10} = 1584893$$

This value must be multiplied by 9

$$9 \times 1584893 = 14264039$$

The two factors are added and divided by 24.

$$\frac{9464360 + 14264039}{24} = \frac{23728399}{24} = 988683$$

$$L_{dn} = 10 \text{ Log } 988683 = 60 \text{ dB}$$

Obviously, this example is more easily accomplished using a calculator.

2.3.6 Distance Attenuation

Sound waves for many situations may be approximated by a free spherical progressive wave. This is analogous to waves propagating radially from a small sphere. The emitted sound intensity spreads out from the source with continuously increasing radii. In the absence of any losses (absorption), the sound power must remain constant (conservation of energy). Therefore, the intensity at a given distance from the source must be proportional to the inverse of the spherical surface area (radius squared). The sound level attenuation as a function of distance can easily be computed. The "inverse square law" of attenuation, as it is commonly called, is 6-decibel reduction for each doubling of distance from its origin. Figure 2.4 can be used for determining the sound pressure level at different source-receiver distances.

For example, if the sound level at 200 meters is 92 dB, the sound level at 950 meters is obtained by entering the graph at a ratio of 4.75 and reading 13.5 dB attenuation. Subtracting 13.5 from 92 provides the sound level of 78.5 dB. Alternately, a calculator can be used for determining distance attenuation.

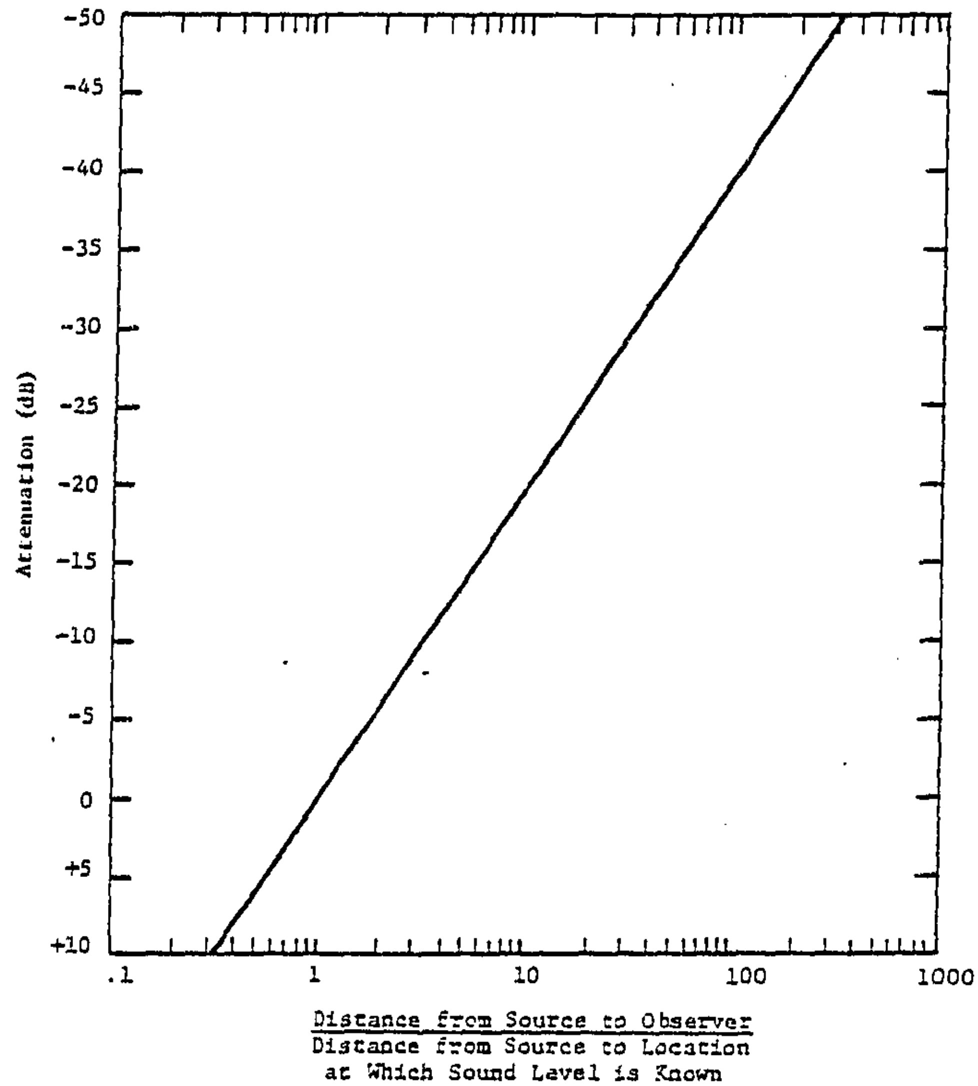


Figure 2.4 - Distance Attenuation

Note: For point sources only. Either small source or large distance from large source. Distance to source is at least three times typical dimension of source.

$$\text{Attenuation} = 20 \text{ Log } \left(\frac{950}{200}\right)$$

$$L_{p950} = L_{p200} - 20 \text{ Log } \left(\frac{950}{200}\right) = 92 - 20 \text{ Log } \left(\frac{950}{200}\right)$$

$$L_{p950} = 92 - 13.5 = 78.5 \text{ dB}$$

Note that this relationship only holds for small sources or for large distances (three times the major dimensions) from large sources.

Sound level attenuation calculated by this procedure assumes free field conditions and does not include the attenuation due to air absorption and effects of ground cover, such as trees and brush. Discussions of these additional attenuation effects which can be significant over very large distances are available in several references found in the bibliography at the end of this section.(2) In urban areas where many reflecting surfaces and free field conditions do not exist, attenuation may be less than 6 dB/DD. Caution, therefore, should be exercised in using these figures.

Traffic noise for the flowing highway traffic does not radiate in a similar manner. The sound propagates not as if from a small sphere, but as if from a cylinder. The attenuation factor for this case is approximately 3 decibels for each doubling of distance. For certain traffic flows, the attenuation factor is between the spherical and the cylindrical. An often used quantity for traffic noise attenuation with distance is 4.5 decibels for each doubling of distance.

2.3.7 Effect of Reflective Surfaces

Often conditions at a measurement location are far from ideal. A microphone placed too close to a sound reflecting surface will respond to both the sound traveling directly from the source and the sound reflecting from the surface. An error, as much as about 4 decibels, can result.

Small objects, which are no closer to the source than 5 meters, chain link fences or low-lying vegetation should not be considered reflecting surfaces.

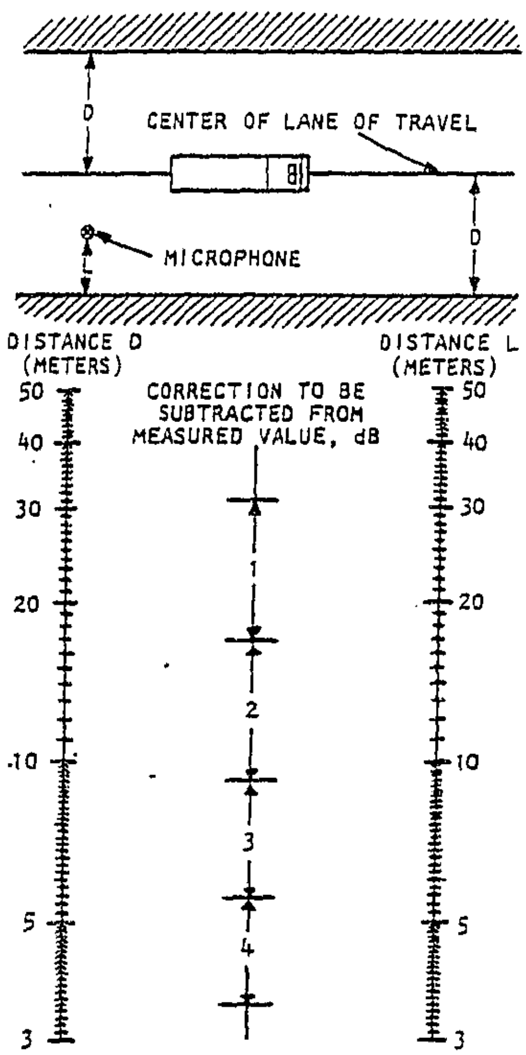
For situations where reflecting surfaces affect the measurement accuracy, approximate corrections for reflections can be made. These corrections, based on the distance the microphone or source is from the reflecting surface, are presented in Table 2.1.[3] The corrections are subtracted from the measured values.

The special case for reflecting surfaces near roadways has been investigated and a nomograph has been prepared, see Figure 2.5.[4] Note that corrections for reflecting surfaces on either side of the roadway can be found. The examiner must estimate the distance (D) between the centerline of the lane of travel and the nearest reflecting surface. The distance (L) from the microphone to its nearest reflecting surface is also determined. To determine the correction, locate the two distances on their respective axes on the nomogram, Figure 2.5. Connect the two points by a straight line.

Table 2.1 Correction Factors to be Subtracted from Measured Values due to Reflecting Surfaces

Distance microphone or source is from reflecting surface[a] Meters (feet)	Correction dB
31 (100)	0.5
15 (50)	1
8 (25)	2
4 (12)	3
2 (6)	4
1 (3)	5
0.3 (1)	6

[a]The reflecting surface should be larger than 6 m x 6 m x 3 m (20 ft x 20 ft x 10 ft)



NOTE: 1. L is distance from microphone to nearest reflecting surface.
2. D is distance from centerline of lane to nearest reflecting surface.
3. Also use this nomograph for one reflecting surface.

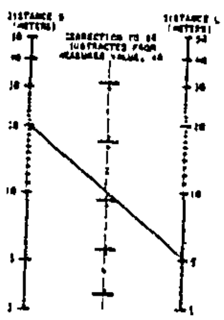
CORRECTIONS FOR REFLECTING SURFACES

FIGURE 2.5

The correction is found at the intersection of this line and the central axis. Subtract this correction from the measured values.

Example: Automobile noise levels are measured at a location along a thoroughfare. Apartment houses are on one side of the road while large warehouses are on the other. The microphone is located 15 meters from the nearest lane of traffic but is only 5 meters from the walls of the apartment building. This lane of traffic is 35 meters from the warehouses on the other side of the roadway. The automobile noise is measured at an A-weighted sound level of 85 dB. What is the corrected value of automobile noise?

The distances D and L for the nomograph, Figure 2.5, are 20 meters and 5 meters, respectively. A line between these points passes through the correction value of 2 dB which must be subtracted from the measured value (see Figure 2.5). Thus, the corrected sound level for the automobile is 85 - 2 = 83 dB.



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"Noise Emission Standards for Construction Equipment: Background Document for Portable Air Compressors," USEPA 550/9-76-004, December 1975.

"Handbook of Noise Ratings," Karl S. Pearsons, et al, NTIS Report N74-23275, April 1974.

"Experimental Study of the Propagation of Sound Over Ground," Francis M. Wiener and David N. Keast, JASA Vol. 31, Number 6, 1959.

"Predicting Community Response to Blast Noise," CERL Technical Report E-17, December 1973.

Standards

American National Standards Institute

S1.1-1960 (R1971	Acoustical Terminology
S1.4-1971	Sound Level Meters, Specifications for
S1.6-1967 (R1971)	Preferred Frequencies and Band Numbers for Acoustical Measurements
S1.8-1969 (R1974)	Preferred Reference Quantities for Acoustical Levels
S1.10-1966 (R1971)	Calibration of Microphones, Method for the
S1.11-1966 (R1971)	Octave, Half-Octave, and Third-Octave Band Filter Sets, Specifications for
S1.12-1967 (R1972)	Laboratory Standard Microphones, Specifications for
S1.13-1971	Sound Pressure Levels, Methods for the Measurement of
S3.20-1973	Psychoacoustical Terminology
S3-W-39	The Effects of Shock and Vibration on Man

International Standards Organization (ISO)

R31 - Part VII-1965	Quantities and Units of Acoustics
R266-1962	Preferred Frequencies for Acoustical Measurements
R-1996-1971	Acoustics - Assessment of Noise with Respect to Community Response
ISO 2204-1973	Acoustics - Guide to the Measurement of Airborne Acoustical Noise and Evaluation of Its Effects on Man
ISO 2631-1974	Guide for the Evaluation of Human Exposure to Whole-Body Vibration

International Electrotechnical Commission (IEC)

IEC 123 (1961)	Sound Level Meters, Recommendations for
IEC 179 (1965, 73)	Precision Sound Level Meters
IEC 225 (1966)	Octave, Half-Octave, and Third-Octave Band Filters Intended for the Analysis of Sounds and Vibrations

National Bureau of Standards

NBS 386	Standards on Noise Measurements, Rating Schemes and Definitions: A Compilation

2.5 REFERENCES

1. American National Standards Institute S1.6-1967 (R1971) "Preferred Frequencies and Band Numbers for Acoustical Measurements."

2. Werner, F. M. and D. N. Keast, "Experimental Study of the Propagation of Sound over Ground," JASA Vol. 31, Number 6, 1959.

3. "Chicago Urban Noise Study," Bolt Beranek and Newman Report No. 1411, Nov. 1970.

4. State of Oregon "Motor Vehicle Sound Measurement Procedures Manual," NPC S-21.

INSTRUMENTATION 3

3.0 INSTRUMENTATION

3.1 INTRODUCTION

Noise measuring instruments and support equipment such as wind speed indicators, hygrometers, tachometers, and watches are used in the noise measurement methods presented in this Code of Current Practices. In the following sections, the theory and techniques for each instrument are discussed.

3.2 SOUND LEVEL METERS

The basic components of a sound level meter are the microphone, an amplifier, a filter, a detector, and a read-out device. These components are shown schematically in Figure 3.1.

The microphone is a transducer which converts time-varying sound pressure to a time-varying electrical signal. The voltage of this signal is very low and needs to be increased. This is accomplished by the amplifier. Most sound level meters contain an electronic circuit which varies the voltage of the signal in a desired manner. Normally, this circuit, called a filter, varies the signal voltage as a function of frequency. The A-weighting network (filter) discussed in Section 2.3.2 reduces the voltage a great deal in the low frequencies in an attempt at simulating the human ear's effect on sound as one hears it. At the outlet of the filter, the signal is still time-varying. But in order to provide a read-out in decibels, the signal must be detected. That is, the square root of the mean (average) of the square

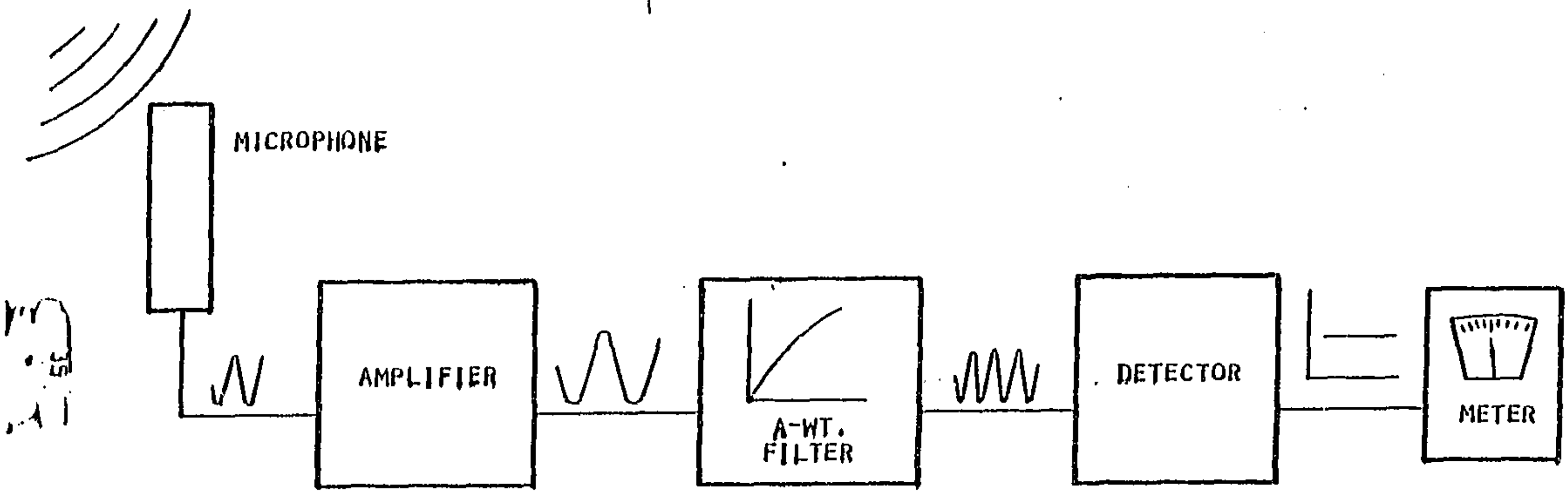


FIGURE 3.1 SOUND LEVEL METER

of this signal (rms) is determined by another electronic circuit. In this section of the sound level meter, the logarithm of the rms voltage is also obtained. The <u>detector</u>, in effect, changes the signals' characteristics from alternating current (A.C.) to direct current (D.C.). The <u>read-out</u> is usually a voltmeter with a needle movement which displays the voltage output of the detector on a scale in decibels.

• <u>Microphone</u>

There are a number of different types of microphones in use. The most common are the ceramic (piezoelectric), the condenser, and the electret microphones. Some electrodynamic microphones are available but they are less common.

The ceramic microphone consists of a diaphragm which is fastened to a piezoelectric crystal. Sound pressure is converted into a force which bends the crystal. When a piezoelectric crystal is strained, it produces a voltage. The condenser microphone also uses a diaphragm to produce motion. This motion changes the electrical capacitance formed between the thin diaphragm and a back plate. When a high D.C. polarizing voltage is applied to the capacitor, a time-varying voltage, proportional to the acoustic pressure, is produced. The electret microphone works on the condenser principle. A suitable plastic coating applied to the thin diaphragm maintains its own polarization (D.C. voltage). The capacitance change caused by motion of the diaphragm produces a voltage.

The voltage produced by the microphone may not be linearly related to the sound pressure due to the microphone geometry and construction. The sensitivity of common microphones decreases at very low frequency (less than 20 Hz), is flat (linear) for frequencies between 50 Hz and 8000 Hz, and increases above 8000 Hz. The frequency characteristics of a one-half inch condenser microphone are shown in Figure 3.2. Two frequency characteristics are shown. Note that the microphone response is more linear for sounds reaching it from all directions than from a sound reaching it along its axis. <u>It is important, therefore, to follow all microphone manufacturer (or sound level meter manufacturer) instructions for the orientation of their microphones for the most accurate results.</u>

• <u>Amplifier</u>

The amplifier used in a sound level meter is similar to the amplifier used in a good HiFi system. Its purpose is to increase the output voltage and output power without distorting the signal. The frequency response for the sound level meter amplifier shall be flat from below 20 Hz to above 20,000 Hz.

The amplifier must increase the output voltage in steps. Ten decibel steps are most often used.

• <u>Filter</u>

Weighting networks are a type of filter provided with the sound level meter to present a measure of how sound is perceived by an individual. In community noise measurements, the A-weighting network gives good correlation

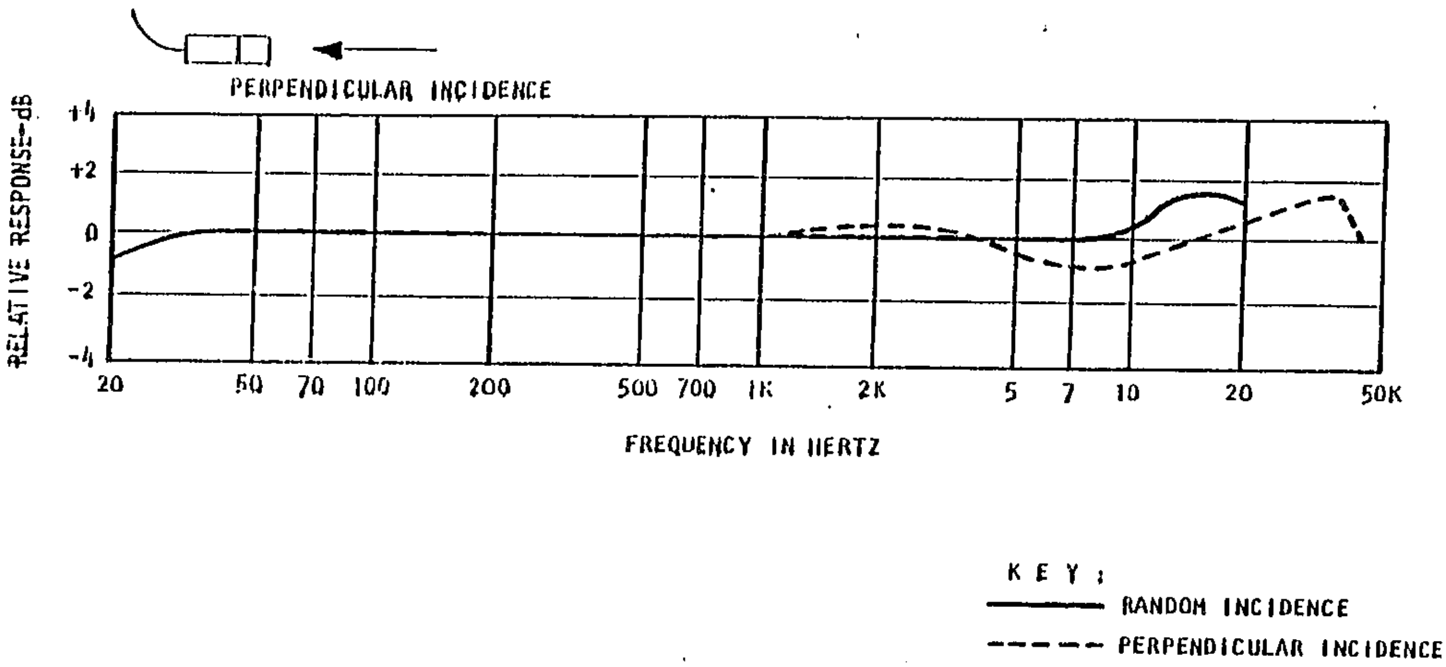


FIGURE 3.2 FREQUENCY CHARACTERISTICS OF ONE HALF INCH CONDENSER MICROPHONE

with human perception. Some sound level meters are also equipped with B-, C-, and flat-designated weighting networks. Differences between the sound pressure levels measured with the C or flat weightings and the A-weighting provide a good approximation of the ratio of high to low frequency distribution of a noise. The ideal A-, B-, and C-weighting network response curves, as specified by ANSI S1.4-1971, are shown in Figure 2.2.

A frequency analyzer is basically an electronic filter which selectively passes only those frequencies for which it is tuned. In this way, the level read on the meter is related to the energy content at the tuned frequency or contained in the band of frequencies passed. These analyzers may be an integral part of sound level meter systems, or they may be separate units that must be attached to separate read-out devices. In any case, instructions from the instrument manufacturer must be followed carefully.

The octave band analyzer uses the most common set of filters used for noise measurements today. Octave bands are the widest of the common band widths used for analysis and thus provide spectral information of sound pressure requiring a minimum number of measurements.

An octave band is defined as having an upper band-edge frequency equal to twice the lower band-edge frequency. The center frequency of an octave band is found from the square root of the product of the upper and lower band-edge frequencies. However, rather than specifying the upper and lower band-edge frequencies, national and international standards on octave band analyzers have specified the center frequencies and from these the upper and lower band-edges. The standardized octave band center frequencies are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, and 16000 Hz. Octave denotes a doubling. Note that not only are the band widths of each octave band one octave wide, but also the interval between center frequencies is one octave. Figure 3.3 shows the general octave band shape of a band pass filter with a center frequency of 1000 Hz.[1] Octave bands increase in width with increasing frequency, thereby permitting more sound energy to be transmitted in the upper bands than in the lower. For example, at 100 Hz, the band width is 70.7 Hz wide, while at 1000 Hz, it is 707 Hz and at 10,000 Hz it is 7070 Hz wide.

• <u>Detector</u>

The electrical signal from the microphone is typically comprised of the sum of many components at different frequencies. The square root of the mean of the square of the signal (rms) is required prior to obtaining and displaying the logarithm of this value in decibels. Common detectors rectify the signal (convert from a.c. to d.c.) and average it using a resistance/capacitance (RC) circuit. Two averaging circuits are provided; a "FAST" response circuit and a "SLOW" response circuit. At the "FAST" setting, the meter needle indicates the true indication of the level within 200 to 250 milliseconds after a 1000 Hz tone is applied. The overshoot

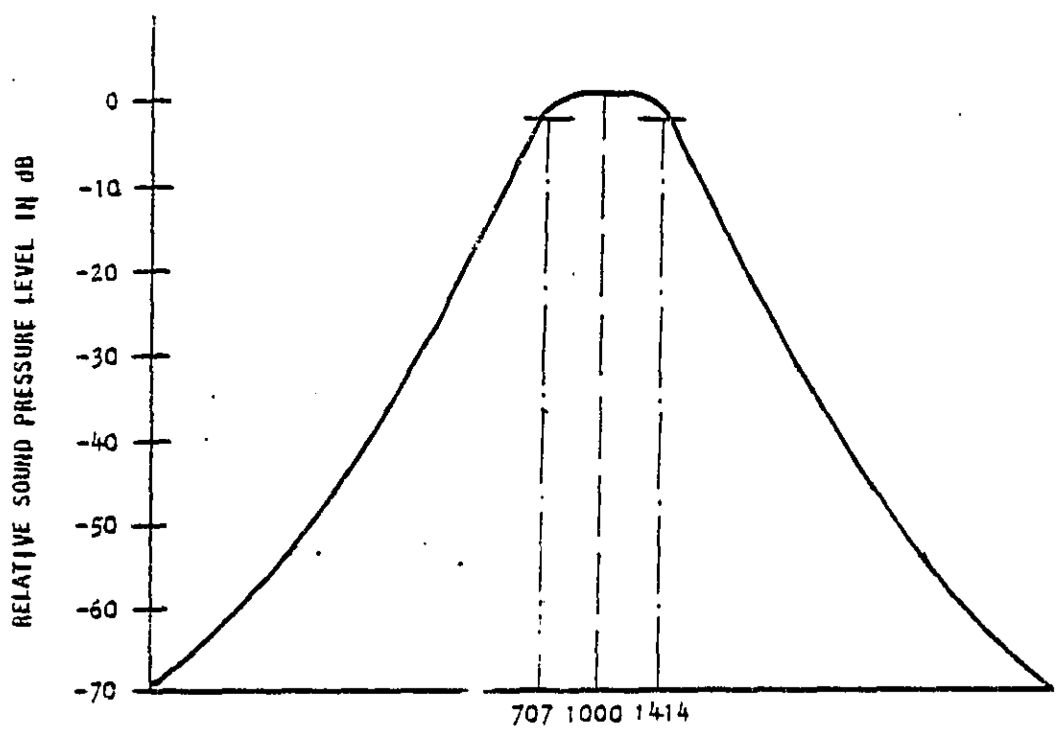


FIGURE 3.3 TYPICAL OCTAVE BAND FILTER CHARACTERISTIC AND EXAMPLE OF BANDWIDTH* AT 1000 HERTZ

*Bandwidth is specified in terms of the half power point (3 dB).

(amount the needle rises above the correct reading) before that time is not greater than 1 decibel. The "SLOW" setting averages the sound level for a longer period with little overshoot. For a rapidly fluctuating sound signal, the "SLOW" setting may not have a fast enough response to measure the signal.

Read Out Device

The sound level meter output can be displayed on a graphic recorder or by a needle on a scale. The scale used with most sound level meters has a range of at least 15 decibels with increments of 1 decibel. Newer sound level meters have scales with a 20 decibel or greater range.

The meter range is adjusted (signal attenuated) so that the needle reads on-scale. Some meter scales have a display indicating -5 to 0 to +10. A 0 dB indication represents the setting of the amplifer, say 60 dB. A +7 indication would be read as 67 dB. A -3 indication would be read as 57 dB.

3.3 COMMUNITY NOISE ANALYZERS (AMPLITUDE DISTRIBUTION ANALYZERS)

Unless a sound signal (or vibration signal) is at a constant level, a problem exists in how to describe the fluctuating signal. Amplitude distribution analyzers (also called statistical distribution analyzers) measure ambient sound over long periods of time. These units contain a series of counters each of which corresponds to a unique (or small range) sound level. The analyzer can display the number of times a particular sound level occurred during the measurement period (histogram) or the percentage of time a sound level was exceeded during the measurement period (cumulative distribution).

A number of these analyzers will calculate from the acquired data, the equivalent sound level, L_{eq}, and the day/night sound level, L_{dn}. Certain models are equipped with batteries, microphones, and special enclosures which allow the unit to operate unattended even under adverse weather conditions. An option is available which includes an anemometer. If wind speeds exceed a preselected level, the sound data acquired during this occurrence is disregarded.

3.4 WINDSCREEN

The movement of air around a microphone causes turbulence which in turn generates undesired noise at the diaphragm of the microphone. This noise can effectively mask the sound signal under study even though it may be inaudible to the human ear. In cases where measurements must be made in the presence of wind or where wind gusts are suspect during the course of measurement, a microphone windscreen should always be employed.

Windscreens are generally either spherical or cylindrical in shape, made of foamed polyvinyl, open-celled polyurethane, or a silk-covered grid. The windscreen is attached directly over the microphone. They are limited in their effectiveness; therefore, measurements should not be made when the wind speed exceeds 20 km/hr (12 mph).

The windscreen has the secondary advantage of protecting the expensive microphone from damage due to inadvertent blows or falls.

3.5 <u>ACOUSTIC CALIBRATOR</u>

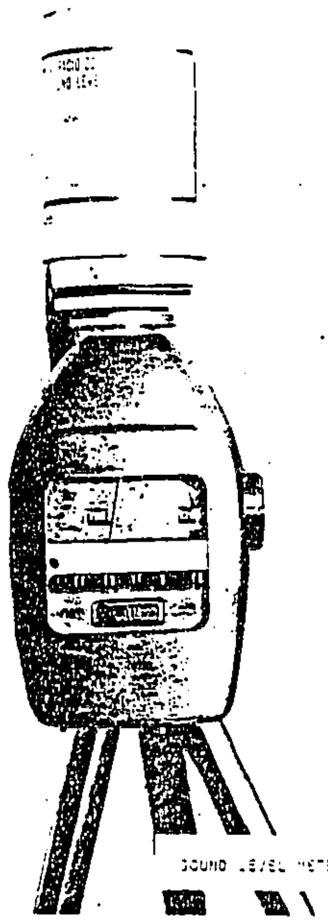
The acoustic calibrator provides a means for conducting an overall system check and calibration of the sound level meter. Calibrators are generally compact and rugged so that they may be used effectively in the field. They consist basically of a sound source generated in a small cavity using battery-driven electronic circuitry. Some calibrators generate a single frequency at a stated sound pressure level, while others are tunable to several preselected pure tones, all at a known sound pressure level.

Calibrators are specifically designed for various microphones so <u>it is important that the proper calibrators be used</u>. Otherwise, errors may result or microphones may be permanently damaged.

The sound level meter reading is adjusted to match the calibrator sound pressure level. For calibrators which emit sound at 1000 Hz, the calibration can be accomplished using any weighting network. Otherwise, sound level meters must be calibrated using the flat or C-weighting scale.

Calibrator output is affected by changes in atmospheric (barometric) pressure. Care must be taken when using the calibrator at atmospheric pressures other than standard conditions. Calibrator manufacturers provide correction curves for calibrator use at atmospheric conditions other than standard. Calibrators must be checked on a routine basis to ensure the level of sound emitted has not changed.

The following photograph shows calibration of a sound level meter.



SOUND LEVEL METER CALIBRATION PROCEDURE

Figure 3.4

3.6 ANEMOMETER

Wind noise can cause variations in microphone sound level measurements. To ensure that conditions are acceptable for sound measurements, however, it is important to be able to measure wind speed. An anemometer is used for this purpose.

Anemometers are typically of one of two types, pressure tube or rotation. The pressure tube type is based on the principle that wind blowing across the mouth of a tube produces a vacuum, while wind blowing into the mouth of a tube produces a pressure, both proportional to the wind speed. A rotation anemometer uses a set of open cups or an aerovane to produce rotation (similar to a windmill). This rotation drives a small generator which produces a voltage proportional to the wind speed.

3.7 TACHOMETER

A tachometer is used to measure rotational speed of an engine. Tachometers are of three major types. Electrical tachometers use a signal from the vehicle's ignition system to indicate engine speed. An induction tachometer requires that a sensor be clipped onto a spark plug wire. Since the relationship between engine firing rate and rotational speed varies with the number of engine cylinders, multiple scales or conversion tables are required for correct determination of rotational speed. Some engines used on motorcycles and recreation vehicles introduce complications. Two stroke engines are designed so that each cylinder fires every revolution (standard automobile engines fire once every second revolution). Some engines are designed for cylinder firing every revolution. Therefore, tachometer readings must be interpreted very carefully.

Since diesel engines have no spark ignition systems, some method other than an electrical tachometer must be employed to measure rotational speed. An electromechanical tachometer is directly connected to the engine drive shaft to obtain the motion for a generator which produces a voltage proportional to rotational speed.

Optical tachometers may also be used. These units utilize a light beam reflecting from a mark on the drive shaft or fan. The light is pulsed at a high rate until synchronism occurs (stroboscopic effect) and the mark (or fan) apparently stops rotating. The engine speed is then read from a calibrated dial.

3.8 REFERENCES

1. American National Standards Institute S1.8-1966 (R1971) "Specifications for Octave, Half-Octave, and Third-Octave Filter Sets."

VIBRATION

4

4.0 VIBRATION

4.1 INTRODUCTION

Biological effects of structure-borne vibration upon exposed humans depend upon many complicated interrelated factors.[2] These include the amplitude and frequency of the vibration, its locational site, area, direction of application, and individual variations in susceptibility as are dependent upon physical state, age, muscle tone, size and weight, etc. The kinds of effects depend largely upon the vibration frequency which may range from 0.1 to 1,000,000 Hz. Adverse effects may range from motion sickness (kinetosis) which occurs principally for vibration between 0.1 and 10 Hz to local tissues heating and possible cell damage at frequencies in the ultrasonic range above 20,000 Hz.

Vibration is an oscillatory motion of gas particles (sound), fluids, or solids. Vibration is most commonly used to describe wave motion of solids. Vibration of a solid structure at a point can be described by many parameters, including displacement, velocity, and acceleration. These quantities can be determined by different instruments, but acceleration is easiest to measure using accelerometers.

Acceleration, velocity, and displacement are interrelated. Acceleration is the time rate of change of velocity, and velocity is the time rate of change of displacement. Therefore, by obtaining the acceleration as a function of time at a point, all the other parameters can be determined.

4.2 VIBRATION CRITERIA

Basic threshold acceleration values for acceptable vibration environments have been proposed by the Committee on Hearing, Bioacoustics and Biomechanics based on present and proposed International Standards Organization (ISO) standards.[1,2] Table 4.1 contains these proposed values as a function of building types or spaces depending upon the time of day and whether the vibration is impulsive or not. The acceleration values shown in the table should cause less than 1 percent of the population to complain.

Acceleration levels higher than those shown in Table 4.1 for hospital operating areas should not be allowed without careful study and analysis. For residential and similar areas, higher continuous acceleration than the values shown in the table may be allowed for shorter times without causing complaints. Note that allowable values for office spaces are twice that of residential areas, while values for factory areas are four times that of residential areas.

Very high acceleration levels, particularly from blasting or high airborne noise (sonic boom) may cause structural damage. A structural vibration (velocity) limit of 0.05 m/sec (acceleration of 1 m/sec^2 for 3 Hz) is suggested as a safe limit to prevent structural damage. For historical sites or structures of particularly high value, an acceleration of 0.05 m/sec^2 is suggested as a safe upper limit.

Table 4.1

Basic Threshold Acceleration Values for Acceptable Vibration Environments

Daytime is 7 am to 10 pm. Nighttime is 10 pm to 7 am.

All Values are Meters/Sec^2

Type of place	Time of day	Continuous or intermittent rms acceleration	Impulsive shock excitation peak acceleration
Hospital Operating Rooms and Other Such Critical Areas	Day	.0036	.005
	Night	.0036	.005
Residential	Day	$\frac{.072}{\sqrt{t}}$	$\frac{.1}{\sqrt{N}}$
	Night	.005	.01
Office	Anytime	$\frac{.14}{\sqrt{t}}$	$\frac{.2}{\sqrt{N}}$
Factory and Workshop	Anytime	$\frac{.28}{\sqrt{t}}$	$\frac{.4}{\sqrt{N}}$

t = duration seconds of vibration; for durations greater than 100 sec, use t as 100 sec.

N = the number of discrete shock excitations that are one sec or less in duration. For more than 100 excitations, use N=100.

Note: 1 g = 9.8 m/sec^2

4.3 ACCELEROMETER AND VIBRATION METER

Accelerometers, a common form of vibration pickup or transducer, are most often constructed using a piezoelectric body to produce an electrical signal proportional to acceleration. Figure 4.1 is a sketch of the construction of a typical accelerometer. A mass is attached to the piezoelectric crystal in a housing. The mass produces a force on the crystal when it is accelerated. The piezoelectric crystal has the property of producing a low voltage when it is strained (squeezed). Small, light weight accelerometers produce a voltage that ranges from 1 to 5 millivolts per "g" (9.806 m/sec) of acceleration.

Since accelerometers are small and light, they are easily attached to most structures. Accelerometers may be attached using a threaded hole and stud, epoxy glue, or simply by holding it firmly. A light grease is often used with the latter method to ensure a good interface. Manufacturer instructions for mounting should be reviewed. Most accelerometers can be oriented to any direction.

Vibration meters provide a means for displaying the vibration level in decibels or the rms value in English or metric units. The vibration meter is constructed in a similar manner to a sound level meter. The low voltage output of the accelerometer is amplified, detected, and displayed. The detector provides a signal proportional to the rms acceleration which can be directly displayed or converted to acceleration level in decibels, depending upon the meter. Many sound level meters can be used, with suitable calibration, as the indicating instrument for the accelerometer.

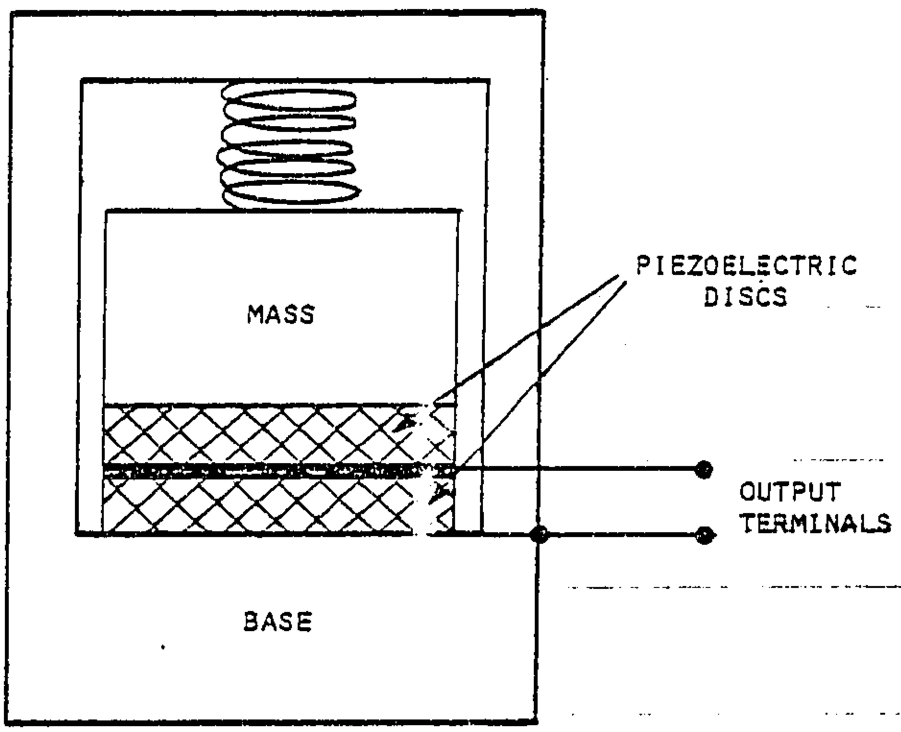


FIGURE 4.1 BASIC ELEMENTS IN AN ACCELEROMETER

4.4 REFERENCES

1. "Guidelines for Preparing Environmental Impact Statements on Noise," Committee on Hearing, Bioacoustics and Biomechanics, National Research Council, 1977.

2. "Vibration Criteria for Occupants in Buildings," (1976 Draft Addendum to ISO Standard 2631-1974.

SECOND SEGMENT
CURRENT PRACTICES

PRACTICAL SUGGESTIONS FOR USERS OF THESE PRACTICES

USE OF THE SOUND LEVEL METER

1. Some microphones are directional. Orient the microphone for the best frequency response. Consult the sound level meter user's manual for the proper orientation.

2. Reflecting and absorptive surfaces (for example, the human body) affect accuracy. The meter reader and others should be as far from the microphone as possible. Use an extension cable supplied by the instrument manufacturer.

3. If the microphone cannot be separated from the meter, the observer should orient himself so as not to be behind the microphone. Stand to the side of a straight line from the microphone to the source as the sound level meter is being read.

4. Calibrate the sound level meter as often as possible. The instrument should be calibrated with all equipment and cables connected. This does not include the windscreen. If calibrations before and after differ, repeat the measurements if possible. For measurements which cannot be repeated, use a lower measurement value as determined from the calibrations. For example, if the pre-test calibration is 114 dB and the post-test calibration is 112 dB, reduce the measured value by 2 decibels. Reject the data if calibration difference exceeds 3 decibels.

5. When moving the sound level meter from one extreme temperature environment to another (e.g., from a heated car to the outside), care should be taken so that moisture does not form on the microphone diaphragm.

SELECTING MEASUREMENT SITES

1. Not all sites will have all the features suggested in the practices. Judgment as to the use of a particular site must be made after a site visit.

2. Small objects such as mailboxes, fence railing, and utility poles will not affect the data if these objects are not <u>very</u> close to the microphone or the source of noise.

3. The area around the measurement site may have shallow slopes.

4. If the site does not meet the necessary requirements but must be used, carefully note the type, amount,

and location of reflecting surfaces, and other problems. Estimate the error that these site problems might cause. Consider this error in assessing compliance.

5. Stationary/source noise measurements should be made at the point of maximum sound level on the receiving property. This location (of max sound level) may, or may not, be at the nearest property line, or vertical extension of that property line (i.e., high rise building).

BACKGROUND AMBIENT SOUND LEVELS

1. Measurements of noise sources should be made when the background ambient sound level is more than 10 decibels less than the sound level of the noise source being measured. This is often not possible to achieve. In this case, use the following table to subtract the background ambient data from the measured data to obtain the noise source contribution. If the background ambient sound level is within 3 decibels of the noise being measured, no assessment of the noise source contribution can be made.

ΔL_A [a] (dB)	Correction [b] (dB)
0	*
1	*
2	*
3	3.0
4	2.5
5	2.0
6	1.5
7	1.0
8	1.0
9	0.5
10	0.5

[a] ΔL_A - the difference between the measured sound level with the noise source operating and the background ambient.

[b] Correction - the value to be subtracted from the measured sound level to determine the source sound level contribution.

2. For passby measurements, note the difference between the maximum sound level as the vehicle passes by and

the background ambient sound level after the vehicle has passed. Note both values and make adjustments as in 1, above.

3. Decreasing the distance to the noise source often decreases the effect of the background ambient sound levels. Afterwards, adjust the measured sound level for distance as discussed in Section 2.3.6.

ENFORCEMENT

1. The presence of a law enforcement officer for roadside measurements and citation is suggested. Measurements can be made from inside a stationary enforcement vehicle if the microphone is positioned outside the vehicle in such a way as to minimize environmental effects (such as reflections, absorption, etc.). The enforcement vehicle must be stationary with its engine off during the tests.

2. Be certain that all portions of the data sheet are completed.

STATIONARY NOISE SOURCES

5

5.0 STATIONARY NOISE SOURCES

5.1 INTRODUCTION

A stationary noise source is a general term used to describe a source or activity which operates within defined boundaries, property lines, or zones. The source includes all machinery, vehicles, or other devices, whether fixed or in motion, which are associated with the normal activity of the land use as long as the source remains within the recognized boundaries. Examples of stationary sound sources include air conditioners, fans, industrial plants, construction sites, truck loading and unloading, and maintenance yards.

Two methods are described for the measurement of non-impulsive sounds emitted from a stationary noise source. One method provides the equivalent sound levels (L_{eq}) or statistical levels for the stationary source, while the second method provides only the maximum (or steady) sound levels. The L_{eq} for a stationary source can be obtained from manual sampling or from sophisticated, automatic noise analyzers.

Equipment is available for measuring community ambient sound levels for long periods (see Section 3.3). This quiet, sophisticated equipment is more expensive than simple sound level meters. These units will, with some variation, acquire, calculate, and display sound level data (e.g., equivalent sound level [L_{eq}], the day/night sound level [L_{dn}] and other statistical sound levels, such as the L_{10}, etc.). These units incorporate minicomputers or microprocessors which digitize sound level measurements, perform simple statistical algorithms and store the results in a memory for later retrieval. In some cases, the digitized sound level data are stored on a magnetic tape cassette for later analysis using a companion instrument. Using these instruments is simply a matter of positioning the microphone at the proper location and then following manufacturer's instructions. Handheld L_{eq}-meters are now becoming available and are relatively inexpensive.

When this equipment is not available, the procedure described in Section 5.2 may be used. It only requires an inexpensive Type 2 sound level meter.

A procedure which provides sound pressure level spectra is described since many communities in their noise ordinances incorporated octave band sound pressure levels (see Section 2.3.1) in lieu of or in addition to A-weighted sound levels.

Impulsive sound levels can be obtained in a manner similar to obtaining maximum sound levels if special equipment (an impulse sound level meter) is used. A procedure to obtain a stationary noise source's impulsive sound level is provided for situations where it is required.

Finally, a procedure to obtain vibration levels is discussed. Vibration magnitude can be measured in terms of displacement, velocity, acceleration, or jerk. Many instruments can measure all of these quantities. Acceleration and displacement are the most typically measured and reported quantities.

5.2 STATIONARY NOISE SOURCE - EQUIVALENT SOUND LEVELS, L_{eq}

5.2.1 PURPOSE

The purpose of this procedure is to provide a useful method to measure the noise emitted from stationary sources including industrial plants, commercial operations, and construction activities. Communities without the funds to purchase statistical distribution analyzers can evaluate statistical sound levels and L_{eq} using a sound level meter and the procedure described below. Measurements are made at locations in accordance with noise control ordinance specifications. If a location is not specified in the ordinance, measurements are made at the property line nearest to the source, or at a point beyond the property line where source sound levels are highest.

5.2.1 EQUIPMENT

The stationary source sound level measurement procedure outlined below requires a sound level meter meeting, as a minimum, ANSI S1.4-1971 specifications for Type 2 sound level meters, an appropriate sound level meter calibrator accurate to ±.5 decibel, an earphone or headphones compatible with the sound level meter and an anemometer (wind speed indicator) accurate to ±10%.

In addition, a windscreen recommended by the microphone manufacturer shall be employed during measurements. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

5.2.3 MEASUREMENT LOCATION

Measurements are made at locations specified in the appropriate nose control ordinance. If a location is not specified in the ordinance, measurements shall be made at the nearest property line of the receiving land use. *If measurements are performed in response to a specific complaint, measurements shall be made at the complainant's property. If the measurements are not being made in response to complaints, they shall be made at the property boundaries of the nearest receiving land use.*

5.2.4 PERSONNEL

Persons technically trained and experienced in the current techniques of sound measurements should select the equipment and conduct the tests. The individual should be familiar with the manufacturer's instructions for the proper use of the equipment.

5.2.5 MEASUREMENT PROCEDURES

Mount the microphone (or sound level meter/microphone combination if the microphone cannot be remotely mounted) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground, and if practical, at least 3 meters (9.8 ft.) from any substantial reflecting surface. The location shall be chosen so that noise sources, other than that being measured, have minimum influence on measurements. A line of sight between the measurement location and the noise source should not be interrupted by any substantial object such as a building, dense trees or barrier (if possible).

Set the meter to "fast" response and A-weighting. Record the time the sample will start. During the sample period, at the end of every 15-second interval, record the instantaneous meter reading on the lower part of the data log (Figure 1).

At the end of each 20-minute sampling period, count the occurrences for each 2 dB-wide noise level band and write the number in the column on the right under "Total." Record the concluding time of the sample in the upper left-hand corner of the data sheet.

The L_{eq} value for the sampling period is calculated using the Computational Work Sheet shown in Figure 2. Enter the number of counts per noise level in Column B. Multiply the counts in Column B by the number in Column C and enter the results in Column D. Add all values in Column B to determine Sum B, add all values in Column D to determine Sum D, and divide Sum D by Sum B. Locate the value in Column C that is approximately equal to Sum D/Sum B. The corresponding value in Column A is equal to L_{eq}.

To determine the L_{10}, count down from the top of the data sheet (Figure 1) until 10 percent of the total count has been reached. Interpolate (linearly) as necessary to provide an estimate of L_{10}. Other statistical levels are determined similarly.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph), or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

The sound level meter shall be calibrated immediately before and after each measurement period. If the two calibrations differ by more than 1 decibel, the measurement shall be repeated.

If, during any of the observations, the measurements are affected by any intrusive noise sources outside the noise source boundaries, such as aircraft, emergency signals, and surface transportation, measurements made during these periods shall not be considered, but the number of observation periods shall be extended until 80 valid measurements are obtained. Vehicles, such as tractor trailer trucks, dump trucks, truck-mixers, etc., which occasionally enter, operate on, and leave the site, shall be considered as part of the stationary source noise activity while within the site boundaries. However, passby of such vehicles, in the area of the measurement location causing difficulty in obtaining valid measurements, shall be considered as intrusions, and handled as in the preceding paragraph.

If possible, measurements shall be made without the sound source operating to determine background (ambient) sound levels. In doing so, the same procedure shall be used. The background (ambient) equivalent sound level shall be at least 10 decibels below the source equivalent sound level. If the background (ambient) equivalent sound levels are from 3 to 10 decibels below the source equivalent sound levels, then corrections to the source sound levels are applied in accordance with Table 1. If the background (ambient) equivalent sound level is less than 3 decibels below the source equivalent sound level, then the contribution of the source equivalent sound level to the overall sound level is less than or equal to the background (ambient) equivalent sound level. Therefore, no determination of the source contribution can be made.

GENERAL

Operator ______

Date ______

Time ______ To ______

Day S M T W Th F S

Wind Speed ______ Direction ______

Temp. ______ Rel. Hum. ______

Other Weather ______

EQUIPMENT

Type ______

Serial # ______

Cal. Date ______

Micro. Height ______

Micro. Distance to Wall ______

SLM Setting ______ Fast, ______ Slow

Other ______

SITE

Site No. ______

Location ______

______

Site Description ______

______

______

______

SITE SKETCH

MISCELLANEOUS

Traffic Count: Autos ______

Trucks ______ Other ______ Total ______

Comments ______

______

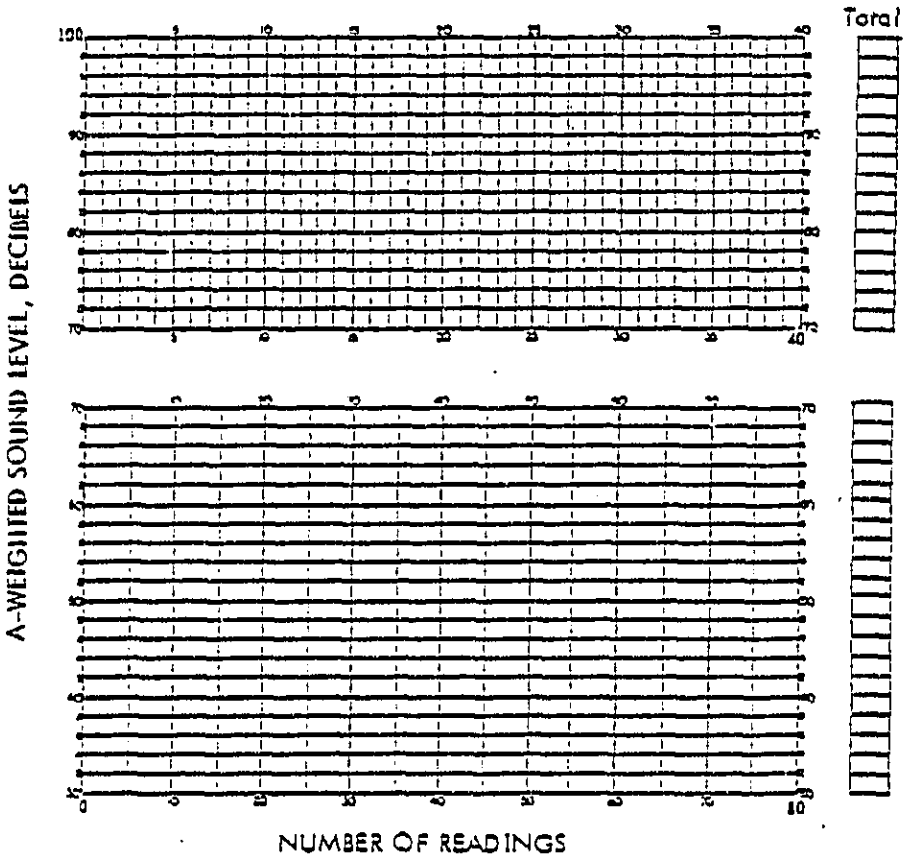


Figure 1. Community Sound Level Data Sheet

A Noise Level Band, dB	B Count		C Relative Noise Energy		D Relative Total Noise Energy
100		x	79,400	=	
98		x	50,100	=	
96		x	31,600	=	
94		x	20,000	=	
92		x	12,600	=	
90		x	7,940	=	
88		x	5,010	=	
86		x	3,160	=	
84		x	2,000	=	
82		x	1,260	=	
80		x	794	=	
78		x	501	=	
76		x	316	=	
74		x	200	=	
72		x	126	=	
70		x	79.4	=	
68		x	50.1	=	
66		x	31.6	=	
64		x	20.0	=	
62		x	12.6	=	
60		x	7.94	=	
58		x	5.01	=	
56		x	3.16	=	
54		x	2.00	=	
52		x	1.26	=	
50		x	.794	=	
48		x	.501	=	
46		x	.316	=	
44		x	.200	=	
42		x	.126	=	
40		x	.0794	=	
38		x	.0501	=	
36		x	.0316	=	
34		x	.0200	=	
32		x	.0126	=	
30					

Sum B = ________ Sum D = ________

Sum D/Sum B = ________ $\boxed{L_{eq} = \text{\_\_\_\_\_\_\_\_ dB}}$

DATA REQUIREMENTS:

- Each noise reading must be taken at a standard time interval between measurements.
- Each noise level recorded is the instantaneous level.

STEP	PROCEDURE
1	Enter number of counts per noise level in Column B.
2	Multiply the counts in Column B by the number in Column C and enter the result in Column D.
3	Add all values in Column B to determine Sum B, add all values in Column D to determine Sum D and divide Sum D by Sum B.
4	Locate the value in Column C that is approximately equal Sum D/Sum B. The corresponding value in Column A is equal to L_{eq}. Interpolate to the nearest 0.5 dB.

EXAMPLE

Given the following count data, find L_{eq}

Noise Level	Number of Occurrences
84	II
82	–
80	IIII
78	IIII IIII I
76	IIII
74	–
72	

Using Steps 1 through 4 gives

A	B		C		D
84	2	x	2,000	=	4,000
82	0	x	1,260	=	0
80	5	x	794	=	3,970
78	11	x	501	=	5,511
76	4	x	316	=	1,264
74	0	x	200	=	0
72					

Sum B = 22 Sum D = 14,745

Sum D/Sum B = 670 $\boxed{L_{eq} = 78 \text{ dB}}$

* by linear interpolation in Column C and Column A.

Figure 2. Computational Work Sheet

TABLE 1

Difference between measured sound level with source operating and background ambient - dB	Subtract values from measured sound level to determine source sound level contribution - dB
0	*
1	*
2	*
3	3.0
4	2.5
5	2.0
6	1.5
7	1.0
8	1.0
9	0.5
10	0.5

*Can not determine. Background ambient must be lower.

$$L_s = 10 \log_{10} [10^{L_p/10} - 10^{L_o/10}]$$

L_s is stationary source sound level contribution

L_p is measured sound level with source operating

L_o is background ambient sound level with source not operating

5.3 STATIONARY NOISE SOURCE - MAXIMUM SOUND LEVELS

5.3.1 PURPOSE

The purpose of this procedure is to provide a method to measure the maximum A-weighted sound level, L_A, and the sound pressure levels in each frequency octave band emitted by stationary noise sources.

5.3.2 EQUIPMENT

The procedure requires a sound level meter meeting, as a minimum, ANSI S1.4-1971 specifications for Type 2 sound level meters and a compatible octave band analyzer. *In some instances, the octave band analyzer may be attached to the sound level meter, while in other cases it is a separate accessory.* The octave band analyzer must meet, as a minimum, ANSI S1.11-1971 (R-1966) Specifications for Class II filter sets. A sound level calibrator accurate to ±.5 decibel, an earphone or headphones compatible with the sound level meter, and an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr are also required. A windscreen recommended by the microphone manufacturer shall be employed at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

5.3.3 MEASUREMENT LOCATIONS

Measurements shall be made at the nearest property line of the receiving land use. *If measurements are performed* in response to a specific complaint, measurements shall be made at the complainant's property. If the measurements are not being made in response to complaints, they shall be made at the property boundaries of the nearest receiving land use.

5.3.4 PERSONNEL

It is recommended that persons technically trained and experienced in the current techniques of sound measurements select the equipment and conduct the tests. The individual should be familiar with the manufacturer's instructions for the proper use of the equipment.

5.3.5 MEASUREMENT PROCEDURES

Mount the microphone (or sound level meter/microphone combination if the microphone cannot be remotely mounted) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground, and if practical, at least 3 meters (9.8 ft.) from any substantial reflecting surface. The location shall be chosen so that noise sources, other than that being measured, have minimum influence on measurements. A line of sight between the measurement location and the noise source shall not be interrupted by any substantial object such as people, buildings, dense trees, or barriers (if possible).

The noise measurement location, with site features and dimensions, shall be sketched on a survey data sheet (Figure 1) to provide a record which can be used if follow-up measurements are required.

A) <u>A-Weighted Sound Level</u>

Set the sound level meter on A-weighting mode "fast" response and record the maximum sound level observed during the measurement period. *Figure 1 is a facsimile of a suggested data sheet.*

B) <u>Octave Band Sound Pressure Levels</u>

Set the sound level meter on flat (linear or C-weighting) mode and "fast" response. Set the octave band filter to its lowest frequency setting (*usually 31.5 Hz*). Record the maximum sound pressure level observed during the measurement period (*usually longer than two minutes*). *Figure 1 is a facsimile of a suggested data sheet.* Set the octave band filter to the next higher octave band and repeat the measurement until the sound pressure level for each octave band is obtained. *Due to microphone response characteristics at high frequencies, the highest desired frequency may be 8000 Hz.*

If possible, the background ambient octave band sound pressure levels shall be 10 decibels below the source octave band sound pressure levels. Measurements shall be made without the source operating, if possible, to determine if these conditions exist.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph), or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

5.3 STATIONARY NOISE SOURCE - MAXIMUM SOUND LEVELS

5.3.1 PURPOSE

The purpose of this procedure is to provide a method to measure the maximum A-weighted sound level, L_A, and the sound pressure levels in each frequency octave band emitted by stationary noise sources.

5.3.2 EQUIPMENT

The procedure requires that a sound level meter meets, (as a minimum) ANSI S1.4-1971 specifications for Type 2 sound level meters and a compatible octave band analyzer. *In some instances, the octave band analyzer may be attached to the sound level meter, while in other cases it is a separate accessory.* As a minimum, the octave band analyzer must meet ANSI S1.11-1971 (R-1966) Specifications for Class II filter sets. A sound level calibrator accurate to ±.5 decibel, an earphone or headphones compatible with the sound level meter, and an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr are also required. A windscreen recommended by the microphone manufacturer should be employed at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system should be checked annually for accuracy by its manufacturer or a certified laboratory.

5.3.3 MEASUREMENT LOCATIONS

Measurements shall be made at the nearest property line of the receiving land use. *If measurements are performed* in response to a specific complaint, measurements shall be made at the complainant's property. If the measurements are not being made in response to complaints, they shall be made at the property boundaries of the nearest receiving land use.

5.3.4 PERSONNEL

It is recommended that persons technically trained and experienced in the current techniques of sound measurements select the equipment and conduct the tests. The individual should be familiar with the manufacturer's instructions for the proper use of the equipment.

5.3.5 MEASUREMENT PROCEDURES

Mount the microphone (or sound level meter/microphone combination if the microphone cannot be remotely mounted) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground, and if practical, at least 3 meters (9.8 ft.) from any substantial reflecting surface. The location shall be chosen so that noise sources, other than that being measured, have minimum influence on measurements. A line of sight between the measurement location and the noise source shall not be interrupted by any substantial object such as people, buildings, dense trees, or barriers (if possible).

The noise measurement location, with site features and dimensions, shall be sketched on a survey data sheet (Figure 1) to provide a record which can be used if follow-up measurements are required.

A) A-Weighted Sound Level

Set the sound level meter on A-weighting mode "fast" response and record the maximum sound level observed during the measurement period. *Figure 1 is a facsimile of a suggested data sheet.*

B) Octave Band Sound Pressure Levels

Set the sound level meter on flat (linear or C-weighting) mode and "fast" response. Set the octave band filter to its lowest frequency setting (*usually 31.5 Hz*). Record the maximum sound pressure level observed during the measurement period (*usually longer than two minutes*). *Figure 1 is a facsimile of a suggested data sheet.* Set the octave band filter to the next higher octave band and repeat the measurement until the sound pressure level for each octave band is obtained. *Due to microphone response characteristics at high frequencies, the highest desired frequency may be 8000 Hz.*

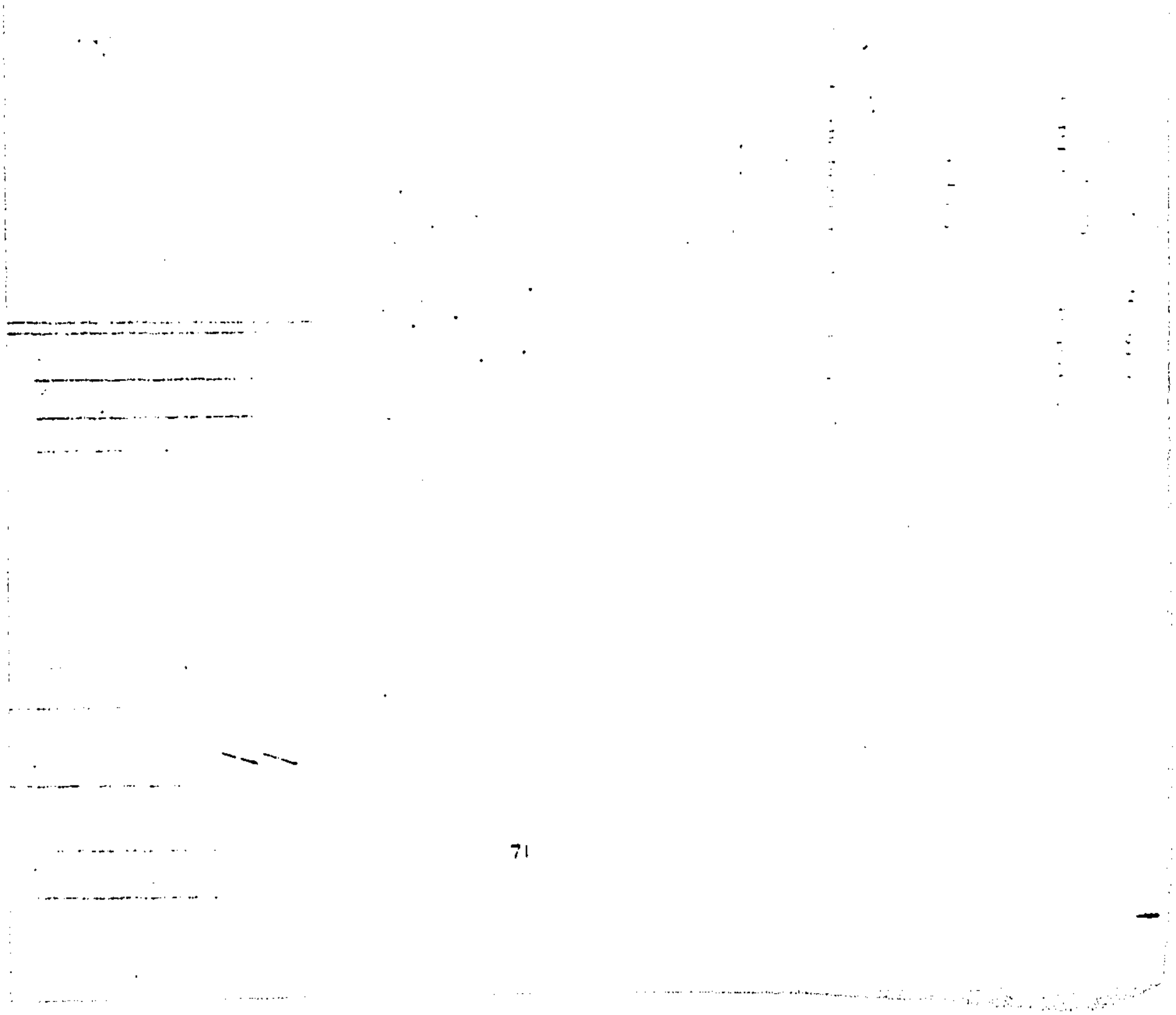
If possible, the background ambient octave band sound pressure levels shall be 10 decibels below the source octave band sound pressure levels. Measurements shall be made without the source operating, if possible, to determine if these conditions exist.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph), or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

The sound level meter shall be calibrated immediately before and after each measurement period. If the two calibrations differ by more than one decibel, the measurements shall be repeated after the sound measurement system has been adjusted.

The following photograph shows measurements being made at an industrial operation.



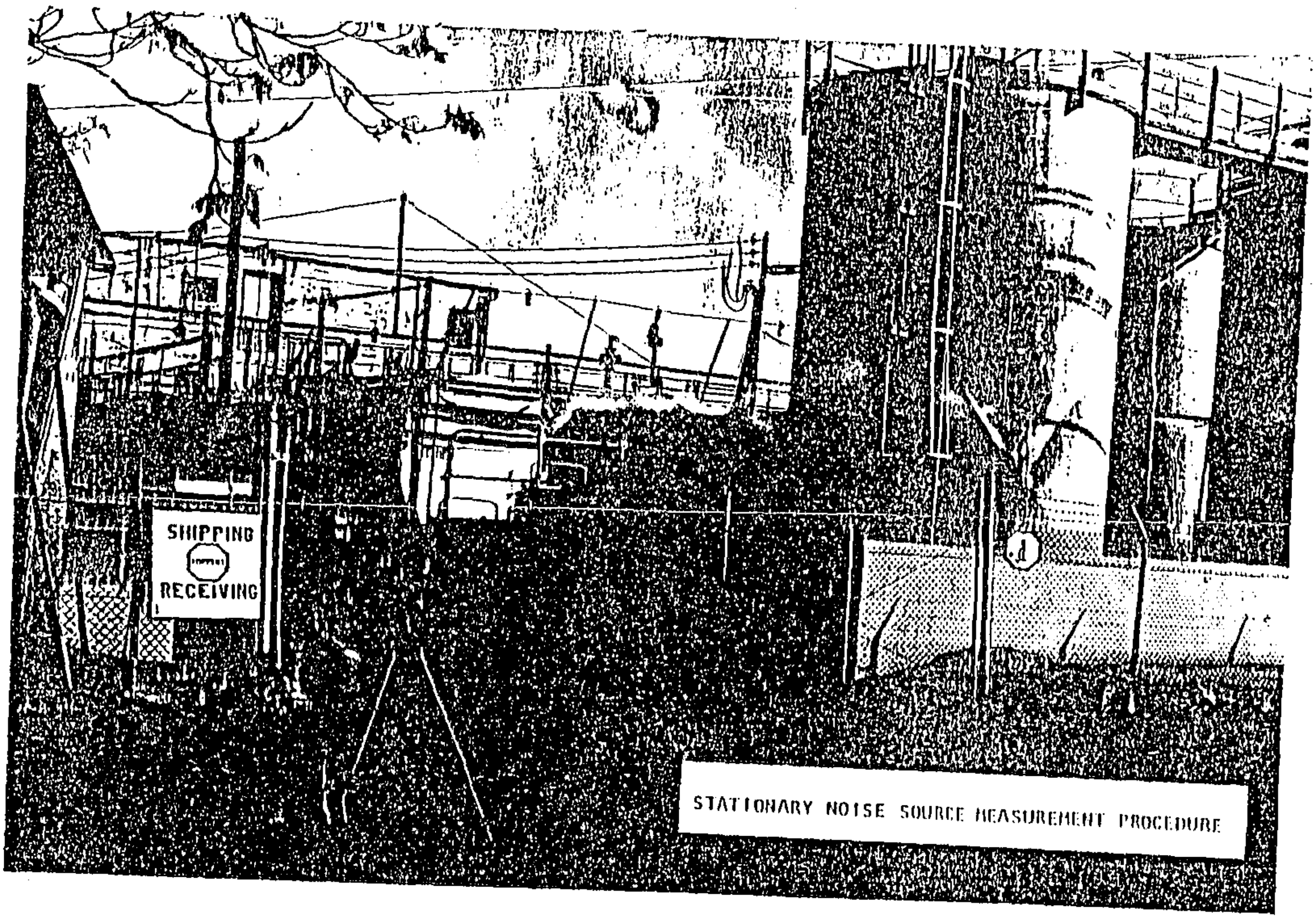

SHIPPING
RECEIVING
STATIONARY NOISE SOURCE MEASUREMENT PROCEDURE

FIGURE [illegible]

FIGURE 1. EXAMPLE: NOISE MEASUREMENT REPORT FORM

Examiner: ____________________ Date: ____________

Municipality: ____________________ Test Type: ____________________
Address: ____________________

Noise Source: ____________________ Address: ____________________

Type of Receiving Property: Residential ☐ Commercial ☐ Industrial ☐
Complainant: ____________________ Address: ____________________

Sound Level Meter Manuf: ____________ Calibrator Manuf: ____________ Micro. Manuf: ____________
Type: ____________ Type: ____________ Type: ____________
Serial #: ____________ Serial #: ____________ Serial #: ____________

Meter Check Batt. ☐ Windscreen ☐ A-Weighting ☐ ☐Fast ☐Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions ____________ Temperature ______ %RH ________ Wind Velocity ____________

Sketch of Site

dB Ref. 20 μPa		BACKGROUND	LOCATION 1	2	3	4	5	6	7	8	9	10
Oct-Band Freq. Hz	A-wt.											
	31.5											
	63											
	125											
	250											
	500											
	1 k											
	2 k											
	4 k											
	8 k											

5.4 STATIONARY NOISE SOURCE - IMPULSIVE SOUND LEVELS

5.4.1 PURPOSE

A method of measuring impulsive sound emissions of a stationary noise source is described. An impulsive sound is one characterized by brief increases in sound pressure which significantly exceed the background ambient sound pressures. The duration of any single impulse is typically less than one second.

5.4.2 EQUIPMENT

A Type 1 Impulse sound level meter meeting ANSI S1.4-1971 sound level meter specifications and IEC 179A impulse specifications shall be used for all impulse measurements. These meters have detectors which can measure signals with crest factors* as high as 20 decibels. *A meter with a peak-hold feature is suggested.*

Other equipment required for this procedure include an appropriate sound level meter calibrator accurate to ±.5 decibel and an anemometer (wind speed indicator) accurate to ±10%.

In addition, a windscreen recommended by the microphone manufacturer shall be employed during measurements. *This practice reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

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*Crest factor is $20 \log \frac{\text{peak-pressure}}{\text{rms pressure}}$

5.4.3 MEASUREMENT LOCATIONS

Measurements shall be made at the nearest property line of the receiving land use. *If measurements are made in response to a specific complaint, measurements shall be made at the complainant's property. If the measurements are not in response to complaints, they shall be made at the property boundaries of the nearest receiving land use.*

5.4.4 PERSONNEL

Persons technically trained and experienced in the current techniques of sound measurements should select the equipment and conduct the tests. The individual should be familiar with the manufacturer's instructions for the proper use of the equipment.

5.4.5 MEASUREMENT PROCEDURES

Mount the microphone (or sound level meter/microphone combination if the microphone cannot be remotely mounted) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground, and if practical, at least 3 meters (9.8 ft.) from any substantial reflecting surface or noise source other than that being measured. A line of sight between the measurement location and the noise source should not be interrupted by any substantial object such as people, buildings, dense trees, or barriers (if possible). Measurements should be made at several locations at the receiving land use property line.

The measurement location, with site features and dimensions, should be indicated on a survey data sheet (Figure 2). This procedure provides a record of the measurement locations for future reference.

The meter should be set for impulsive noise measurements and linear response. The range should be adjusted so as to provide on-scale indications of the impulsive sound levels.

Measurements should not be made when the wind speed exceeds 20 km/hr (12 mph), when it is raining, or snowing.

Measurements should not be made during environmental conditions (temperature, humidity) that the instrument manufacturer deems unacceptable.

The sound level meter should be calibrated immediately before and after each measurement period. If the two calibrations differ by more than 1 decibel, the measurements should be repeated after the sound level meter is adjusted.

FIGURE 2. EXAMPLE: NOISE MEASUREMENT REPORT FORM

Examiner:______________________________________ Date:____________________

Municipality:____________________________ Test Type:______________________________
Address: ____________________________

Noise Source:____________________________ Address:______________________________

Type of Receiving Property: Residential ☐ Commercial ☐ Industrial ☐
Complainant:____________________________ Address:______________________________

Sound Level Meter Manuf:____________ Calibrator Manuf:____________ Micro. Manuf:____________
Type:____________ Type:____________ Type:____________
Serial #:____________ Serial #:____________ Serial #:____________

Meter Check Batt. ☐ Windscreen ☐ A-Weighting ☐ ☐Fast ☐Slow Response Calibration Pretest____dB Posttest____dB

Test Conditions General Weather Conditions____________ Temperature______ %RH________ Wind Velocity____________

Sketch of Site

MID-BAND FREQ. Hz	dB Ref. 20 µPa	BACK-GROUND	LOCATION 1	2	3	4	5	6	7	8	9	10
	A-wt.											
	31.5											
	65											
	125											
	250											
	500											
	1 k											
	2 k											
	4 k											
	8 k											

5.5 VIBRATION

5.5.1 PURPOSE

The purpose of this procedure is to provide a method to measure vibration levels for comparison with perceptibility or impact standards.

5.5.2 EQUIPMENT

The equipment necessary for measuring vibration include a vibration transducer and vibration analyzer. The system is required to have sensitivity to accelerations as low as 0.001 g at frequencies between 1 and 10 Hz and as large as 1 g for frequencies above 200-300 Hz. *Instruments having features that acceptably meet these requirements are commercially available.* In addition, a vibration calibrator is required to calibrate the system by means of providing a known vibration (acceleration) input.

5.5.3 MEASUREMENT LOCATIONS

Measurements are to be performed at locations that correspond to the point or points of complaint and should be carried out upon that surface which is affecting the input of vibration to the complainant.

5.5.4 PERSONNEL

Persons technically trained and experienced in the current techniques of sound and vibration measurements should select the equipment and conduct the tests. The individual should be familiar with the manufacturer's instructions for the proper use of the equipment.

5.5.5 MEASUREMENT PROCEDURE

Particular attention must be paid to the location and placement or mounting of the transducer. The unit shall be mounted on a rigid and smooth surface that experiences the vibration that is to be measured. The axis of the unit will designate the direction of the component of vibration being measured, and consequently, this information shall be recorded. The transducer may be mounted by any of several methods. *Generally, a threaded hole or a bolt is provided in the base of the transducer which permits mounting the unit either directly to a surface, to a special adaptor that may then be cemented to a surface, or to a magnetic base that will attach readily and securely to surfaces of ferro-magnetic materials. The transducer may also be mounted by means of double-sided tapes, cements (for permanent type installations), or greases.* In all cases, the mating surfaces shall be smooth and free of dirt. *A light coating of oil or grease is recommended on metallic mating surfaces that will be in direct contact.* The measurement system of accelerometer and instrumentation shall be calibrated prior to and after measurements.

Manufacturers' operating instructions for the measurement of vibrations should be followed. The rms amplitude of the vibration parameter measured (acceleration) should be recorded. (See Figure 1, Vibration Measurement Report Form)

FIGURE 1. EXAMPLE: VIBRATION MEASUREMENT REPORT FORM

Examiner:______________________________ Date:______________

Municipality:______________________ Test Type:______________________
Address: ______________________

Noise Source:______________________ Address:______________________

Type of Receiving Property: Residential ☐ Commercial ☐ Industrial ☐
Complainant:______________________ Address:______________________

Vibration Transducer Manuf:__________ Vibration Analyzer Manuf:__________ Calibrator Manuf:__________
Type:__________ Type:__________ Type:__________
Serial #:__________ Serial #:__________ Serial #:__________

Analyzer Check Batt. ☐ Calibration Pretest ___dB Posttest ___dB Surface Mounting Technique __________

Test No.	Vibration Parameter Measured/Axis	Vibration Level

Sketch of Transducer Location

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AMBIENT SOUND

6

6.0 AMBIENT SOUND

6.1 INTRODUCTION

The Model Community Noise Control Ordinance, Article X, specifies development restrictions for habitable and institutional facilities at land use areas exposed to excessive noise. The day/night average sound level is used as the descriptor of environmental sound. Evaluation of an area's day/night sound level requires the sampling of ambient sound during daytime and nighttime periods at a number of locations at the land use area being studied.

It is desirable to measure the ambient sound continuously for long periods of time (at least 24 hours). Without automatic and unattended sound level data processing equipment, continuous sampling is prohibitively expensive.

Equipment is available for measuring community ambient sound levels for long periods (see Section 3.3). These equipment are, typically, quite sophisticated and therefore more expensive than Type 2 sound level meters. These units will, with some variation, acquire, calculate, and display sound level data (e.g., equivalent sound level [L_{eq}], the day/night sound level [L_{dn}] and other statistical sound levels). These units incorporate mini-computers or microprocessors which digitize sound level measurements, perform simple statistical algorithms and store the results in a memory for later retrieval. In some cases, the digitized sound level data are stored on a magnetic tape cassette for later analysis using a companion instrument.

Using these instruments is simply a matter of positioning the microphone at the proper location and then following manufacturer's instructions.

When this equipment is not available, the procedure described in the following section may be used. It requires an inexpensive Type 2 sound level meter. This procedure is described in much greater detail in "Assessment Manual: Acoustical Survey," Wyle Laboratories, 1978.

6.2 AMBIENT SOUND LEVEL MEASUREMENT METHOD

6.2.1 PURPOSE

The purpose of this sampling method is to provide communities with an inexpensive method to evaluate the day/night sound level at a land-use area. Communities without the funds to purchase automatic unattended monitoring instruments can evaluate L_{dn} using a sound level meter. A trade-off between sophisticated equipment and dedicated volunteers or personnel is required.

6.2.2 SAMPLING PERIODS

Sound level measurements shall be made during daytime (0700-2200) and nighttime (2200-0700) periods. Continuous measurements are the most desirable. Measurements for 20 minutes each hour are representative of an hour of continuous data. Practical considerations (personnel, costs, etc.) often limit the amount of data which can be collected. Sound level sampling can be accomplished for a 20 minute period as often as possible during the day. For areas with little change in sound levels, few samples are required to represent the day/night sound level, while at locations with large variations in sound levels, measurements each hour are required. A minimum sampling scheme includes a single measurement during each of four measurement periods.

Morning - *Measurements made during hours 0700-0900*
Midday - *Measurements made during hours 0900-1600*
Evening - *Measurements made during hours 1600-2200*
Nighttime - *Measurements made during hours 2200-0700*

6.2.3 EQUIPMENT

The community sound level measurement procedure outlined below requires a sound level meter meeting ANSI S1.4-1971 specifications for Type 2 sound level meters, a sound level meter calibrator accurate to ±.5 decibel, earphone or headphones compatible with the sound level meter, and an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr. In addition, a windscreen recommended by the microphone manufacturer shall be employed during measurement periods. *This practice reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

6.2.4 PERSONNEL

It is recommended that persons technically trained and experienced in the current techniques of sound measurements select the equipment and conduct the tests.

6.2.5 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/microphone combination if the microphone cannot be remotely mounted) on a tripod at a height of 1.2 meters (4 ft.) above the ground, and if practical at least 3 meters (9.8 ft.) from any substantial reflecting surface or any roadway. When circumstances dictate, measurements may be made at greater distances and heights and closer to reflecting surfaces providing these facts are noted. If a site plan for proposed construction is available, select a location at the building line.

Set the meter to "fast" response and A-weighting. Record the time the sample will start. During the sample period, at the end of every 15-second interval, record the instantaneous meter reading on the lower part of the data log (Figure 1). For levels less than 70 dB, use slashed lines in the appropriate 2 dB-wide noise level band. Above 70 dB, fill in the form using the source codes given on the right side of the data log.

At the end of each 20-minute sampling period, count the occurrences for each 2 dB-wide noise level band and write the number in the "Total" column on the right. Record the concluding time of the sample in the upper left-hand corner of the data sheet.

The L_{eq} value for the sampling period is calculated using the Computational Work Sheet shown in Figure 2. Enter the number of counts per noise level in Column B. Multiply the counts in Column B by the number in Column C and enter the results in Column D. Add all values in Column B to determine Sum B, add all values in Column D to determine Sum D, and divide Sum D by Sum B. Locate the value in Column C that is approximately equal to Sum D/Sum B. The corresponding value in Column A is equal to L_{eq}.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph), when it is raining, or snowing.

Measurements should not be made during environmental conditions (temperature, humidity) deemed unacceptable by the instrument manufacturer.

The sound level meter should be calibrated immediately before and after each measurement period. If the two calibrations differ by more than 1 decibel, the measurement should be repeated after the sound level meter is adjusted.

6.2.6 <u>DAY/NIGHT SOUND LEVEL CALCULATIONS</u>

To calculate the L_{dn}, a computational sheet similar to that shown in Figure 3 is used.

<u>Twenty-four Hour Survey</u>

Enter the number of hours per noise level in Column B. Add 10 decibels to the L_{eq} value computed before entering it on the work sheet for those samples between the hours of 10 P.M. and 7 A.M. (e.g., an L_{eq} of 54 for the hour between midnight and 1 A.M. is considered as 64 dB). Multiply the hours in Column B by the number in Column C and enter the result in Column D. Add all values in Column D to determine the Sum D. Divide Sum D by 24. Locate the value in Column C that is approximately equal to Sum D/24. The corresponding value in Column A is equal to the day/night sound levels L_{dn}.

<u>Minimum Four Period Sampling Scheme</u>

Enter the number of hours corresponding to the morning period in Column B for the corresponding noise level band. For the minimum four period sampling scheme, the morning period is from 0700-0900, or 2 hours in length. Repeat this procedure for the midday (7 hours), evening (6 hours and nighttime

(9 hours) periods. Add 10 decibels to the L_{eq} value for the nighttime period before entering it on the work sheet. If more than one period has the same L_{eq} value, add the hours together and enter this total in Column B opposite the corresponding sound level. Multiply the hours in Column B by the number in Column C and enter the result in Column D. Add all values in Column D to determine the Sum D. Divide Sum D by 24. Locate the value in Column C that is approximately equal to Sum D/24. The corresponding value in Column A is equal to the day/night sound levels L_{dn}.

GENERAL

Operator ____________________

Date ____________________

Time __________ To __________

Day S M T W Th F S

Wind Speed ______ Direction ______

Temp. __________ Rel. Hum. ______

Other Weather ____________________

EQUIPMENT

Type ____________________

Serial # ____________________

Cal. Date ____________________

Micro. Height ____________________

Micro. Distance to Wall __________

SLM Setting _____ Fast, _____ Slow

Other ____________________

SITE

Site No. ____________________

Location ____________________

____

Site Description ____________

____

____

____

SITE SKETCH

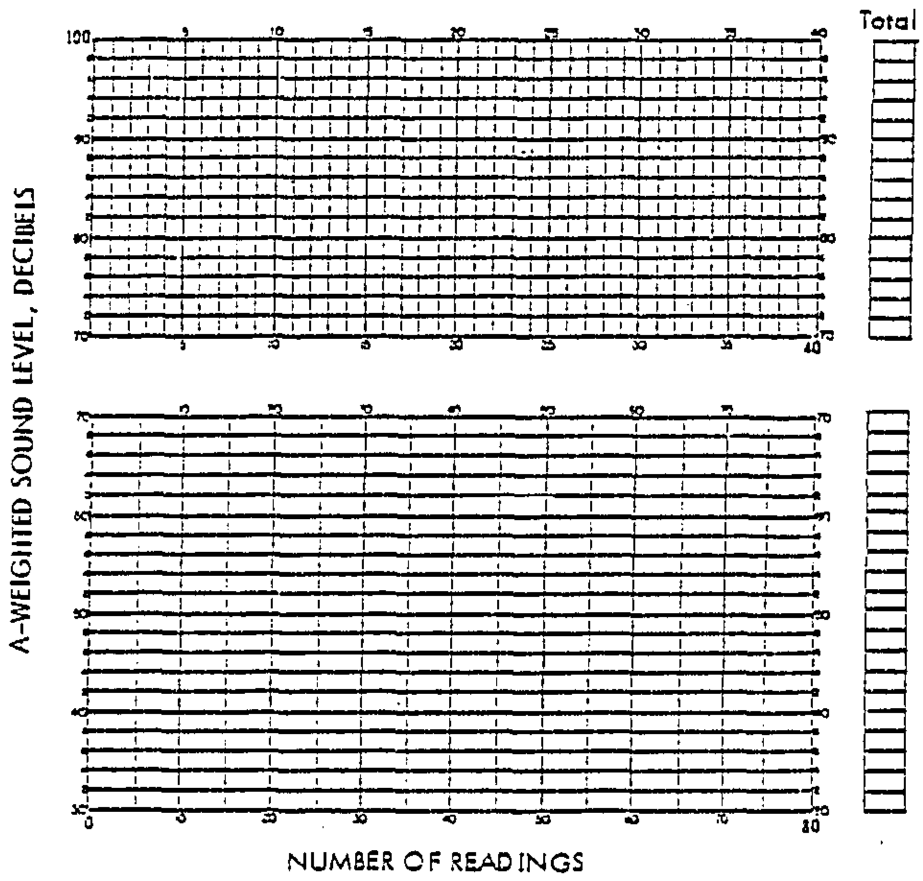
MISCELLANEOUS

Traffic Count: Autos ____________________

Trucks _____ Other _____ Total __________

Comments ____________________

____



Code for Noises Above 70 dB

TRANSPORTATION

E_____ EMER. VEH.
P_____ SMALL PLANE
J_____ JET
H_____ HELICOPTER
R_____ RAILROAD
T_____ TRUCK
A_____ AUTO
B_____ BUS
M_____ MOTORCYCLE
W_____ WATER CRAFT
V_____ OFF RD. VEH.
____

MACHINERY

C_____ CONSTRUCTION EQUIP.
Y_____ YARD MAINT. EQUIP.
F_____ FACTORY EQUIP.
h_____ HOUSEHOLD EQUIP.
____

OTHER

D_____ DOG
L_____ LOUD SPEAKERS
____
____
____

Figure 1. Community Sound Level Data Sheet

A Noise Level Band, dB	B Count		C Relative Noise Energy		D Relative Total Noise Energy
100		x	79,400	=	
98		x	50,100	=	
96		x	31,600	=	
94		x	20,000	=	
92		x	12,600	=	
90		x	7,940	=	
88		x	5,010	=	
86		x	3,160	=	
84		x	2,000	=	
82		x	1,260	=	
80		x	794	=	
78		x	501	=	
76		x	316	=	
74		x	200	=	
72		x	126	=	
70		x	79.4	=	
68		x	50.1	=	
66		x	31.6	=	
64		x	20.0	=	
62		x	12.6	=	
60		x	7.94	=	
58		x	5.01	=	
56		x	3.16	=	
54		x	2.00	=	
52		x	1.26	=	
50		x	.794	=	
48		x	.501	=	
46		x	.316	=	
44		x	.200	=	
42		x	.126	=	
40		x	.0794	=	
38		x	.0501	=	
36		x	.0316	=	
34		x	.0200	=	
32		x	.0126	=	
30					

Sum B = ______

Sum D/Sum B = ______

Sum D = ______

L_{eq} = ______ dB

DATA REQUIREMENTS:

- Each noise reading must be taken at a standard time interval between measurements
- Each noise level recorded is the instantaneous level

STEP	PROCEDURE
1	Enter number of counts per noise level in Column B.
2	Multiply the counts in Column B by the number in Column C and enter the result in Column D.
3	Add all values in Column B to determine Sum B, add all values in Column D to determine Sum D and divide Sum D by Sum B.
4	Locate the value in Column C that is approximately equal Sum D/Sum B. The corresponding value in Column A is equal to L_{eq}. Interpolate to the nearest 0.5 dB.

EXAMPLE

Given the following count data, find L_{eq}

Noise Level	Number of Occurrences
84	II
82	–
80	IIII
78	IIII IIII I
76	IIII
74	–
72	

Using Steps 1 through 4 gives

A	B		C		D
84	2	x	2,000	=	4,000
82	0	x	1,260	=	0
80	5	x	794	=	3,970
78	11	x	501	=	5,511
76	4	x	316	=	1,264
74	0	x	200	=	0
72					

Sum B = 22

Sum D = 14,745

Sum D/Sum B = 670

$\boxed{L_{eq} = 78 \text{ dB}}$

* by linear interpolation in Column C and Column A.

Figure 2. Computational Work Sheet

A SOUND LEVEL BAND, dB	B COUNT		C RELATIVE SOUND ENERGY		D RELATIVE TOTAL SOUND ENERGY
100					
98		x	79,400	=	
96		x	50,100	=	
94		x	31,600	=	
92		x	20,000	=	
90		x	12,600	=	
88		x	7,940	=	
86		x	5,010	=	
84		x	3,160	=	
82		x	2,000	=	
80		x	1,260	=	
78		x	794	=	
76		x	501	=	
74		x	316	=	
72		x	200	=	
70		x	126	=	
68		x	79.4	=	
66		x	50.1	=	
64		x	31.6	=	
62		x	20.0	=	
60		x	12.6	=	
58		x	7.94	=	
56		x	5.01	=	
54		x	3.16	=	
52		x	2.00	=	
50		x	1.26	=	
48		x	.794	=	
46		x	.501	=	
44		x	.316	=	
42		x	.200	=	
40		x	.126	=	
38		x	.0794	=	
36		x	.0501	=	
34		x	.0316	=	
32		x	.0200	=	
30		x	.0126	=	

Sum D = ________

Sum D/24 = ________ L_{dn} = ________ dB

EXAMPLE: 24-HOUR SURVEY

Time of Day	Hourly L_{eq}
0700-0800	62
0800-0900	64
0900-1000	62
1000-1100	62
1100-1200	58
1200-1300	56
1300-1400	54
1400-1500	54
1500-1600	58
1600-1700	66
1700-1800	66
1800-1900	62
1900-2000	60
2000-2100	58
2100-2200	56*
2200-2300	54*
2300-2400	52*
2400-0100	52*
0100-0200	50*
0200-0300	48*
0300-0400	48*
0400-0500	48*
0500-0600	48*
0600-0700	48*

*10-decibel penalties are added to these nighttime values

A	B	C	D
66	3	50.1	150
64	2	31.6	63.2
62	6	20.0	120
60	2	12.6	25.2
58	8	7.94	63.5
56	1	5.01	5.01
54	2	3.16	6.32

Sum D = 432.93

Sum D/24 = 18.04 L_{dn} = 62

Figure 3. L_{dn} Computational Work Sheet

6.3 BIBLIOGRAPHY

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AUTOMOBILES

7

7.0 AUTOMOBILES

7.1 INTRODUCTION

Two test procedures for the measurement of automobile noise are described. One is a method which measures automobile passby noise while the vehicle is operating on local roads and streets. The other procedure requires the vehicle to operate at 3000 rpm engine speed while stationary test measurements are made. Both were developed as supplements to the EPA/NIMLO "Model Community Noise Control Ordinance" (EPA 550/9-76-003) (Article IX, 9.1), but may be adopted as an enforcement method for a community noise ordinance based on an alternate model.

A survey of State and local agencies, automobile manufacturers, and national standards groups such as American National Standards Institute, provide an indication of current measurement procedures in use. Figure 7.1 presents a matrix of the major features of each method studied. These methods were carefully examined and the best features of each were used to develop the methods presented here.

Test site conditions often affect the accuracy of the measured data. Since it is sometimes difficult to control site conditions, adjustments to the measured data are often needed when desired test site conditions (Section 7.2.4) cannot be attained. These adjustments are discussed in Section 2.3

A test procedure using full throttle acceleration was considered. A consensus of enforcement agents contacted indicates that such a test is dangerous, requires excessive space and personnel, and is time consuming.

A stationary test procedure is presented which requires noise measurements to be made .5 meter (20 inches) from a vehicle's exhaust outlet. At this distance, the exhaust noise is the principal noise measured. Enforcement officials have indicated that modified or damaged exhaust systems are the principal cause of noncomplying vehicles. Measurements made using this procedure are repeatable and defensible. An engine speed of 3000 rpm was selected for the test after consultation with the industry and local agencies. In the future, noise data from stationary tests will have been correlated with "in use" automobile noise and its effects on public health and welfare. Since a stationary vehicle noise standard is not discussed in the EPA/NIMLO Model Community Noise Control Ordinance, those municipalities wishing to adopt this procedure will have to adopt an ordinance to suit their needs.

EQUIPMENT

VEHICLE: AUTOMOBILE

MEASUREMENT METHOD	TEST TYPE	Sound Level Meter	Microphone	Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions
Florida - Highway Vehicle Test Procedure	IN-SITU	Type 1, 2, or S2A meeting ANSI specifications	Matched to SLM	Annual calibration by manufacturer	Windscreen optional	Standard form	a) Standard site - no reflecting surface within 100' radius of car at passby point or 100' radius of microphone. b) Restricted site-reflecting surfaces. No measurements within 100' of tunnel or overpass. No overhang within 50' of microphone line or center of line of travel.
Minneapolis, Minn. - Highway Vehicle Test Procedure	IN-SITU	Any sound level meter No standard	Any microphone No standard		Windscreen "when appropriate"		Concrete or asphalt roadway surface; dry and free of bumps or cracks.
Oregon - On Highway Sound Level Measurements	IN-SITU	Type II Minimum ANSI S1.4-1971	Random Incidence Microphone	Calibrated prior to each use; yearly lab. calibration	Windscreen	Data Forms; clipboard; tripod; wind meter; psychrometer	Highway - a) Standard site: no reflecting surfaces within 100' radius of microphone and microphone point. b) Restricted site: reflecting surfaces within 100'. All sites: concrete or asphalt; no tunnels or overpasses; no reflecting surfaces within 10'.
Florida - New Vehicle Test Procedure	TEST SITE	Precision SLM as per ANSI specifications		Calibration before and after each use or every 2 hours as a minimum if instrument is used >2 hours	Windscreen	Tachometer Anemometer	Flat response. No reflecting surfaces within 100' of a) microphone, b) point 50' before microphone point, c) point 50' beyond microphone point. Ground surface: smooth asphalt or concrete in Δ area between microphone and two 50' points.
Oregon - New Vehicle Test Procedure	TEST SITE	Type II Minimum ANSI S1.4-1971		Lab. calibration annually	Windscreen optional Recorder	Sling psychrometer; wind gauge; data form	Flat response. No reflecting surfaces within 100' of a) microphone, b) point 50' before microphone point, c) point 50' beyond microphone point. Ground surface: smooth asphalt or concrete in Δ area between microphone and two 50' points.
SAE J986a - Sound Level for Passenger Cars	TEST SITE	Type I SLM ANSI S1.4-1971		Before and after each test	Optional mag. recorder or graphic level recorder (SAE J184)	Tachometer Anemometer	Flat open space free of large reflecting surfaces from vehicle or microphone. Surface of ground free from snow, grass, loose soil or ashes.
Barrington, Ill. - Vehicle Noise Enforcement Procedure	IN-SITU	As per SAE	As per SAE	Before and after each test or every 2 hours as minimum	As per SAE		Highway - a) Standard site: no reflecting surfaces within 100' radius of microphone and microphone point. b) Restricted site: reflecting surfaces within 100'. All sites: concrete or asphalt; no tunnels or overpasses; no reflecting surfaces within 10'.
Hawaii - Vehicular Noise for Oahu - Department of Health, Hawaii	IN-SITU	No specification	No specification	Calibrator meeting ANSI S1.4-1971	Windscreen "when appropriate"		Dry roadway. Concrete or asphalt, no loose material.
Grand Rapids, Mich. - Stationary Automobile Test	STATIONARY	Type 2 SLM ANSI S1.4-1971		Calibrated at 1000 Hz at start and end of each test series. Annual calibration of calibrator.	Windscreen with less than ±.5 dB effect on system sensitivity	Anemometer with ±10% accuracy. Tachometer ±2% accuracy. Data sheets.	
Oregon - Department of Environmental Quality - Stationary Motor Vehicle Test	STATIONARY			Calibration each time used. Yearly lab. calibration	Windscreen used	Standard form	Free of sound reflecting objects within 50' of microphone and 50' of vehicle.
Chicago, Ill. - New Motor Vehicle Noise Measurement	TEST SITE	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour intervals			Normal concrete or asphalt; no reflective surfaces within 100' of microphone or 100' of centerline of vehicle path from throttle open to throttle closed point. Ground clear of standing water.
Chicago, Ill. - Motor Vehicle Operation Noise Measurement	IN-SITU	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour intervals			Preferred location 100' clear area around microphone and microphone point. Surface of ground normal, highway without water.

	SITE		INSTALLATION				VEHICLE OPERATION
Meteorological Criteria/ Corrections	Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria/ Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary/ Engine Operation	Passby/ Operation	Auxiliary Equipment Operation
	Nomogram for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point.	Ambient must be 10 dB below vehicle L_p	50' May be 26' to 118'. Corrections to 50' included	2'-6' above roadway surface; 3½' above surface on which microphone stands		Normal highway operation	
		Ambient + vehicle = ambient + 3 dB	Noise level criteria given at 20', 25' and 50'			Different limits for >35 mph and <35 mph	
Max. wind speed 10 mph. Always use windscreen. No rain or snow.	Surfaces must be parallel to lane of travel. Nomogram for correction.	Max. vehicle must raise pre- and post-ambient 6 dB or more. Ambient must be 10 dB below vehicle max.	35'-118' Correction to 50' in Table	If cable is used, microphone on tripod. 4.5' above road surface; <6' above ground at microphone		—	
Wind velocity <12 mph		Ambient noise must be 10 dB lower than vehicle noise	50' ±1' from centerline of vehicle path	4' ±1" above the roadway		Highest gear so that vehicle begins at < 2/3 max. rpm and ends at less than max. rpm and <35 mph, full throttle	With and without equipment
Wind velocity <10 mph			50' ±1' from centerline of lane of travel	Microphone or SLM on tripod aimed at microphone point. 4' ± ½' above roadway surface		Lowest gear so that vehicle reaches max. rpm at <30 mph, throttle fully opened	Normal temp. (engine), no overdrive used
Wind velocity <10 mph		At least 10 dB lower than vehicle noise	50' (15 m) from centerline of lane of travel	4' above ground plane		30 mph at 25' from microphone point. Use lowest gear so that 25' past microphone point engine is at max. rated rpm.	Normal engine temp. Allow 3 min. cooling between runs
Wind velocity <12 mph	Nomogram for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point.	Ambient at least 10 dB lower than vehicle noise	50' Corrections for from 26' to 118'	2'-6' above roadway surface; 3.5' above microphone surface			
		Ambient cannot be greater than vehicle alone	22'-50' use spherical spreading law to normalize to 50' distance				
Wind velocity <12 mph No rain or snow	No reflecting surfaces. 50' in front and behind microphone point. 25' "above" and "below" microphone	At least 6 dB below vehicle noise chart for correction	35' from vehicle path centerline	4.5' above ground level = 3.5' to 6' above road surface, oriented as per instructions	Max governed speed with wide open throttle, clutch engaged, gear in neutral		No aux. equipment operating. Disengage fan if possible
Wind <10 mph Rain cannot be falling. Ground can be wet.			25' ±4" from rear or either side of vehicle	Position is at max. L_p. 4.5' above the ground or orientation as per specs.	Open throttle to reach max. recom. rpm or max. governed rpm		
Wind speed <12 mph	No reflecting surfaces. 100'	10 dB below vehicle sound level	50' ±1' from centerline of vehicle travel	Microphone on 60' ext. cable on tripod. 4' ±1' above surface.		Auto. trans. (1st gear) Standard trans. (2nd gear), wide open throttle, 50' before microphone point	
	Correction table for large reflecting surface at least 20' x 20'	10 dB below vehicle sound level	50' from centerline of traffic	On tripod on ext. cable 50' from center of traffic lane, 4 ±1' above surface			

Figure 7.1
Automobile Noise Measurement

MEASUREMENT

Personnel Required	Sound Quantity Measured	Sound Quantity Reported	Measurement Statistical Requirements	Other Data Reported	References	Other Comments
Driver, technician. Tech. trained and certified by highway patrol.	A-wt L_p as vehicle passes	Highest L_p as vehicle passes			California Highway Patrol "Sound Measurement Procedures" HPM 83.3	
	A-wt L_p fast response	Highest level as vehicle passes			ANSI SLM Spec. S1.4-1971	Includes form for reporting
	A-wt L_p fast response maximum as vehicle passes	Average of two highest readings within 2 dB of each other on each side	4 runs/side of vehicles		California Vehicle Sound Measurement Procedure	Deceleration test when warranted
Technician and driver. No bystander within 50' of microphone or vehicle.	A-wt L_p fast response	Average of two highest readings within 2 dB of each other on each side	4 runs/side of vehicles	Wind velocity, humidity, temperature		2 dB grace for variation in equipment and test site. Optional deceleration noise
Observer and driver, allows one additional person within 50' of vehicle or microphone	Fast response A-wt, network max. level noted	Average of two highest on each side (within 2 dB). Lowest of two averages is reported.	4 runs/side of vehicle or for side producing obviously higher levels			2 dB grace
Driver and technician, no other people within 50'		Maximum A-wt level				
	A-wt fast response, max. level					
Driver, no more than two technicians	Max. A-wt level average of two readings	Background ambient	Measure on both sides of vehicles with multiple exhaust until 2 max. measurements within 2 dB are achieved			
	Highest sound level A-wt fast response	Highest sound level which is no more than 1 dB above next highest level				
Driver, technician, no closer than 50' from microphone or vehicle	A-wt fast response, max. level noted	Highest of two sides	4 runs/side. Average of 2 highest (within 2 dB) for each side		SAE Procedures	
Technician, no one within 50' to rear or side of microphone	A-wt fast response, max. level					Reflection correction factor is simpler to use yet most comprehensive. 1 dB grace given.

7.2 AUTOMOBILES: PASSBY MEASUREMENT PROCEDURE

7.2.1 PURPOSE

A method for obtaining sound level measurements of automobiles operating on thoroughfares is described. It is difficult to control site conditions which affect the accuracy of sound level measurements at a road measurement site. If the preferred measurement site cannot be attained, adjustments to sound level measurements may be necessary. These adjustments are discussed in Section 2.3.

7.2.2 INSTRUMENTATION

The instrumentation necessary for the procedures includes a Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer. The windscreen should be used at all times for it reduces the influence of wind-induced noise at the microphone.

The entire sound level measurement system should be checked annually for accuracy by its manufacturer or a certified laboratory.

7.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with the test procedure and corrections which may have to be applied.

7.2.4 MEASUREMENT SITE

The preferred measurement site shall be flat, open and free of reflecting surfaces such as parked vehicles, signboards, buildings, or hillsides, within a 30 meter (98.5 ft.) radius of the microphone and a 30-meter (98.5 ft.) radius of a passing automobile (Figure 1) at the lane of traffic closest to the microphone. *Sites may be prequalified at various locations in a community.*

For those sites that do not meet the above specifications, adjustments to the measured noise level values are required. These adjustments are discussed in Section 2.3.

Within the area specified above, the traffic lane should be a straight run. The surface of the ground in the measurement area should be hard, dry, free from snow, standing water, soil, or other extraneous material.

7.2.5 VEHICLE OPERATION

Vehicles are observed during normal roadway operation. When measuring the noise level of a given vehicle, other vehicles on the same roadway should be outside of the measurement area as shown in Figure 1.

7.2.6 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/microphone combination) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Locate the microphone at a distance of 15 meters (50 ft.) from the centerline of the lane of traffic. If the microphone cannot be located 15 meters from the traffic lane, distances of from 7 meters to

30 meters are acceptable. Adjustments are then made to the sound level measurements to correct them to the standard distance. The adjustments are discussed in Section 2.3. The microphone should be oriented per manufacturers' specifications.

Set the sound level meter to fast response and A-weighting. Observe the meter as the vehicle passes the microphone. Note the highest sound level observed on a data sheet (Figure 2).

Measurements shall be made only when the A-weighted sound level, including noise from wind and sources other than the vehicle being measured, is at least 10 decibels lower than the sound level of the vehicle. Background ambient sound measurements shall be made immediately before and after measurements or at regular intervals not to exceed 10 minutes.

Measurements should not be made when it is raining or snowing, or when wind speed exceeds 20 km/hr (12 mph). Measurements should not be made during environmental conditions (temperature, humidity) as indicated by the instrument manufacturer as unacceptable.

An external calibration of the sound level meter shall be made at regular intervals not to exceed 2 hours. If the calibration differs by more than 1 decibel, measurements taken between calibrations shall not be considered valid and the sound level meter shall be adjusted.

The following figure shows a passby test procedure. The same configuration applies to bus, truck and motorcycle noise measurements.

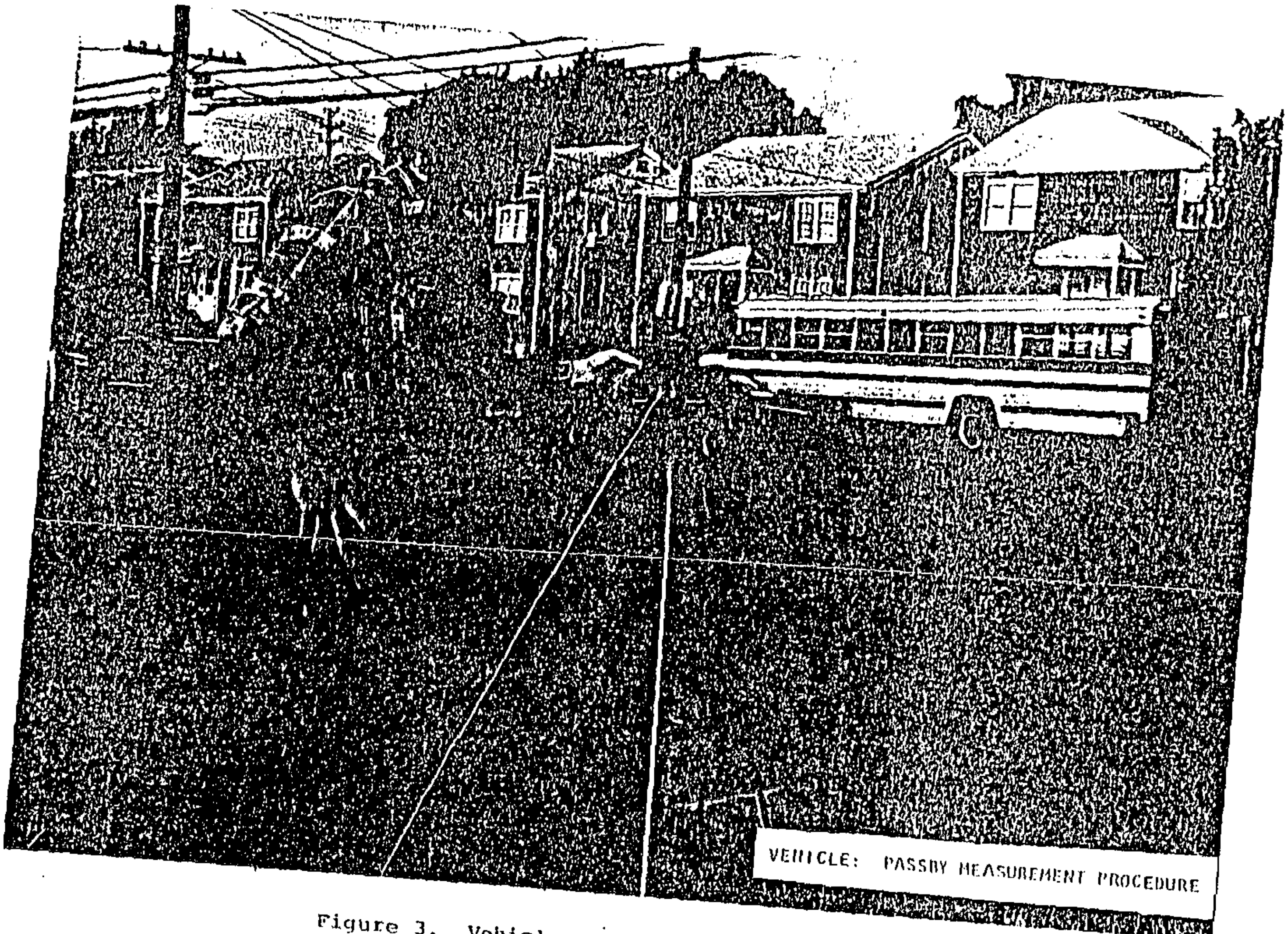

Figure 3. Vehicle: Passby Measurement Procedure

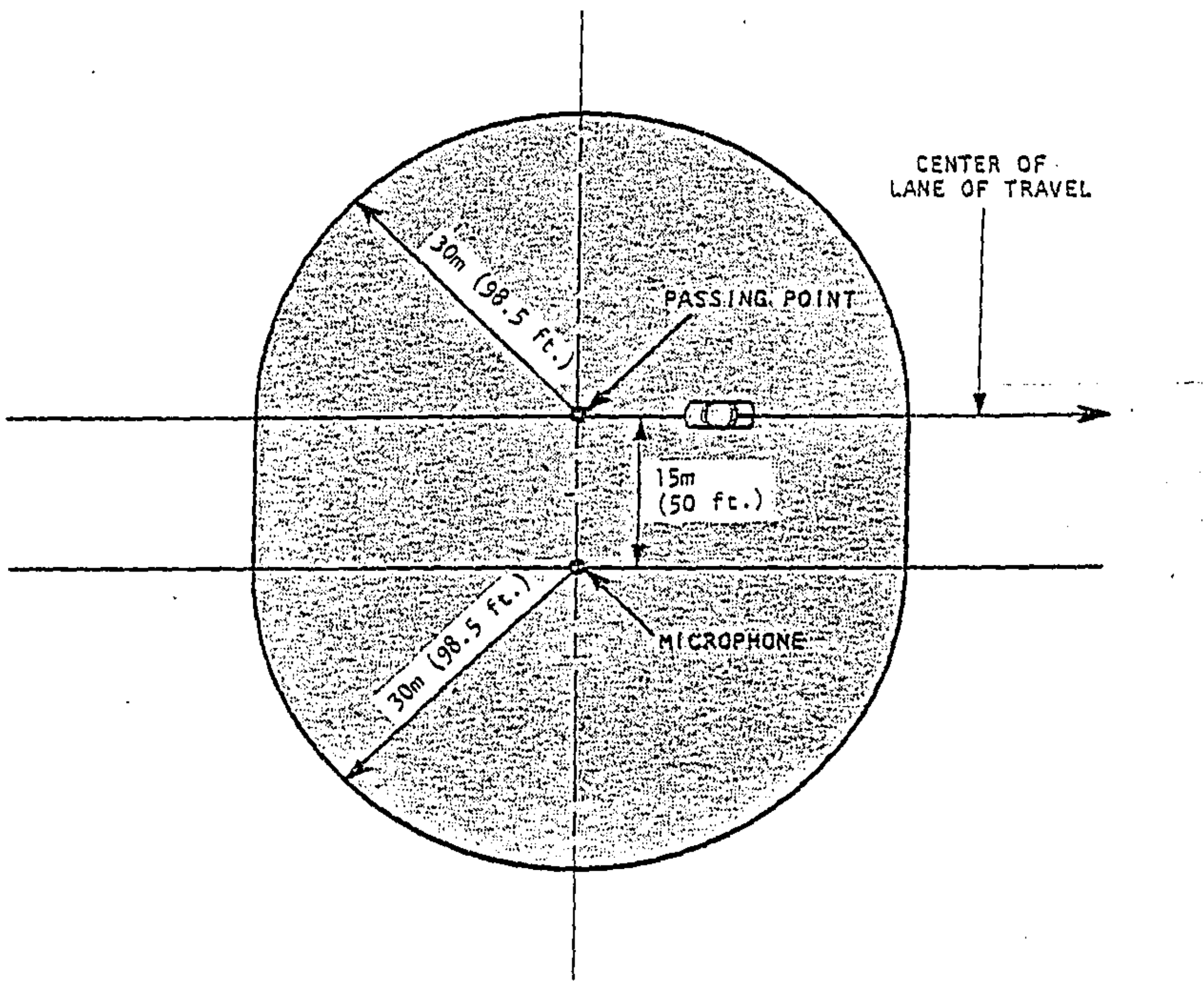

Figure 1. Preferred Roadside Test Site

Figure 2. Example: Vehicle Noise Measurement Report Form

Examiner: ______________________ Date: ____________ Time: ____________

Vehicle: ______________________ Test Type: ______________________

Vehicle Make: ____________ Vehicle Type: ____________ License: ____________ Model: ____________ Year ______

Registered Owner: ______________________ Address: ______________________

Operator: ______________________ License #: ____________ Address: ______________________

Sound Level Meter Manuf: ____________ Calibrator Manuf: ____________ Micro. Manuf: ____________
Type: ____________ Type: ____________ Type: ____________
Serial #: ____________ Serial #: ____________ Serial #: ____________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions ____________ Wind Speed ____________ m/sec ____________ Other Sources

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation ____________

7.3 AUTOMOBILES: STATIONARY TEST

7.3.1 PURPOSE

The purpose of this test method is to provide a simple cost effective procedure which is repeatable and defensible. This test procedure allows the examiner to conduct the vehicle noise test at a proper test site under desired operating conditions.

7.3.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 dB; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachometer* accurate to ±5% of full deflection; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The entire sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

7.3.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

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*The tachometer shall be compatible with 4, 6, and 8 cylinder engines. All manufacturers' specifications for the tachometer's use shall be followed. See Section 3.7 for a discussion of tachometers.

7.3.4 TEST SITE

This site shall be flat, open, and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 7 meters (23 ft.) of the vehicle. *An empty portion of a parking lot may be satisfactory (Figure 1). A number of sites in the community may be prequalified.*

7.3.5 VEHICLE OPERATION

The engine shall be at normal running temperature with the transmission in neutral or park. Sound level measurements are made at an average steady-state engine speed of 3000 rpm.

7.3.6 MEASUREMENT PROCEDURE

Set the sound level meter on A-weighting, "fast" response. Place the microphone (or microphone/sound level meter combination) on a tripod at the same height above the ground as the vehicle exhaust outlet (Figure 2). The microphone shall be positioned with its longitudinal axis parallel to the ground, 500 mm (20 in.) from the edge of the exhaust outlet, and 45 ±10 degrees from the axis of the outlet. If the exhaust outlet is located 300 mm (12 in.) or more inboard from the vehicle body, the microphone shall be located 200 mm (8 in.) from the vehicle body at the specified angle.

Observe the sound level meter while the automobile operates as described in Section 7.3.5. Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the vehicle under test, are at least 10 dB lower than the sound from the vehicle under test. Observe the background ambient sound level before and after each test.

Note vehicle model noise measurement results and other pertinent data on a data sheet. (Figure 3 contains a suggested format.)

For vehicles with multiple exhausts, the measurement shall be repeated at each exhaust outlet and all results reported on the data sheet.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) instrument manufacturer instructions deem unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than 1 decibel, the measurements shall be repeated after the sound level meter has been adjusted.

A stationary automobile noise measurement is shown in the following photograph.

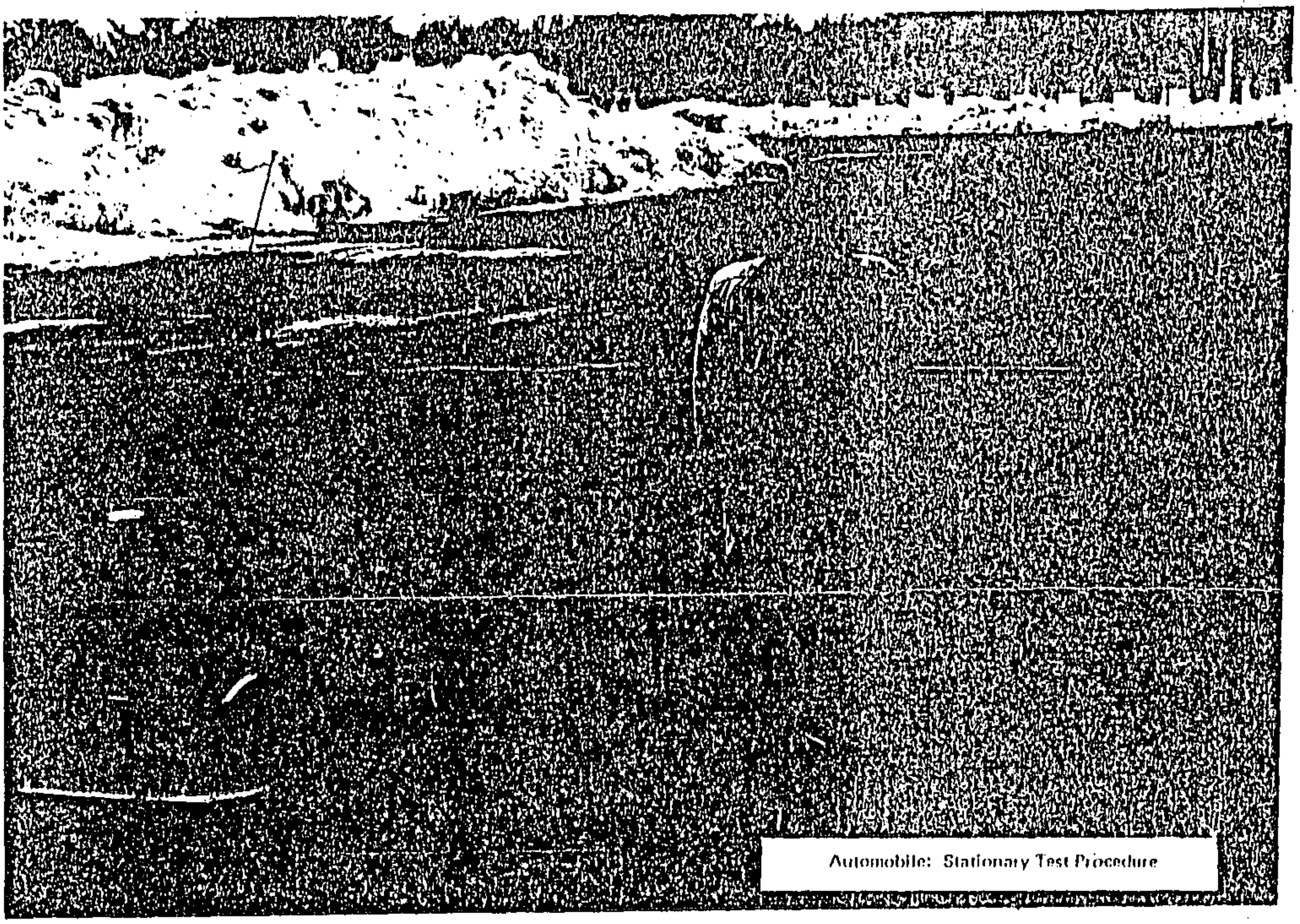
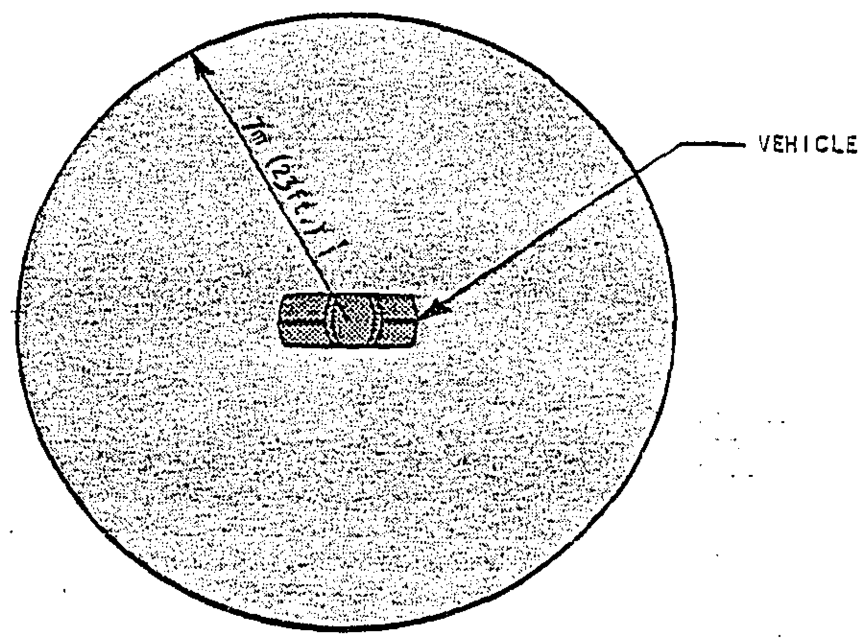


Figure 1. Automobile: Stationary Test Procedure

TEST SITE



MICROPHONE LOCATIONS

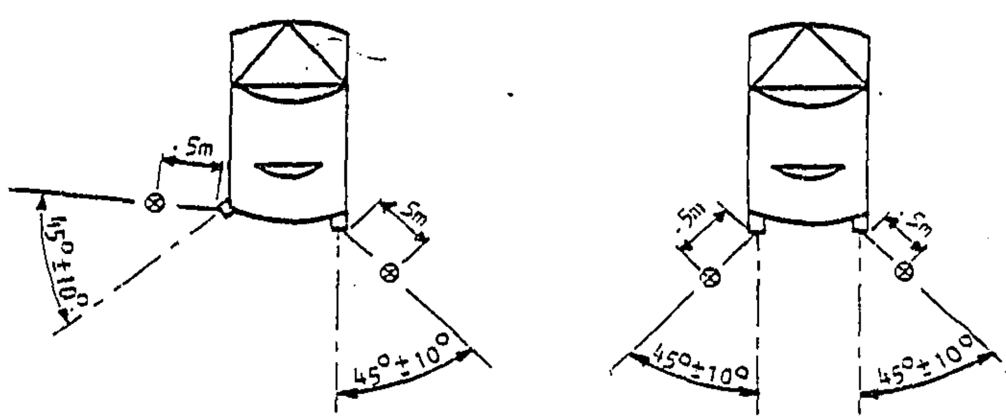


Figure 2. Stationary Automobile Test Site

Figure 3. Example: Vehicle Noise Measurement Report Form

Examiner: ______________________________ Date: __________ Time: __________

Vehicle: ______________________________ Test Type: ______________________________

Vehicle Make: ______________ Vehicle Type: __________ License: __________ Model: __________ Year _____

Registered Owner: ______________________________ Address: ______________________________

Operator: ______________________ License #: __________ Address: ______________________________

Sound Level Meter Manuf: ______________ Calibrator Manuf: ______________ Micro. Manuf: __________
Type: ______________ Type: ______________ Type: __________
Serial #: ______________ Serial #: ______________ Serial #: __________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ______________________ Wind Speed ______________ m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

7.4 BIBLIOGRAPHY

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BUSES

8

8.0 BUSES

8.1 INTRODUCTION

Two bus noise measurement methods are presented in support of Article IX Section 9.1 Motor Vehicles and Motorcycles on Public Rights-of-Way of the Model Community Noise Control Ordinance. A stationary bus noise regulation is not provided in Article IX, Section 9.1, but an applicable enforcement method is presented here for communities desiring to adopt this type of regulation.

The two noise measurement methods presented were selected after a thorough analysis of current available sound level test procedures for buses. The evaluation matrices for automobiles (Figure 7.1) and trucks (Figure 15.1) were considered in selecting these noise measurement procedures.

Both the passby and stationary test methods for buses are similar to those for automobiles. In the stationary test, the height of the microphone above the ground is 1.2 meters (4 ft.) at a distance of 7 meters (23 ft.) from the vehicle rather than the microphone height and distance required for automobiles. The microphone position selected for bus noise tests is similar to the position used for truck noise tests. Buses, in size and other characteristics, are considered closer to trucks than to automobiles. The federal Department of Transportation has used this microphone position for a noise test procedure for trucks quite successfully.

8.2 BUSES: PASSBY MEASUREMENT PROCEDURES

8.2.1 PURPOSE

A method for obtaining sound level measurements of buses operating on thoroughfares is described. It is difficult to control site conditions which affect the accuracy of sound level measurements at a road measurement site. If the preferred test conditions cannot be attained, adjustments to sound level measurements are made as outlined in Section 2.3.

8.2.2 INSTRUMENTATION

The instrumentation necessary for the procedures includes a Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system should be checked annually to verify its accuracy by its manufacturer or a certified laboratory.

8.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with the test procedure and corrections which may have to be applied.

8.2.4 TEST SITE

The preferred site used for measurements shall be flat, open and free of reflecting surfaces such as parked vehicles, signboards, buildings, or hillsides, within a 30 meter (98.5 ft.) radius of the microphone and a 30 meter (98.5 ft.) radius of a passing vehicle (Figure 1) at the lane of traffic closest to the microphone.

Whenever possible, the site selected for monitoring should meet the preferred site specifications. For those sites which do not meet the above specifications, adjustments to the measured noise level values are required. These adjustments are outlined in Section 2.3. *Sites may be prequalified at various locations in the community.*

Within the area specified above, the traffic lane should be a straight run. The surface of the ground in the measurement area shall be hard, dry, and free from snow, standing water, soil, or other extraneous material.

8.2.5 VEHICLE OPERATION

Vehicles are observed during normal roadway operation. When measuring the noise level of a given vehicle, other vehicles on the same roadway shall be outside of the measurement area shown in Figure 1.

8.2.6 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/ microphone combination) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Locate the microphone at a distance of 15 meters (50 ft.) from the centerline of the lane of traffic. If the microphone cannot be located 15 meters (50 ft.) from the traffic lane, adjustments are then made to the sound level measurements to correct them to the standard distance. The adjustments are discussed in Section 2.3 of this document. The microphone shall be oriented per manufacturers' specifications.

Set the sound level meter to "fast" response and A-weighting. Observe the meter as the vehicle passes the microphone. Note the highest observed sound level on a data sheet (Figure 2).

Measurements should be made only when the A-weighted sound level, including noise from wind and sources other than the vehicle being measured, is at least 10 decibels lower than the sound level of the vehicle. Background ambient sound measurements should be made immediately before and after measurements or at regular intervals not to exceed 10 minutes.

Measurements should not be made when it is raining or snowing, or when wind speed exceeds 20 km/hr (12 mph).

Measurements should not be made during environmental conditions (temperature, humidity) which the instrument manufacturers deem unacceptable.

An external calibration of the sound level meter should be made at regular intervals not to exceed 2 hours. If the calibration differs by more than 1 decibel, measurements taken between calibrations shall not be considered valid and the sound level meter shall be adjusted.

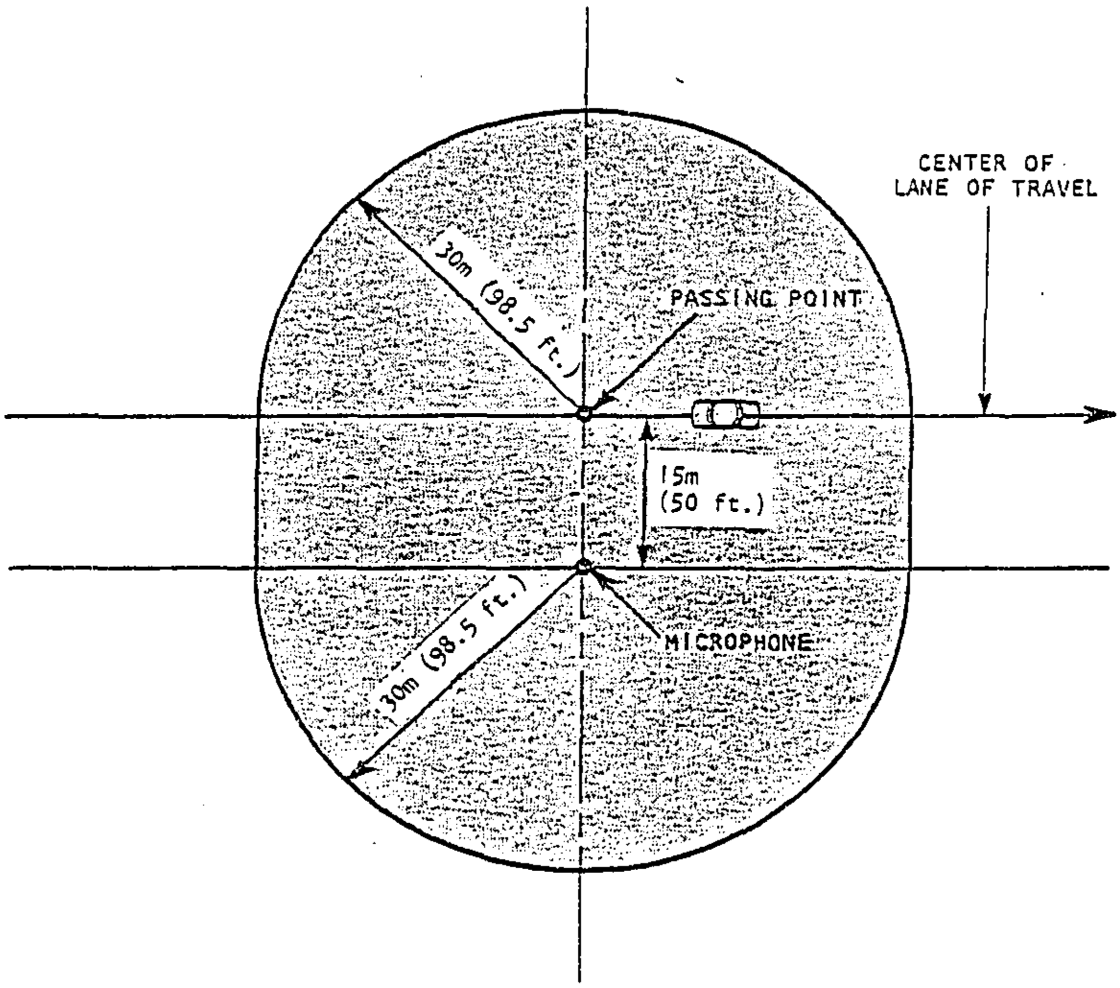


Figure 1. Preferred Roadside Test Site

Figure 2. Example: Vehicle Noise Measurement Report Form

Examiner: ____________________ Date: __________ Time: __________

Vehicle: ____________________ Test Type: ____________________

Vehicle Make: __________ Gross Wt: __________ License: __________ Model: __________ Year: ______

Registered Owner or Operator ____________________ Address: ____________________

Sound Level Meter Manuf: __________ Calibrator Manuf: __________ Micro. Manuf: __________
Type: __________ Type: __________ Type: __________
Serial #: __________ Serial #: __________ Serial #: __________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions __________ Wind Speed __________ m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

8.3 BUSES: STATIONARY METHOD

8.3.1 PURPOSE

The purpose of this stationary noise test procedure is to provide a method to measure bus sound levels which are repeatable and defensible. This type of test can be accomplished at a preferred site under desired operating conditions.

8.3.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachometer* accurate to ±5% at full scale; and a windscreen recommended by the microphone manufacturer are required for the stationary noise test. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone and protects the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

8.3.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

*The tachometer shall be compatible with 4, 6, and 8 cylinder engines. All manufacturers' specifications for the tachometer's use shall be followed. See Section 3.7 for a discussion of tachometers.

8.3.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 15 meters (50 ft.) of the vehicle and microphone. *An empty portion of a parking lot may be satisfactory.*

8.3.5 VEHICLE OPERATION

Turn off all auxiliary equipment which is installed on the bus and is not associated with the operation of the vehicle while in transit. The engine shall be at normal running temperature with the transmission in neutral or park. Attach the tachometer per manufacturer's instructions. For governed engines, the engine is accelerated to maximum governed speed with wide open throttle. For ungoverned engines, the engine is accelerated to speed at maximum rated horsepower.

8.3.6 TEST PROCEDURE

Set the sound level meter on A-weighting and "fast" response. Place the microphone on a tripod at 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground at a distance of 7 meters (23 ft.) ±.5 m (±20 in.) from the vehicle centerline on a line perpendicular to the exhaust outlet (see Figure 1).

Observe the sound level meter as the bus is operated as described in Section 8.3.5. Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the vehicle under test, are at least 10 decibels lower than the noise from the vehicle under test. Observe the background ambient sound level before and after each test.

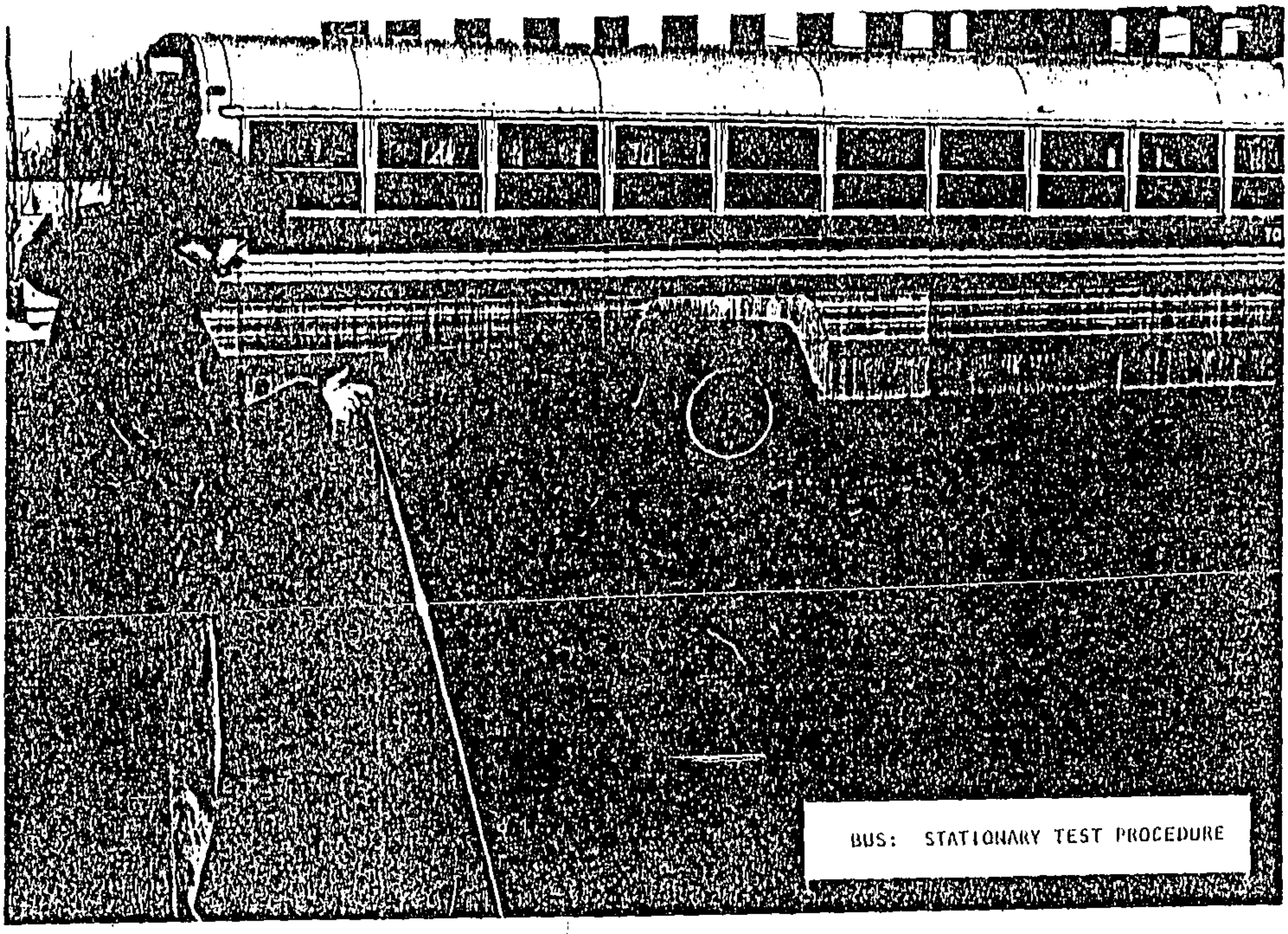
Note vehicle model, operation data and noise measurement results on a data sheet. (Figure 2 contains a suggested format.)

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the sound level meter has been adjusted.

The following photograph shows a bus noise measurement being made.



BUS: STATIONARY TEST PROCEDURE

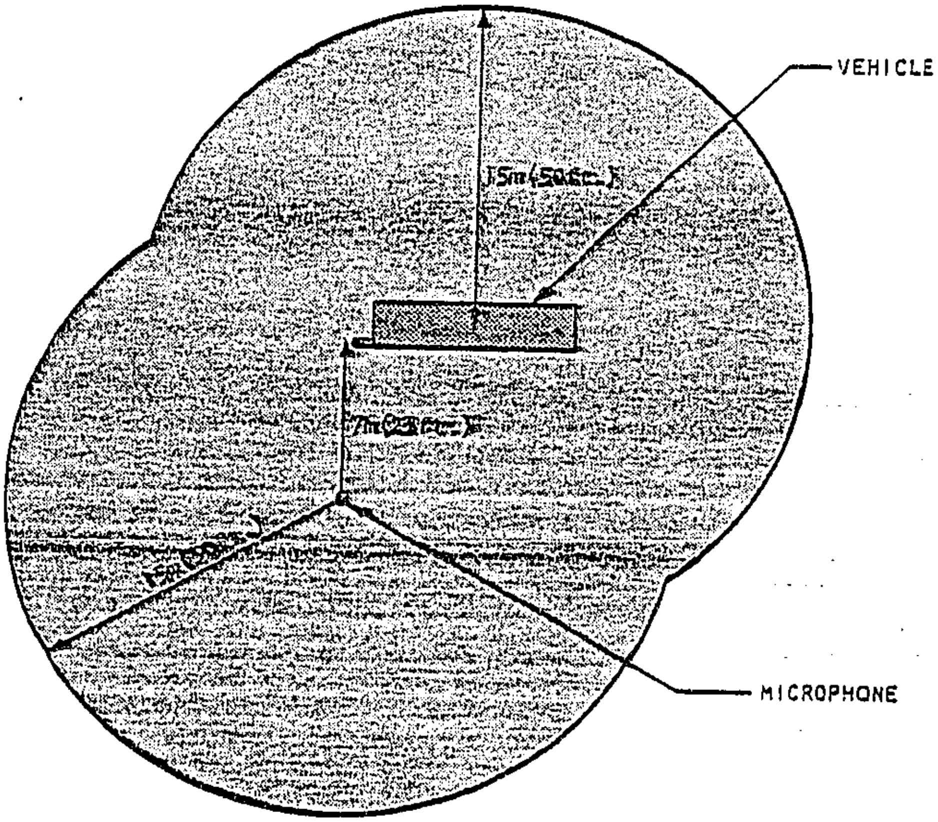


FIGURE 1
STATIONARY BUS TEST SITE

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:______________________ Date:__________ Time:________

Vehicle:______________________ Test Type:______________________

Vehicle Make:______________________ License:______________ Year________

Registered Owner or Operator:______________________ Address:______________________

Sound Level Meter Manuf:______________ Calibrator Manuf:______________ Micro. Manuf:__________
Type:______________ Type:______________ Type:__________
Serial #:______________ Serial #:______________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ______________ Wind Speed__________m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

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9

CONSTRUCTION EQUIPMENT

9.0 CONSTRUCTION EQUIPMENT

9.1 INTRODUCTION

Construction site activity is a significant contributor to community noise. Construction noise is discussed as a prohibited act in Article VI, Section 6.2.6 of the Model Community Noise Control Ordinance. However, construction equipment noise is not discussed as separate noise sources requiring legislation in the Model Community Noise Control Ordinance. A measurement procedure is presented which can be used to identify the principal contributors to construction site noise. Modification of a community's noise ordinance may be required for communities instituting such controls.

Numerous methods for measurement of construction equipment noise were reviewed and evaluated. Figure 9.1 presents the evaluation matrix. A test method~~, based on EPA's~~ noise measurement procedure for portable air compressors, is also presented.

Equipment noise levels and the amount of time the equipment is in its noisiest mode can be used to compute the average sound level (L_{eq}) contributed by the equipment to the total site average sound level.

The computation is accomplished in the following manner. The noise of each item of construction equipment is measured using the test procedure presented in this section. The typical amount of time that the equipment is in its noisiest operating mode is also noted. The distance from the center of equipment activity to the construction site boundary is determined. These data are used in the following equation to determine the average sound level contribution of the equipment to the site average sound level L_{eq}.

$$\text{Equipment:} \quad \bar{L}_{eq} = \bar{L}_p - 20 \log(d) + 10 \log(U.F.) - dB$$

$\bar{L}_p$ is the average of the measurements at 7 meters

d is the distance from equipment activity to site boundary

U.F. is the usage factor. It is the ratio of the period of time the equipment is in its noisiest mode of operation to the period used to determine the site average sound level (or one hour)

The site average sound level is measured using the procedure provided in Section 5.2.

EQUIPMENT

VEHICLE - Construction Equip. > 20bhp

Measurement Method	Test Type	Sound Level Meter	Microphone	Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions
SAE J88a [illegible] Sound Level Meas. Mobile Construction Equip.	TEST SITE	Type 1 ANSI	[illegible]	Acoustical calibrator Field calibration before & after tests	Windscreen (Opt.)	Mag. Tape Recorder (Opt.) Anemometer R.P.M. Indicator ±3%. Thermometer	100' vehicle path - no bystander Clear 100' radius within 50' Hard-packed or solid surface free of vegetation
Florida - New Vehicle Test Procedure	TEST SITE	Precision SLM as per ANSI specifications		Calibration before and after each use or every 2 hours as a minimum if instrument is used >2 hours	Windscreen	Tachometer Anemometer	Flat response. No reflecting surfaces within 100' of a) microphone, b) point 50' before microphone point, c) point 50' beyond microphone point. Ground surface: smooth asphalt or concrete in a area between microphone and two 50' points.
Barrington, Ill. - Vehicle Noise Enforcement Procedure	IN-SITU	As per SAE	As per SAE	Before and after each test or every 2 hours as minimum	As per SAE		Highway - a) Standard site: No reflecting surfaces within 100' radius of microphone and microphone point. b) Restricted site: reflecting surfaces within 100'. All sites: concrete or asphalt; no tunnels or overpasses; no reflecting surfaces within 10'.
Minneapolis, Minn. - Highway Vehicle Test Procedure	IN-SITU	Any sound level meter	Any microphone		Windscreen "when appropriate"		Concrete or asphalt roadway surface; dry and free of bumps or cracks.
Chicago, Ill. - New Motor Vehicle Noise Measurement		Same as 188-152					
Grand Rapids, Mich. - Stationary Automobile Test	STATIONARY	Type 2 SLM ANSI S1.4-1971		Calibrated at 1000 Hz at start and end of each test series. Annual calibration of calibrator.	Windscreen with less than 0.5 dB effect on system sensitivity	Anemometer with ±10% accuracy. Tachometer ±2% accuracy. Data sheets.	
Metropolitan Washington	IN-SITU	Type 1 SLM ANSI S1.4-1971		Before and after each test	Optional mag. recorder or graphic level recorder (SAE J184)	Tachometer Anemometer	Flat open space free of large reflecting surfaces from vehicle or microphone. Surface of ground free from snow, grass, loose soil or ashes.

SITE		INSTALLATION					VEHICLE OPERATION	
Meteorological Criteria/ Corrections	Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary Engine Operation	Passby/ Operation	Auxiliary Equipment Operation	Personnel Required
Record all ambient conditions. Wind < 12 mph	No large reflecting surfaces in 100'	At least 10dBA lower than that equip.	4' above ground 50' from vehicle or path center line		Operate at max. setting for normal use at max noise level		Apply loads to get max noise levels. Second gear or ½ gear ratios. Move 3/4 of rated power source speed, 33 mph. Full throttle thru meas. area, then closed.	Tech-trained & experience
Max. wind speed 10 mph. Always use windscreen. No rain or snow.	Surfaces must be parallel to lane of travel. Nomogram for correction.	Max. vehicle must raise pre- and post-ambient 6 dB or more. Ambient must be 10 dB below vehicle max.	35'-118' Correction to 50' in Table	If cable is used, microphone on tripod. 4.5' above road surface; <6' above ground at microphone				
Wind velocity <12 mph	Nomogram for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point.	Ambient at least 10 dB lower than vehicle noise	50' Corrections for from 25' to 118'	2'-6' above roadway surface; 3.5' above microphone surface				Driver and technician, no other people within 50'
		Ambient + vehicle = ambient + 3 dB	Noise level criteria given at 20', 25' and 50'			Different limits for >35 mph and <35 mph		
Wind velocity <12 mph No rain or snow	No reflecting surfaces. 50' in front and behind microphone point. 35' "above" and "below" microphone	At least 8 dB below vehicle noise chart for correction	35' from vehicle path centerline	4.5' above ground level = 3.5' to 6' above road surface, oriented as per instructions	Max governed speed with wide open throttle, clutch engaged, gear in neutral		No aux. equipment operating. Disengage fan if possible	Driver, no more than two technicians
Wind velocity <10 mph		At least 10 dB lower than vehicle noise	50' (15 m) from centerline of lane of travel	4' above ground plane		30 mph at 25' from microphone point. Use lowest gear so that 25' past microphone point engine is at max. rated rpm.	Normal engine temp. Allow 1 min. cooling between runs	Observer and driver, allow one additional person within 50' of vehicle or microphone

Figure 9.1
Construction Equipment Noise Measurement

MEASUREMENT

Sound Quantity Measured	Sound Quantity Reported	Measurement Statistical Measurements	Other Data Reported	References	Other Comments
A-wt. slow response	Record highest reading from each side of vehicle Average of 2 Report loudest side				
A-wt L_p fast response	Highest level as vehicle passes			ANSI SLM Spec, S1.4-1971	Includes form for reporting
	Maximum A-wt level				
Max. A-wt level average of two readings	Background ambient	Measure on both sides of vehicles with multiple constant until 2 max. measurements within 2 dB are achieved			
Fast response A-wt. network Max. level noted	Average of two highest on each side (within 2 dB). Lowest of two averages is reported.	4 runs/side of vehicle or for side producing obviously higher levels			2 dB grace

9.2 CONSTRUCTION EQUIPMENT

9.2.1 PURPOSE

A procedure which can be used by communities to measure the noise of individual construction equipment at a site is described. The procedure is designed to enable these measurements to be made while other equipment is operating on the site. The noise of individual equipment is used to determine the equipment which is the major contributor to construction site noise.

9.2.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications) a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachometer* accurate to ±5% at full scale; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

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*Tachometers shall be compatible with both two and four stroke engines. A mechanical tachometer may be required for ungoverned diesel engines, see Section 3.7.

9.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests shall be trained in the operation of sound level meters and familiar with this test procedure.

9.2.4 TEST SITE

If possible, the construction equipment being tested shall be moved to an area at the construction site as flat, open, and free from large reflecting surfaces and other noise sources as possible.

9.2.5 EQUIPMENT OPERATION

Stationary equipment (e.g., pavement breakers, air compressors, cranes, concrete trucks) are operated at load and performance (i.e., engine speed, breaking rate) which are typical of its normal operation.

Mobile equipment (e.g., graders, scrapers, dozers) shall be operated in a stationary position with the engine at governed speed, or if ungoverned, at the engine speed corresponding to rated horsepower and, if possible, with auxiliary equipment operating.

9.2.6 MEASUREMENT PROCEDURE

Set the sound level meter/microphone on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Measurements are made 7 meters (23 ft.) ±8 cm (±3 in.) from a plane formed by the major components of the equipment under test (see Figure 1). Set the sound level meter for "fast" response and A-weighting. Operate the equipment for a sufficient period to allow a repeatable maximum sound level reading to be observed. A total of four equi-spaced measurements are made 7 meters (23 ft.) from the equipment surface. Figure 1 presents reference surfaces for common equipment types. The reported sound level for the equipment unit is the arithmetic average of all four measurements.

Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the equipment under test, are at least 10 decibels lower than the noise from the equipment under test. Observe the background ambient sound level before and after each test.

If the background ambient sound levels are within 10 decibels of the measured sound levels, either adjust the measured sound levels for other noise or repeat the measurements at a distance less than 7 meters (23 ft.) from the equipment (Section 9.2.7).

Note equipment model, operation data and noise measurement results on a data sheet. Figure 2 contains a suggested format.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the sound level meter is adjusted.

The following photograph shows a construction equipment noise measurement being made.

9.2.7 ADJUSTMENTS FOR HIGH AMBIENT NOISE CONDITIONS

Measurements are valid when the background ambient A-weighted sound levels, which include wind noise and all sources other than the equipment under test, are more than 10 decibels lower than the measured sound levels. Observe the background ambient sound level before and after each test. If these conditions are not met, two options exist:

1. Measurements can be made at locations less than 15 meters (23 ft.) from the equipment being studied. The distance should be selected so that background ambient sound levels are at least 10 decibels lower than the measured sound levels. Carefully note the distance used for the measurements. Table 1 can be used to adjust the measured sound levels to a standard 7-meter (23 ft.) distance. If measurements are made at distances from the equipment less than twice the equipment major dimension, near field effects can result in questionable results. Therefore, this situation should be avoided. The following alternative can be used.

2. Measurements of the source and of the background ambient sound levels are made at the 7-meter (23 ft.) distance. Corrections are applied to the measured sound levels in accordance with Table 2 if the background ambient sound level is from 3 to 10 decibels below the measured sound level. If the background ambient sound level is 0 to 3 decibels below the measured sound levels, measurements closer to the source should be made, being aware of the near field effects described in Option 1 above.

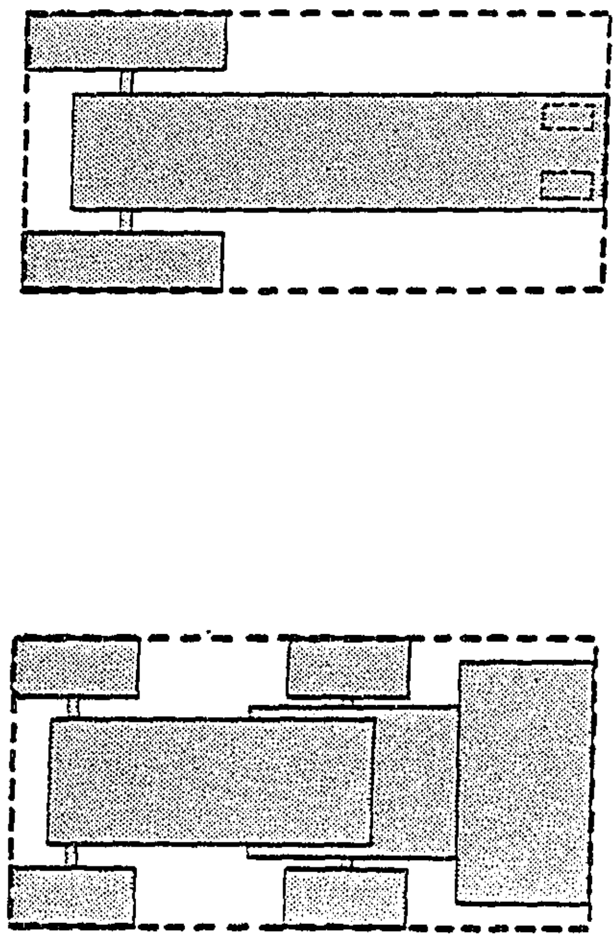

Figure 1. Reference Surface for Construction Equipment

Note: Equipment shaded.
Reference surface indicated by broken lines.

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner: ______________________ Date: __________ Time: __________

Vehicle: ______________________ Test Type: ______________________

Vehicle Make: __________ Gross Wt: __________ License: __________ Model: __________ Year: ______

Registered Owner or Operator ______________________ Address: ______________________

Sound Level Meter Manuf: __________ Calibrator Manuf: __________ Micro. Manuf: __________
Type: __________ Type: __________ Type: __________
Serial #: __________ Serial #: __________ Serial #: __________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions __________ Wind Speed __________ m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

TABLE 1

ADJUSTMENTS FOR MEASUREMENTS MADE AT DISTANCES OTHER THAN 15 METERS

Distance, Meters	Correction to be Added, dB
3	-7.5
4	-5.0
5	-3.0
6	-1.5
7	0
8	1.0
9	2.0
10	3.0
11	4.0
12	4.5
13	5.5
14	6.0
15	6.5

TABLE 2

CORRECTION FACTORS FOR BACKGROUND AMBIENT SOUND LEVELS

$$L_s = 10 \log_{10} [10^{L_p/10} - 10^{L_o/10}]$$

L_s is stationary source sound level contribution

L_p is measured sound level with source operating

L_o is background sound level with source not operating

Difference between L_p and L_o	Subtract Values from L_p to get L_s
0	*
1	*
2	*
3	3.0
4	2.5
5	2.0
6	1.5
7	1.0
8	1.0
9	0.5
10	0.5

*Cannot be determined. Background levels must be lower.

9.3 BIBLIOGRAPHY

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MOTORBOATS 10

10.0 MOTORBOATS

10.1 INTRODUCTION

The Model Community Noise Control Ordinance contains a section (Article VI, Section 6.2.15) which specifies maximum allowable motorboat noise. The measurement procedure presented in this section is based on the Society of Automotive Engineers Recommended Practice J-34B.

10.2 MOTORBOATS

10.2.1 PURPOSE

The purpose of this measurement procedure is to provide a means for enforcement officials to measure motorboat noise from a position on shore or at a floating platform. It is based on an industry accepted procedure developed by the Society of Automotive Engineers.

10.2.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

10.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

10.2.4 TEST SITE

The test site shall be located on a portion of the body of water where the boat can operate along a straight line in a safe manner. The water depth at 25 meters (82 ft.) from the shoreline or a measurement platform is sufficient to allow normal operation of the motorboat being tested. Three points are established by marker buoys (Figure 1):

- Starting Point: A point 30 meters (98.5 ft.) ahead of a perpendicular to the boat path passing through the microphone (onshore).

- Entrance Point: A point 15 meters (50 ft.) ahead of a perpendicular to the boat path passing through the microphone (onshore).

- End Point: A point 15 meters (50 ft.) beyond a perpendicular to the boat path passing through the microphone (onshore).

If the measurements are made on shore, the area along the test site shall be flat, open and free of large reflecting surfaces such as vehicle, signboards, buildings, or hillsides within 30 meters (98.5 ft.) of the microphone.

10.2.5 MOTORBOAT OPERATION

Start the motorboat from a standstill at the starting point and approach the entrance point at one-quarter throttle (approximate). Upon reaching the entrance point, open the engine throttle fully. Maintain this condition until the end point is reached. Deceleration can then begin.

10.2.6 MEASUREMENT PROCEDURE

Set the sound level meter/microphone on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the surface of the water. The microphone shall be located 25 meters (82 ft.) ±25 cm (±10 in.) from the boat's path as indicated in Figure 1.

If the on shore test site requirements outlined in Section 10.2.4 cannot be accomplished, the microphone can be placed on an anchored boat 25 meters (82 ft.) from the path of the motorboat being tested. Care must be taken that the measurement platform is free of reflecting surfaces.

Set the sound level meter for "fast" response and A-weighting. Observe the sound level meter while the boat passes. The maximum sound level observed while the boat is between the entrance and end points shall be noted on a data sheet. (Figure 2 contains a suggested format.)

Repeat the procedure in the opposite direction. The reported sound level for the motorboat is the maximum of the two measurements. Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the boat under test, are at least 10 decibels lower than the noise from the boat under test. Observe the background ambient sound level before and after each test.

Note motorboat and engine models, operating data, and noise measurement results on a data sheet (Figure 2).

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated, after the sound level meter is adjusted.

The following photograph shows a noise measurement of a motorboat being made.

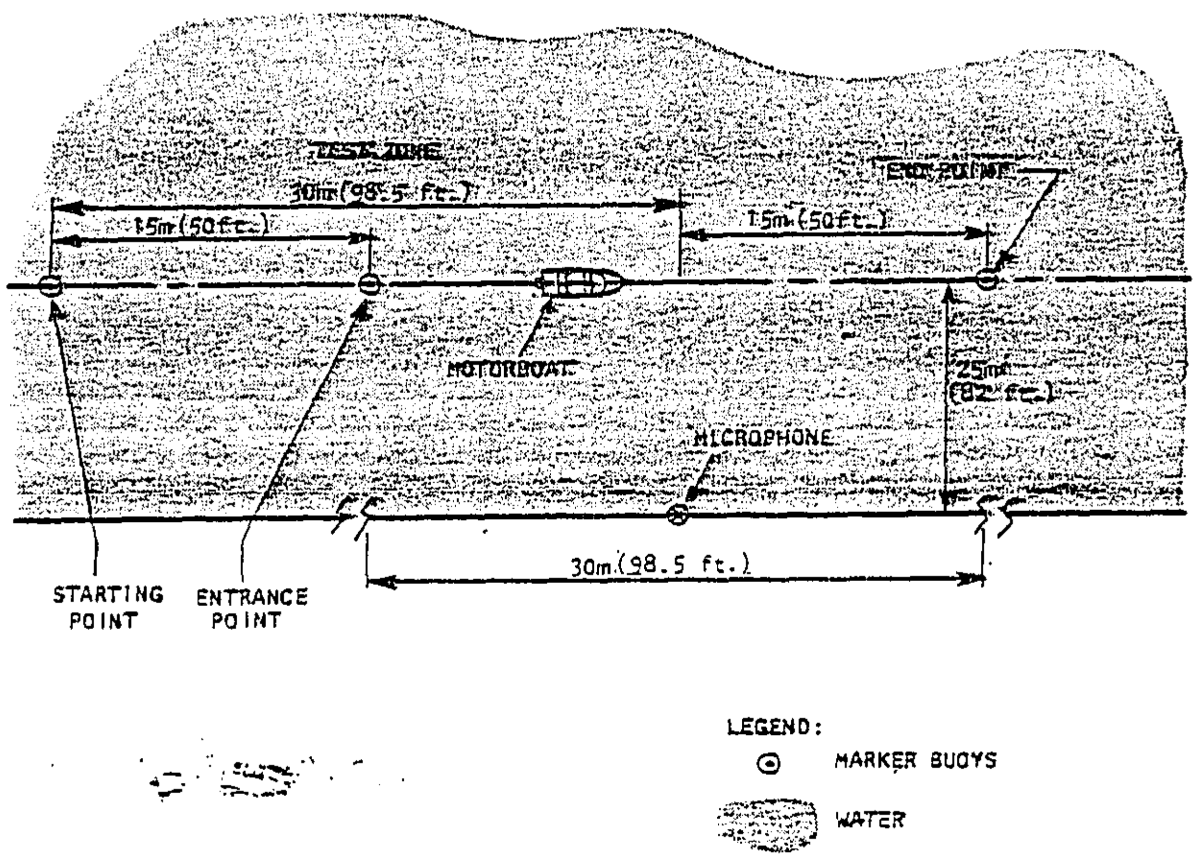

FIG. 1 TEST SITE FOR MOTORBOAT NOISE MEASUREMENT PROCEDURE

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:______________________ Date:__________ Time:__________

Vehicle:______________________ Test Type:______________________

Vehicle Make:__________ Vehicle Type:__________ License:__________ Model:__________ Year____

Registered Owner:______________________ Address:______________________

Operator:______________ License #:__________ Address:______________________

Sound Level Meter Manuf:__________ Calibrator Manuf:__________ Micro. Manuf:__________
Type:__________ Type:__________ Type:__________
Serial #:__________ Serial #:__________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ______________ Wind Speed__________m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

10.4 BIBLIOGRAPHY

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11.0 MOTORCYCLES

11.1 INTRODUCTION

Two motorcycle noise measurement methods are presented in support of Article IX, Section 9.1 Motor Vehicles and Motorcycles on Public Rights-of-Way of the Model Community Noise Control Ordinance, a passby test procedure and a stationary procedure. A stationary motorcycle noise regulation is not provided in Article IX, Section 9.1, but an applicable enforcement method is presented here for communities desiring to adopt this type of regulation.

These methods were selected after a thorough review and analysis of current available sound level test procedures for motorcycles. Figure 11.1 presents the evaluation matrix used in selecting these methods. In addition, test methods for automobiles (Figure 5.1) were also reviewed.

Although many motorcycles come equipped with tachometers, an external tachometer may be necessary for those vehicles not so equipped. Since the number of cylinders and firing arrangements may differ from motorcycle to motorcycle, care must be taken in correctly wiring and interpreting the indications of an external tachometer. A local automotive supply house or motorcycle shop can supply guidance in purchasing an external tachometer. Due to the large variation in motorcycle engine size and operating characteristics, no one engine speed can be specified for the stationary measurement method. Fifty percent of the speed at maximum rated horsepower is suggested as the best speed to be used.

Figure 11.1
Motorcycle Noise Measurement

MEASUREMENT

Sound Quantity Measured	Sound Quantity Reported	Measurement Statistical Measurements	Other Data Reported	References	Other Comments
Ambt. fast response	Report lowest of 2 sided readings of passby	Four test runs on each side of vehicle		California Highway Patrol H.P.M. 83.3 - "Sound Measurement Procedure" 1-74	
Ambt L_A fast response maximum as vehicle passes	Average of two highest readings within 2 dB of each other on each side	3 runs/side of vehicles		California Vehicle Sound Measurement Procedure	Deceleration test when warranted
Ambt fast response, max. level					
Ambt fast response, max. level noted	Highest of two sides	4 runs/side. Average of 2 highest (within 2 dB) for each side		SAE Procedures	
Ambt fast response, max. level					
Ambt. fast response	Average of four readings within 2dB of each other for each side	Six measurements for each side of motorcycle	Vehicle type model year, test location engine speed and displacement description of equipment used for test		
Ambt. slow response	L_A at loudest side of motorcycle		Vehicle type model year, test location engine speed and displacement description of equipment used for test		
Ambt. L_A fast response			Wind velocity Humidity temperature		2dB space Deceleration test when deemed necessary
Highest sound level done fast response	Highest sound level which is no more than 1 dB above next highest level				
Ambt L_A fast response	Highest level as vehicle passes			ANSI Stand. S1.4-1971	Includes form for reporting

SITE	INSTALLATION			VEHICLE OPERATION			
Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary Engine Operation	Passby/ Operation	Auxiliary Equipment Operation	Personnel Required
Nomograph for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point	Ambient must be 10 dB below vehicle L_p	50' May be 26' to 118'. Corrections to 50' included	2'-6' above roadway surface; 3½' above surface on which microphone stands		Normal highway operation		Driver, technician. Tech. trained and certified by highway patrol.
	Ambient noise must be 10 dB lower than vehicle noise	50' ±1" from centerline of vehicle path	4' ±1" above the roadway		Highest gear so that vehicle begins at < 2/3 max. rpm and ends at less than max. rpm and < 35 mph, full throttle	With and without equipment	
	Ambient + vehicle = ambient + 3 dB	Noise level criteria given at 20', 25' and 50'			Different limits for > 35 mph and < 35 mph		
No reflecting surfaces. 100'	10 dB below vehicle sound level	50' ±1' from centerline of vehicle travel	Microphone on 60' ext. cable on tripod. 4' ±½' above surface		Auto. trans. (1st gear) Standard trans. (2nd gear), wide open throttle, 50' before microphone point		Driver, technician, no closer than 50' from microphone or vehicle
Correction table for large reflecting surface at least 20' x 10'	10 dB below vehicle sound level	50' from centerline of traffic	On tripod on ext. cable 50' from center of traffic lane, 4 ±½' above surface				Technician, no one within 50' to rear or side of microphone
Nomograph for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' feet from microphone and passby point	Ambient at least 10 dB lower than vehicle noise	50' Corrections for from 26' to 118'	2'-6' above roadway surface; 3.5' above microphone surface				Driver and technician, no other people within 50'
	Ambient Sound level must be at least 10 dB below vehicle sound level	15 meters from vehicle path	1.2 meters above ground, oriented per manufacturers specifications		Full throttle acceleration in second gear		Only one person other than rider and observed within 15m of vehicle microphone
	Ambient sound must be at least 10 dB below vehicle sound level	15 meters from exhaust at a 45° angle from plane of motorcycle		Engine in neutral at 50% of maximum rated rpm			Only one person other than rider and observed within 15m of vehicle microphone
		50' ±1' from centerline of lane of travel	Microphone or SLM on tripod aimed at microphone point, 4' ±½' above roadway surface		Lowest gear so that vehicle reaches max. rpm at < 30 mph, throttle fully opened	Normal temp. (engine), no overdrive used	Technician and driver. No bystander within 50' of microphone or vehicle
		25' ±6' from rear or either side of vehicle	Position is at max. L_p 4.5' above the ground or orientation as per specs.	Open throttle to reach max. recom. rpm or max. governed rpm			
	Ambient cannot be greater than vehicle alone	20'-50', Use spherical spreading law to normalize to curve				No aux. equipment operating. Dismount fan if possible	Driver, no more than two technicians

EQUIPMENT

VEHICLE: MOTORCYCLES

Measurement Method		Sound Level Meter	Microphone	Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions	Meteorological Criteria/ Corrections
Florida - Highway Vehicle Test Procedure	IN-SITU	Type 1,2, or S2A meeting applicable ANSI specifications		End-to-end with a minimum of every 2 hours Annual lab. Calibration	Windscreen (opt.)		a) Standard Site - no reflecting surface within 100' of microphone or microphone point. b) Restricted Site	Wind Velocity must be < 12 mph
Florida - New Vehicle Test Procedure	TEST SITE	Precision SLM as per ANSI specifications		Calibration before and after each use or every 2 hours as a minimum if instrument is used > 2 hours	Windscreen	Tachometer Anemometer	Flat Response. No reflecting surface within 100' of a) microphone, b) point 50' before microphone point, c) point 50' beyond microphone point. Ground Surface. Smooth asphalt or concrete in A area between microphone and two 50' points.	Wind velocity < 12 mph
Minneapolis, Minn. - Highway Vehicle Test Procedure	IN-SITU	Any sound level meter No Standard	Any microphone No Standard		Windscreen "when appropriate"		Concrete or asphalt roadway surface; dry and free of bumps or cracks.	
Chicago, Ill. - New Motor Vehicle Noise Measurement	TEST SITE	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour intervals.			Normal concrete or asphalt; no reflective surfaces within 100' of microphone or 100' of centerline of vehicle path from throttle open to throttle closed point. Ground clear of standing water.	Wind speed < 12 mph
Chicago, Ill. - Motor Vehicle Operation Noise Measurement	IN-SITU	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour			Preferred location 100' clear area around microphone and microphone point. Surface of ground normal, highway without water.	
Barrington, Ill. - Vehicle Noise Enforcement Procedure	IN-SITU	As per SAE	As per SAE	Before and after each test or every 2 hours as minimum	As per SAE		Highway - a) Standard Site: No reflecting surfaces within 100' radius of microphone and microphone point; b) Restricted Site: Reflecting surfaces within 100'; All Sites: Concrete or asphalt no tunnels or overpasses; no reflecting surfaces within 10'.	Wind Velocity < 12 mph
EPA Draft Motorcycle Emission Procedure	ACCELERATION	Type S1A per ANSI 1.4 -1971		Calibration flat mode as necessary	Windscreen used at all times	Tachometer with ± 3% accuracy Anemometer accuracy of ± 10% at 20 km/hr	Level, flat and of concrete or sealed asphalt free of reflecting surfaces within 30.5m of microphone and vehicle path	Wind speed < 19 km/hr.
EPA Draft Motorcycle Noise Emission Test Procedure	STATIONARY	Type S1A per ANSI 1.4 -1971		Calibration flat mode as necessary	Windscreen used at all times	Tachometer with ± 3% accuracy Anemometer accuracy of ± 10% at 20 km/hr	Flat open site free of reflecting surfaces within 15m of motorcycle and microphone	Wind velocity < 19 km/hr.
Oregon - New Vehicle Test Procedure	TEST SITE	Type II Minimum ANSI S1.4 -1971		Lab. Calibration annually	Windscreen optional recorder	Sling psychrometer wind gauge data forms	Flat asphalt or concrete surface, no reflecting surface within a) 100' of microphone, b) 50' before microphone point, c) 50' beyond microphone point	Wind velocity < 10 mph
Oregon - Stationary Test Procedure	STATIONARY			Calibration each time used, Yearly lab calibration	Windscreen used	Standard form	Free of sound reflecting objects within 50' of microphone and 50' of vehicle	Wind < 10 mph Rain cannot be falling. Ground can be wet.
Oregon - Highway Noise Procedure	IN-SITU	Type II Minimum ANSI S1.4-1971	Random Incidence Microphone	Calibrated prior to each use; yearly lab. calibration	Windscreen	Data forms; clipboard; tripod; wind meter; psychrometer	Highway - a) Standard Site: No reflecting surfaces within 100' radius of microphone and microphone point; b) Restricted Site: Reflecting surfaces within 100'; All Sites: Concrete or asphalt; no tunnels or overpasses; no reflecting surfaces within 10'.	Max. wind speed 10 mph. Always use windscreen. No rain or snow.

EQUIPMENT

VEHICLE: MOTORCYCLES

MEASUREMENT METHOD		Sound Level Meter	Microphone	Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions	Meteorological Criteria/ Correction
Hawaii - Vehicle Noise for Oahu - Department of	IN-SITU	No specifications	No specifications	Calibrator meeting ANSI S1.4-1971	Windscreen "when appropriate"		Dry roadway. Concrete or asphalt, no loose material.	
Metropolitan Washington		Type 2						
Grand Rapids Michigan	STATIONARY	Type 2 as per ANSI S1.4-1971		Calibrated immediately after measurement of a violation		Anemometer Tachometer Data Form	Hard, dry surface of concrete or sealed asphalt	No rain or snow
SAE J47 - Maximum Sound Level Potential for Motorcycles		Type 1 or S1A meeting ANSI S1.4-1971		Calibrated accuracy ±.5dB Calibrate before and after test		Option to tape record noise. System should meet SAE J184 Tachometer Windscreen	Surface of ground within ∧ formed by microphone + 2 50° points. Must be dry and free of snow, soil and extraneous material.	Wind velocity < 12 mph

SITE		INSTALLATION			VEHICLE OPERATION		
Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary Engine Operation	Passby/ Operation	Ancillary Equipment Operation	Personnel Required
		Microphone located at noise sensitive land use affected by motorcycle					
No reflect. Surfaces 12' fore and aft of cycle; 5' from microphone	Ambient must be 8 dB below vehicle noise	75' from center of vehicle	1½ ft. above ground at microphone; 1' to 2½ above road surface at vehicle; angle of microphone as per manufacturer	Engine warmed in neutral 75% of engine speed at which max. HP is delivered		Monitoring personnel behind microphone	
No reflecting surfaces within 100' radius of a) microphone; b) microphone point; c) point 50' before microphone point; d) point 50' beyond microphone point	10 dB below vehicle noise	50' from center line of vehicle path	4' above ground plane		Vehicles should accelerate and passby microphone point so that vehicle is 25' past microphone point at engine speed corresponding to max. HP. Determine by trial and error		Only rider and observer within 50' of vehicle microphone

Figure 11.1
Motorcycle Noise Measurement
(Con't)

MEASUREMENT

Sound Quantity Measured	Sound Quantity Reported	Measurement Statistical Measurements	Other Data Reported	References	Other Comments
A-wt., L_p fast response maximum measured					
A-wt., fast response maximum level of exhaust side of vehicle	Average of two tests within 2dB of each other				
A-wt., fast response six areas per side of vehicle maximum level	Average of 4 passings within 2dB Highest of two sides is reported				Optional acceleration test

11.2 MOTORCYCLES: PASSBY MEASUREMENT PROCEDURES

11.2.1 PURPOSE

A method for obtaining sound level measurements of motorcycles operating on thoroughfares is described below. It is difficult to control site conditions which affect the accuracy of sound level measurements at a road measurement site. If the preferred measurement site cannot be attained, adjustments to sound level measurements may be necessary. These adjustments are discussed in Section 2.3.

11.2.2 INSTRUMENTATION

The instrumentation necessary for the procedures includes a Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The entire sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

11.2.3 PERSONNEL

Persons responsible for conducting sound level measurements should be trained in the operation of sound level meters and familiar with the test procedure and corrections which may have to be applied.

11.2.4 MEASUREMENT SITE

The preferred site used for measurements shall be flat, open and free of reflecting surfaces such as parked vehicles, signboards, buildings, or hillsides, within a 30 meter (98.5 ft.) radius of the microphone and a 30 meter (98.5 ft.) radius of a passing automobile (see Figure 1) at the lane of traffic closest to the microphone. *Sites may be prequalified at various locations in a community.*

For those sites which do not meet the above specifications, adjustments to the measured noise level values are required. These adjustments are discussed in Section 2.3.

Within the area specified above, the traffic lane shall be a straight run. The surface of the ground in the measurement area shall be hard, dry, and free from snow, standing water, soil, or other extraneous material.

11.2.5 VEHICLE OPERATION

Vehicles are observed during normal roadway operation. When measuring the noise level of a given vehicle, other vehicles on the same roadway should be outside of the measurement area shown in Figure 1.

11.2.6 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/ microphone combination) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Locate the microphone at a distance of 15 meters (50 ft.) from the centerline of the lane of traffic. If the microphone cannot be located

15 meters (50 ft.) from the traffic lane, adjustments are then made to the sound level measurements to correct them to the standard distance. The adjustments are discussed in Section 2.3. The microphone should be oriented per manufacturer's specifications.

Set the sound level meter to "fast" response and A-weighting. Observe the meter as the vehicle passes the microphone. Note the highest observed sound level on a data sheet (Figure 2).

Measurements shall be made only when the A-weighted sound level, including noise from wind and sources other than the vehicle being measured, is at least 10 decibels lower than the sound level of the vehicle. Background ambient sound level measurements shall be made immediately before and after measurements or at regular intervals not to exceed 10 minutes.

Measurements shall not be made when it is raining or snowing, or when wind speed exceeds 20 km/hr (12 mph).

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made at regular intervals not to exceed two hours. If the calibration differs by more than one decibel, measurements taken between calibrations shall not be considered valid and the sound level meter shall be adjusted.

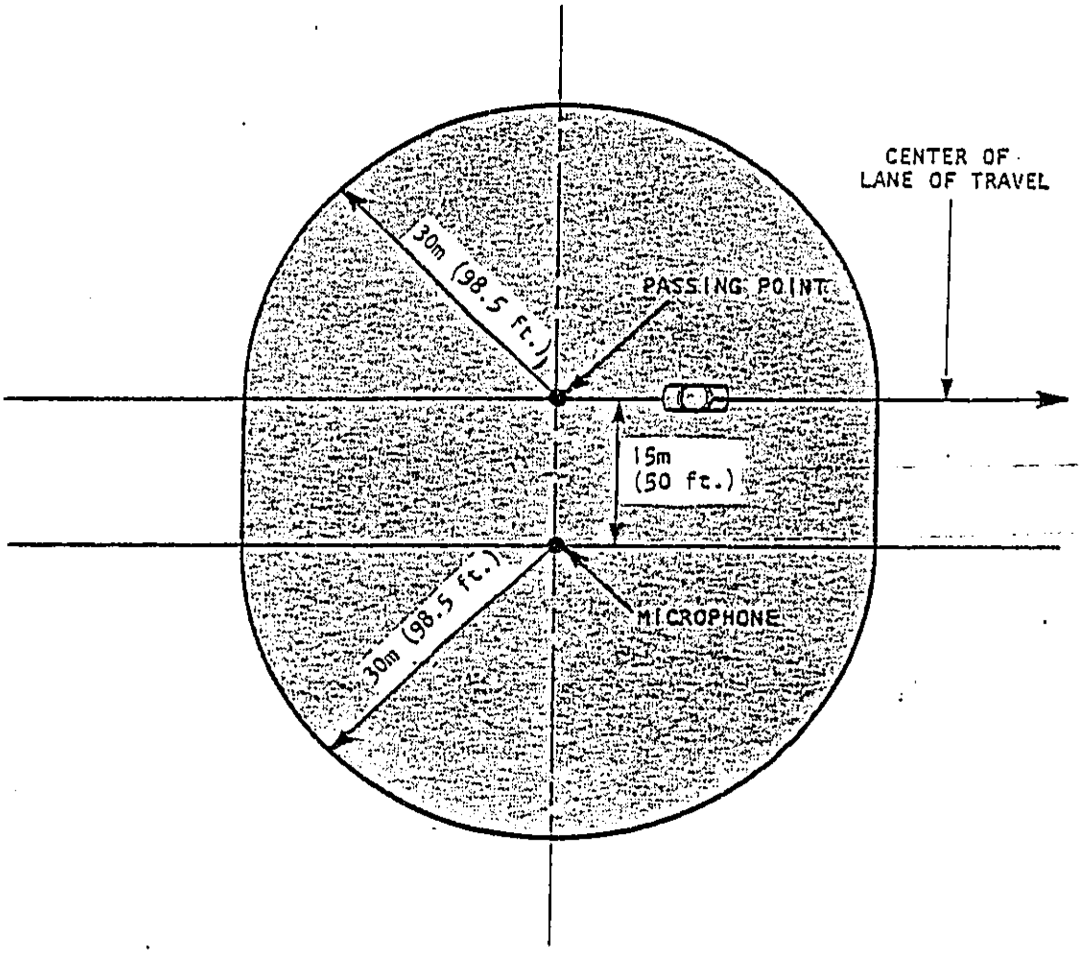

FIGURE 1. PREFERRED ROADSIDE TEST SITE

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:____________________ Date:__________ Time:__________

Vehicle:____________________ Test Type:____________________

Vehicle Make:__________, ________ Vehicle Type:________ License:________ Model:________ Year_____

Registered Owner:____________________ Address:____________________

Operator:____________________ License #:__________ Address:____________________

Sound Level Meter Manuf:__________ Calibrator Manuf:__________ Micro. Manuf:__________
Type:__________ Type:__________ Type:__________
Serial #:__________ Serial #:__________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ____________________ Wind Speed__________m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

MOTORCYCLES

11

11.0 MOTORCYCLES

11.1 INTRODUCTION

Two motorcycle noise measurement methods are presented in support of Article IX, Section 9.1 Motor Vehicles and Motorcycles on Public Rights-of-Way of the Model Community Noise Control Ordinance, a passby test procedure and a stationary procedure. A stationary motorcycle noise regulation is not provided in Article IX, Section 9.1, but an applicable enforcement method is presented here for communities desiring to adopt this type of regulation.

These methods were selected after a thorough review and analysis of current available sound level test procedures for motorcycles. Figure 11.1 presents the evaluation matrix used in selecting these methods. In addition, test methods for automobiles (Figure 5.1) were also reviewed.

Although many motorcycles come equipped with tachometers, an external tachometer may be necessary for those vehicles not so equipped. Since the number of cylinders and firing arrangements may differ from motorcycle to motorcycle, care must be taken in correctly wiring and interpreting the indications of an external tachometer. A local automotive supply house or motorcycle shop can supply guidance in purchasing an external tachometer. Due to the large variation in motorcycle engine size and operating characteristics, no one engine speed can be specified for the stationary measurement method. Fifty percent of the speed at maximum rated horsepower is suggested as the best speed to be used.

11.2 MOTORCYCLES: PASSBY MEASUREMENT PROCEDURES

11.2.1 PURPOSE

A method for obtaining sound level measurements of motorcycles operating on thoroughfares is described below. It is difficult to control site conditions which affect the accuracy of sound level measurements at a road measurement site. If the preferred measurement site cannot be attained, adjustments to sound level measurements may be necessary. These adjustments are discussed in Section 2.3.

11.2.2 INSTRUMENTATION

The instrumentation necessary for the procedures includes a Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The entire sound level measurement system shall be checked annually by its manufacturer or a certified laboratory for accuracy.

11.2.3 PERSONNEL

Persons responsible for conducting sound level measurements should be trained in the operation of sound level meters and familiar with the test procedure and corrections which may have to be applied.

11.2.4 MEASUREMENT SITE

The preferred site used for measurements shall be flat, open and free of reflecting surfaces such as parked vehicles, signboards, buildings, or hillsides, within a 30 meter (98.5 ft.) radius of the microphone and a 30 meter (98.5 ft.) radius of a passing automobile (see Figure 1) at the lane of traffic closest to the microphone. *Sites may be prequalified at various locations in a community.*

For those sites which do not meet the above specifications, adjustments to the measured noise level values are required. These adjustments are discussed in Section 2.3.

Within the area specified above, the traffic lane shall be a straight run. The surface of the ground in the measurement area shall be hard, dry, and free from snow, standing water, soil, or other extraneous material.

11.2.5 VEHICLE OPERATION

Vehicles are observed during normal roadway operation. When measuring the noise level of a given vehicle, other vehicles on the same roadway should be outside of the measurement area shown in Figure 1.

11.2.6 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/ microphone combination) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Locate the microphone at a distance of 15 meters (50 ft.) from the centerline of the lane of traffic. If the microphone cannot be located

15 meters (50 ft.) from the traffic lane, adjustments are then made to the sound level measurements to correct them to the standard distance. The adjustments are discussed in Section 2.3. The microphone should be oriented per manufacturer's specifications.

Set the sound level meter to "fast" response and A-weighting. Observe the meter as the vehicle passes the microphone. Note the highest observed sound level on a data sheet (Figure 2).

Measurements shall be made only when the A-weighted sound level, including noise from wind and sources other than the vehicle being measured, is at least 10 decibels lower than the sound level of the vehicle. Background ambient sound level measurements shall be made immediately before and after measurements or at regular intervals not to exceed 10 minutes.

Measurements shall not be made when it is raining or snowing, or when wind speed exceeds 20 km/hr (12 mph).

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made at regular intervals not to exceed two hours. If the calibration differs by more than one decibel, measurements taken between calibrations shall not be considered valid and the sound level meter shall be adjusted.

11.3 MOTORCYCLES: STATIONARY TEST

11.3.1 PURPOSE

The purpose of this motorcycle stationary noise test procedure is to provide a method which is repeatable and defensible. The stationary test can be accomplished at a preferred test site under desired operating conditions.

11.3.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachometer* accurate to ±5% at full scale; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

11.3.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

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*The tachometer is used if the motorcycle does not have its own tachometer. See Section 3.7 for discussion of tachometers.

11.3.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 7 meters (23 ft.) of the vehicle. *An empty portion of a parking lot is satisfactory.*

11.3.5 VEHICLE OPERATION

The engine shall be at normal running temperature with the transmission in neutral. If the motorcycle does not have a neutral position for the transmission, the rear wheel shall be supported on a stand allowing it to spin freely while the engine operates. The rider shall sit astride the motorcycle in normal riding position. Sound level measurements are made at an average steady-state engine speed equal to 50% of maximum rated engine speed.

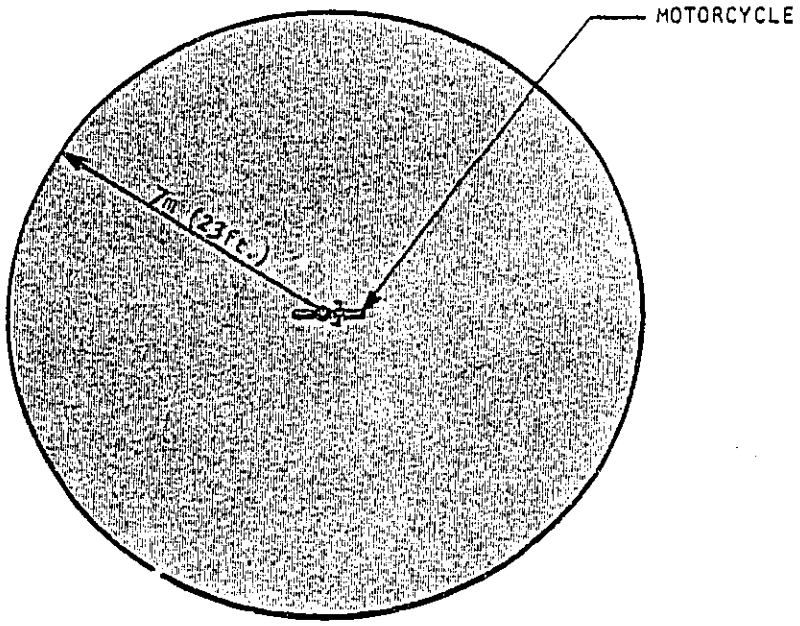
11.3.6 TEST PROCEDURE

Set the sound level meter on A-weighting, "fast" response. Place the microphone or microphone/sound level meter combination on a tripod at the same height above the ground as the motorcycle exhaust outlet. The microphone shall be positioned with its longitudinal axis parallel to the ground 500 mm (20 in.) from the edge of the exhaust outlet, and 45 ±10 degrees from the axis of the outlet (see Figure 1).

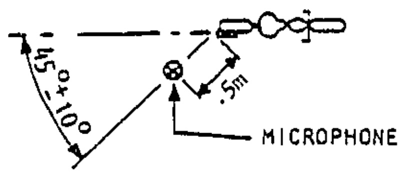
Observe the sound level meter as the motorcycle operates as described in Section 11.3.5. For vehicles with multiple exhausts, the measurements shall be repeated at each exhaust outlet and all results reported on the data sheet. The

MOTORCYCLE: STATIONARY TEST PROCEDURE

TEST SITE



MICROPHONE LOCATION



STATIONARY MOTORCYCLE TEST SITE

FIGURE 1

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:____________________ Date:__________ Time:__________

Vehicle:____________________ Test Type:____________________

Vehicle Make:__________ Vehicle Type:__________ License:__________ Model:__________ Year______

Registered Owner:____________________ Address:____________________

Operator:____________________ License #:__________ Address:____________________

Sound Level Meter Manuf:__________ Calibrator Manuf:__________ Micro. Manuf:__________
Type:__________ Type:__________ Type:__________
Serial #:__________ Serial #:__________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions __________ Wind Speed__________m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

11.4 BIBLIOGRAPHY

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POWERED MODEL VEHICLES

12

12.0 POWERED MODEL VEHICLES

12.1 INTRODUCTION

Model airplanes, boats or cars, powered by small one-cylinder "glow plug" gasoline engines are often annoying community noise sources. Article VI, Section 6.2.11 of the Model Community Noise Control Ordinance considers the noise from powered model vehicles as a prohibited act.

Discussions with numerous local enforcement officials indicated that, in the few cases where citations were issued, the citations were based on noise measurements made at the nearest residential property or noise sensitive land use. No standard measurement procedures were reported by these officials.

Most models are very small noise sources and can be measured in a stationary mode at one meter from the test model. This measurement procedure allows the test to be performed at or near recreational areas where the models can be tested with minimum noise interference from other nearby noise sources. The data obtained from this test method can be used to extrapolate the noise from the model (in flight, for example) to noise sensitive land uses or the recreational area boundaries.

12.2 POWERED MODEL VEHICLES

12.2.1 PURPOSE

This test procedure provides for a method of measuring the noise of powered model vehicles whose engines typically operate continuously at full throttle. A stationary full throttle test procedure is described.

12.2.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accuracte to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by the manufacturer or a certified laboratory to verify its accuracy.

12.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure. An individual is required to hold the vehicle if it cannot be secured to a test stand.

12.2.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 5 meters (15 ft.) of the model. An empty portion of a parking lot may be satisfactory.

12.2.5 POWERED MODEL VEHICLE OPERATION

The vehicle shall be stationary and secured to a test stand or held so that the model is at the same height as the microphone. A test stand might be constructed by securing a platform of quarter-inch plywood, .5 meter (20 in.) square, on a photography tripod. If held, every effort shall be made to minimize the effect of the holder on the measurements. The holder shall not be in the direct line passing through the microphone and model. The engine shall be run at maximum speed.

12.2.6 MEASUREMENT PROCEDURE

Set the sound level meter/microphone on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.). The microphone shall be located 1 meter (3.3 ft.) ±8 cm (±3 in.) from the model. Set the sound level meter on "fast" response and A-weighting. Observe the sound level meter for 30 seconds while the model operates at full throttle. Note the maximum sound level observed.

Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the model under test, are at least 10 decibels lower than the noise from the model under test. Observe the background ambient sound level before and after each test.

Note model description, noise measurement results, and other pertinent data on a data sheet. (Figure 2 contains a suggested format.)

Measurements shall not be made when the wind speed exceeds 19 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the sound level meter is adjusted.

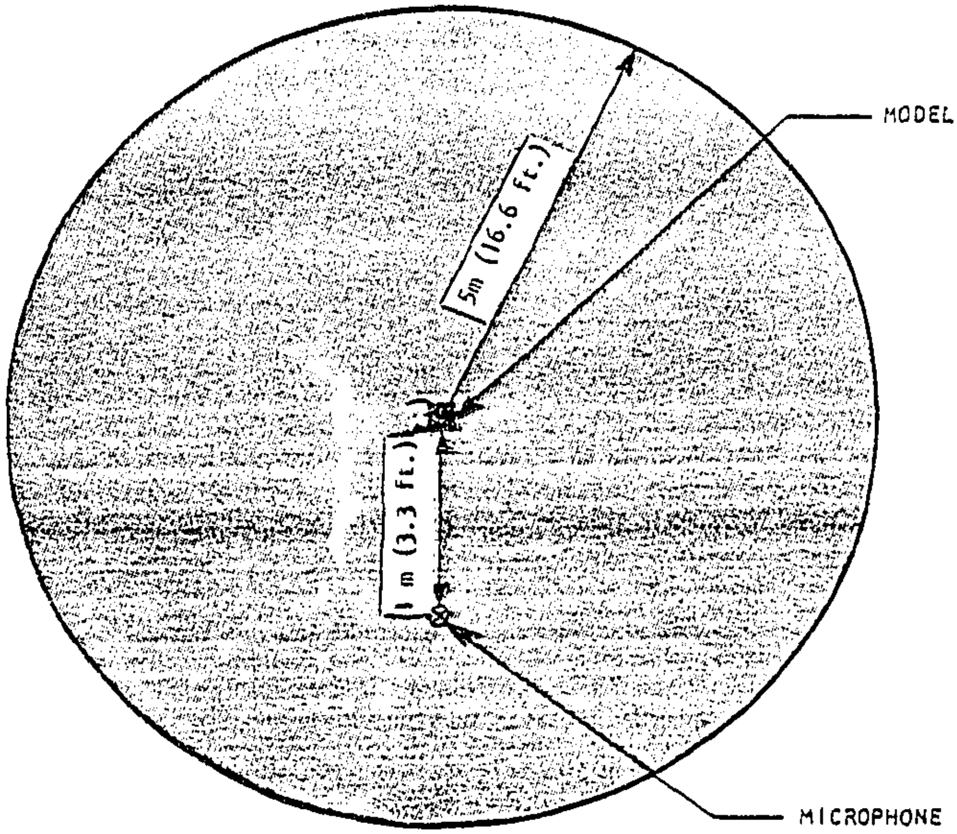

FIGURE 1. TEST SITE FOR POWERED MODEL VEHICLE NOISE MEASUREMENTS

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:______________________________ Date:__________ Time:________

Vehicle:______________________________ Test Type:______________________

Owner:__________________________ Address:__________________________

Sound Level Meter Manuf:____________ Calibrator Manuf:____________ Micro. Manuf:__________
Type:____________ Type:____________ Type:__________
Serial #:____________ Serial #:____________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ______________ Wind Speed __________m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

12.3 BIBLIOGRAPHY

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Council of Governments: Metropolitan Washington, D. C. "Areawide Noise Measurement Procedures Manual."

RECREATION VEHICLES

13

13.0 RECREATIONAL VEHICLES

13.1 INTRODUCTION

Recreational vehicles (off-road motorbikes, go carts, snowmobiles, dune buggies, and others) are often powered by small, air cooled 2 or 4 stroke engines. Because of space, weight and power limitations, the mufflers used on these vehicles are often very simple, no more than spark arrestors. Since the vehicles are not registered for street use, they are often modified or improperly maintained. The Model Community Noise Control Ordinance considers the noise from these vehicles in Article IX, Section 9.2.

Numerous noise measurement procedures were reviewed and evaluated, Figure 13.1. Some of these test procedures incorporate an acceleration test. These tests are complex, require a large test space and can be dangerous to the vehicle and its operator. Since exhaust noise is the dominant vehicle noise, a stationary procedure, requiring measurements at .5 meter (20 in.) from the vehicle's exhaust outlet, is provided. The stationary measurement method provides repeatable and defensible results. It allows the test to be performed at a preferred test site under desired operating conditions.

VEHICLE: RECREATIONAL VEHICLES

MEASUREMENT METHOD	TEST TYPE	Sound Level Meter	Microphone	EQUIPMENT Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions	Meteorological Criteria/ Corrections
Pennsylvania-Dept. of Envir. Control Snowmobiles	TEST SITE	Per SAE J1161						
S.A.E. J1161-Operational sound level meas. proc. Snowmobiles	TEST SITE	Precision Type I ANSI		Accoustic Calib. ±0.5dB Field calibration end-to-end	Windscreen	Mag. Tape Recorder-Opt. Calib. Tan. Speed Indicating System Thermometer, Barometer, Psychrometer, Anemometer, windvane.	Level open-free of large reflecting surfaces	Vehicle path covered max. 3" loose snow over base of firm 2" snow Record atmospher temp. pressure, humidity, wind speed & directic at least every hour. Wind speed < 12 mph-Bar. pre sure 93-103 k Pa
Grand Rapids, Mich. new vehicle test	STATIONARY	Type 2 SLM ANSI S1.4-1971		Calibrated at 1000 Hz at start and end of each test series. Annual calibration of calibrator.	Windscreen with less than ±.5 dB effect on system sensitivity	Anemometer with ±10% accuracy. Tachometer ±2% accuracy. Data sheets.		Wind velocity <12 mph No rain or snow
Illinois-E.P.A.-New vehicle	TEST SITE	Per SAE J1161						
Minneapolis, Minn.	IN-SITU	Any sound level meter No standard	Any microphone No standard	-	Windscreen "when appropriate"		Concrete or asphalt roadway surface; dry and free of bumps or cracks.	
Chicago, Illinois-New vehicle noise meas.	TEST SITE	As per SAE J184 specifications	As per SAE J184 specifications	external end-to-end field calib. before & after each test & every ½ hr. in use			Level open-End pt. 50' beyond microphone pt. Vegetation < 3" tall Bystanders 50' away	Wind speed < 12 mph
Oregon-Dept. of Environmental Quality - Snowmobiles-New	TEST SITE	Type II Minimum ANSI S1.4-1971		Lab. calibration annually	Windscreen optional Recorder	Sling psychrometer; wind gauge; Data form	100' vehicle path 100' radius, clear.	Wind velocity <10 mph

SITE	INSTALLATION				VEHICLE OPERATION			
Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary Engine Operation	Passby/ Operation	Auxiliary Equipment Operation	Personnel Required	Sound Quantity Measured
At least 100' from test path	At least 10dB lower than vehicle test	50' from centerline of vehicle path 4' above surface			Constant speed- 15±2 mph ± 3' variance from centerline		not more than 2 persons. 50' of vehicle path Tech. trained & experienced in tests.	A-wt. slow response- Record highest meter reading of run.
No reflecting surfaces. 50' in front and behind microphone point, 35' "above" and "below" microphone	At least 8 dB below vehicle noise chart for correction	35' from vehicle path centerline	4.5' above ground level = 3.5' to 6' above road surface, oriented as per instructions	Max governed speed with wide open throttle, clutch engaged, gear in neutral		No aux. equipment operating. Disengage fan if possible	Driver, no more than two technicians	Max. A-wt level average of two readings
	Ambient + vehicle = ambient + 3 dB	Noise level criteria given at 20', 25' and 50'			Different limits for >35 mph and <35 mph			
No reflecting surfaces. 100'	10 dB below vehicle sound level	50' ±1' from centerline of vehicle travel	Microphone on 60' ext. cable on tripod. 4' ±1' above surface.		Full throttle acceleration from standing start. Maintain full throttle thru end pt.		Trained and qualified in sound meas. techniques & equip.	A-wt. fast-highest response sound reading during run
		50' ±1' from centerline of lane of travel	Microphone or SLM on tripod aimed at microphone point. 4' ±1' above roadway surface		Standing start-trans. low gear wide open throttle to max. rpm thru max. rpm zone to end pt.		Technician and driver. No bystander within 50' of microphone or vehicle.	A-wt L_p fast response

MEASUREMENT

Figure 13.1 Recreational Vehicle Noise Measurements

Sound Quantity Reported	Measurement Statistical Measurements	Other Data Reported	References	Other Comments
	Repeat test runs until 3 readings within 2dB per side. Average each side-Report highest side		2dB tolerance over sound limit allowed.	
	Measure on both sides of vehicles with multiple exhaust until 2 max. measurements within 2 dB are achieved			
	At least 4 readings on each side of vehicle Average each side & report loudest side as final reading			
Average of two highest readings within 2 dB of each other on each side	4 runs/side of vehicles			2 dB grace for variation in equipment and test site. Optional deceleration noise

13.2 RECREATION VEHICLES

13.2.1 PURPOSE

Recreation vehicles is a general term, used in this context to describe off the road, unlicensed vehicles. Included in this category are go carts, minibikes, motocross motorcycles, snowmobiles, and dune buggies. The described measurement procedure is applicable to all these vehicles.* Snowmobiles may be tested on snow or grass, while the other vehicles shall be tested on a dry, sealed concrete or asphalt surface.

13.2.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachomter** accurate to ±5% of full scale deflection; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

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*In some cases, the vehicle might be licensed for use on public roads. In these cases, procedures for motorcycles and automobiles are applicable.

**Used if the vehicle does not have its own tachometer. See Section 3.7 for a discussion of tachometers.

13.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

13.2.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 7 meters (23 ft.) of the vehicle. *An empty portion of a parking lot may be satisfactory.* Snowmobiles shall be tested on grass or snow. *In this case, an empty field is acceptable.*

13.2.5 VEHICLE OPERATION

The engine shall be at normal running temperature with the transmission in neutral or park. Those vehicles which do not have a neutral gear (e.g., snowmobiles) shall be placed on a stand so that the treads clear the ground and can rotate freely. Sound level measurements are made at an average steady-state engine speed* equal to the governed engine speed, 50% of rpm at rated horsepower, or if the figures are not available, 3500 rpm for engines less than 950 cc displacement and 2800 rpm for engines greater than 950 cc displacement.

13.2.6 MEASUREMENT PROCEDURE

Set the sound level meter on A-weighting, "fast" response. Place the microphone on a tripod at the same height

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*Note: *Different off road vehicles have different engine firing arrangements. If an external tachometer is used to monitor engine speed, care should be taken to ensure that the tachometer is read correctly.*

above the ground as the vehicle's exhaust (see Figure 1). The microphone shall be positioned with its longitudinal axis parallel to the ground 500 mm (20 in.) from the edge of the exhaust outlet and 45 ±10 degrees from the axis of the outlet. If the exhaust outlet is located 300 mm (12 in.) or more inboard from the vehicle body, the microphone shall be located 200 mm (8 in.) from the vehicle body at the specified angle. Observe the sound level meter while the vehicle is operated as described in Section 13.2.5. Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the vehicle under test, are at least 10 decibels lower than the noise from the vehicle under test. Observe the background ambient sound level before and after each test.

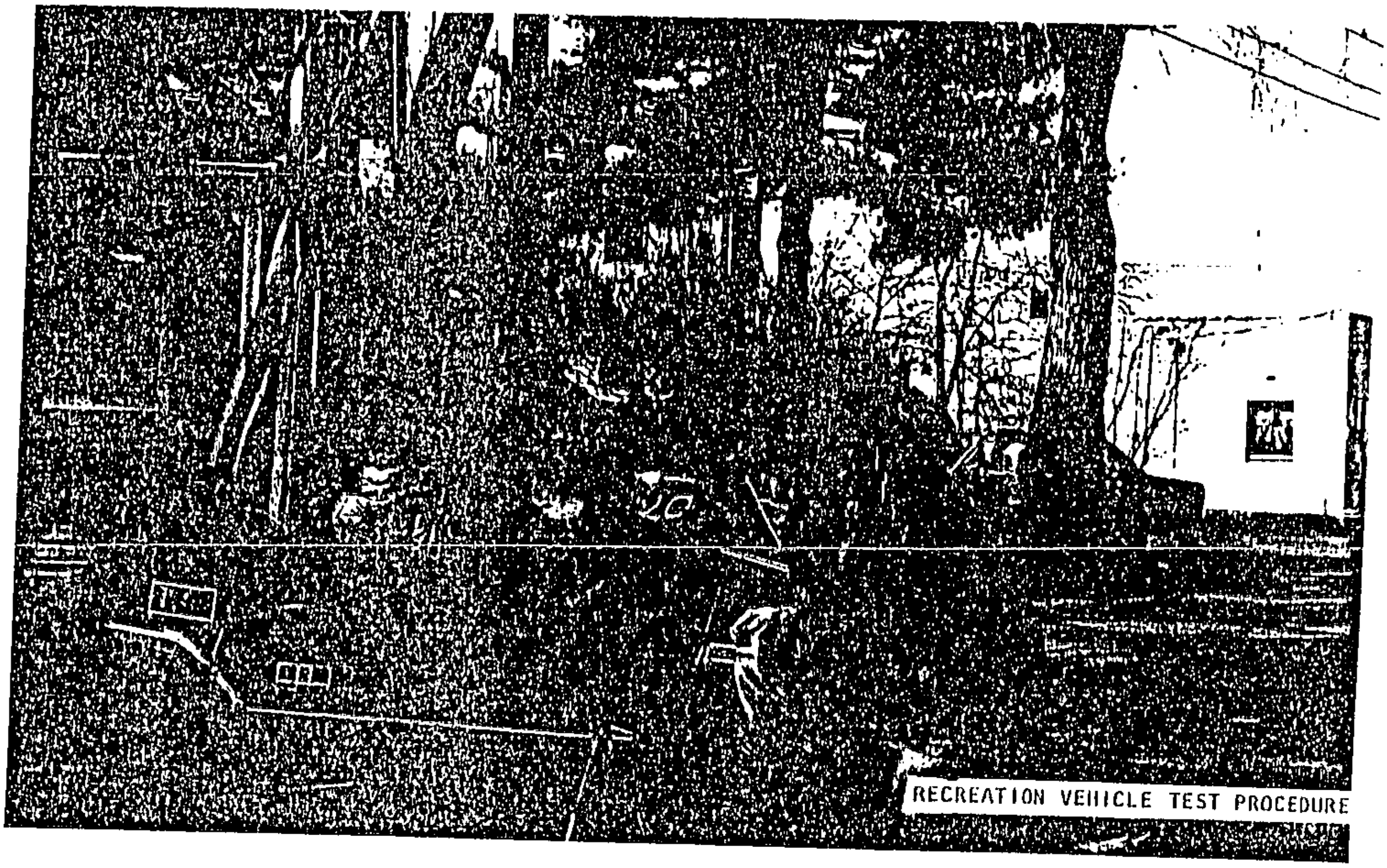
Note vehicle model, noise measurement results, and other pertinent data on a data sheet. (Figure 2 contains a suggested format.)

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

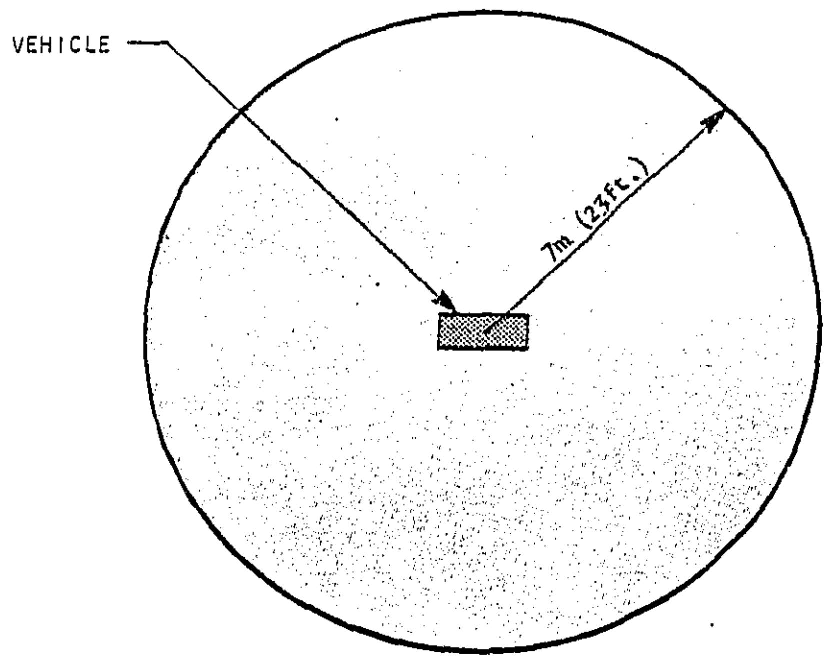
Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the sound level meter is adjusted.

The following photograph shows a noise measurement of a snowmobile being made.


RECREATION VEHICLE TEST PROCEDURE

TEST SITE



TYPICAL MEASUREMENT LOCATIONS

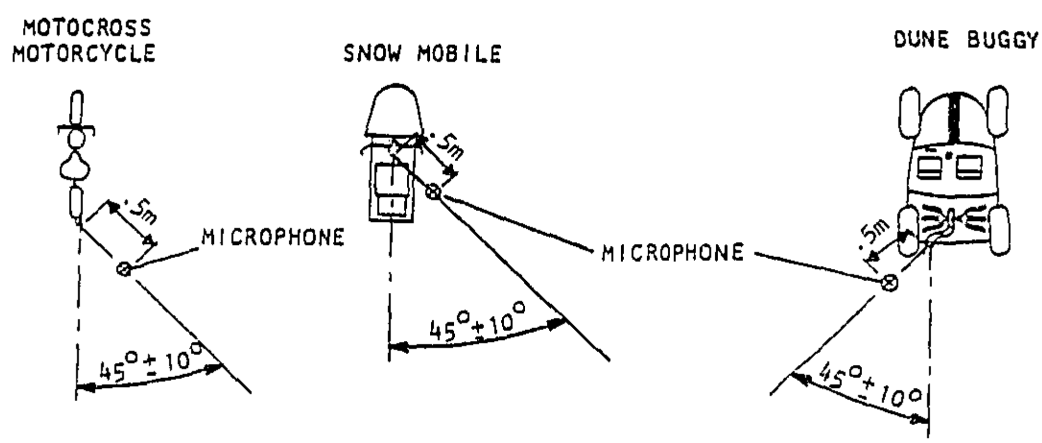


Figure 1. Recreation Vehicle Test Site

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner:______________________________ Date:__________ Time:__________

Vehicle:______________________________ Test Type:______________________________

Vehicle Make:______________ Vehicle Type:__________ License:__________ Model:__________ Year_____

Registered Owner:______________________________ Address:______________________________

Operator:______________________ License #:__________ Address:______________________________

Sound Level Meter Manuf:______________ Calibrator Manuf:______________ Micro. Manuf:__________
Type:______________ Type:______________ Type:__________
Serial #:______________ Serial #:______________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest _____dB Posttest _____dB

Test Conditions General Weather Conditions ______________ Wind Speed __________m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

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REFUSE COLLECTION VEHICLES

14

14.0 REFUSE COLLECTION VEHICLES

14.1 INTRODUCTION

Article IX, Section 9.1.3 of the Model Community Noise Control Ordinance establishes noise emission guidelines for refuse collection vehicles. These vehicles are heavy trucks with a trash compacting mechanism mounted to the frame. The noise from the compactor is measured in a manner similar to the noise from construction equipment such as air compressors. The proposed procedure requires noise measurements to be made at four locations at right angles to each other around the vehicle, while the vehicle is stationary during a normal compaction cycle. In this way, all the significant noise producing components of the vehicles are considered. Since it would be difficult to standardize the amount of refuse to use during the test, the noise measurements are made with the compactor empty.

A simplified in situ test procedure requiring a single measurement at 7 meters at the side of the vehicle midway between the cab and compactor can be used for screening purposes.

14.2 REFUSE COLLECTION VEHICLES

14.2.1 PURPOSE

Since refuse collection vehicles are basically trucks, truck noise level measurement procedures apply when these vehicles are traveling. The compactor is a significant noise source on these vehicles. Therefore, a separate stationary noise test procedure for compacting operations is described.

14.2.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer are required. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The entire sound level measurement system shall be checked annually by the manufacturer or a certified laboratory to verify its accuracy.

14.2.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

14.2.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 15 meters (50 ft.) of the four microphone locations. *An empty portion of a parking lot may be satisfactory.*

14.2.5 REFUSE COLLECTION VEHICLE OPERATION

With the vehicle stationary at the test site, cycle the compactor through normal modes of operation. The compactor shall be empty for the test.

14.2.6 MEASUREMENT PROCEDURE

Place the sound level meter/microphone on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.). The microphone shall be located 7 meters (23 ft.) ±15 cm (±6 in.) from the side of the vehicle (see Figure 1). Set the sound level meter to "fast" response, and A-weighting. Observe the sound level meter for a complete compacting cycle with the compactor empty. The maximum sound level observed during the compacting cycle shall be noted on a data sheet. (Figure 2 contains a suggested format.)

Measurements are repeated for each of the four sides of the vehicle. All four sound levels recorded are reported.

Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the vehicle under test, are at least 10 decibels

lower than the noise from the compactor under test.
the background ambient sound level before and after e.

Note compactor model, operating data and noise m- surement results on a data sheet (Figure 2).

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the sound level meter is adjusted.

The following photograph shows the measurement procedure for a refuse collection vehicle.

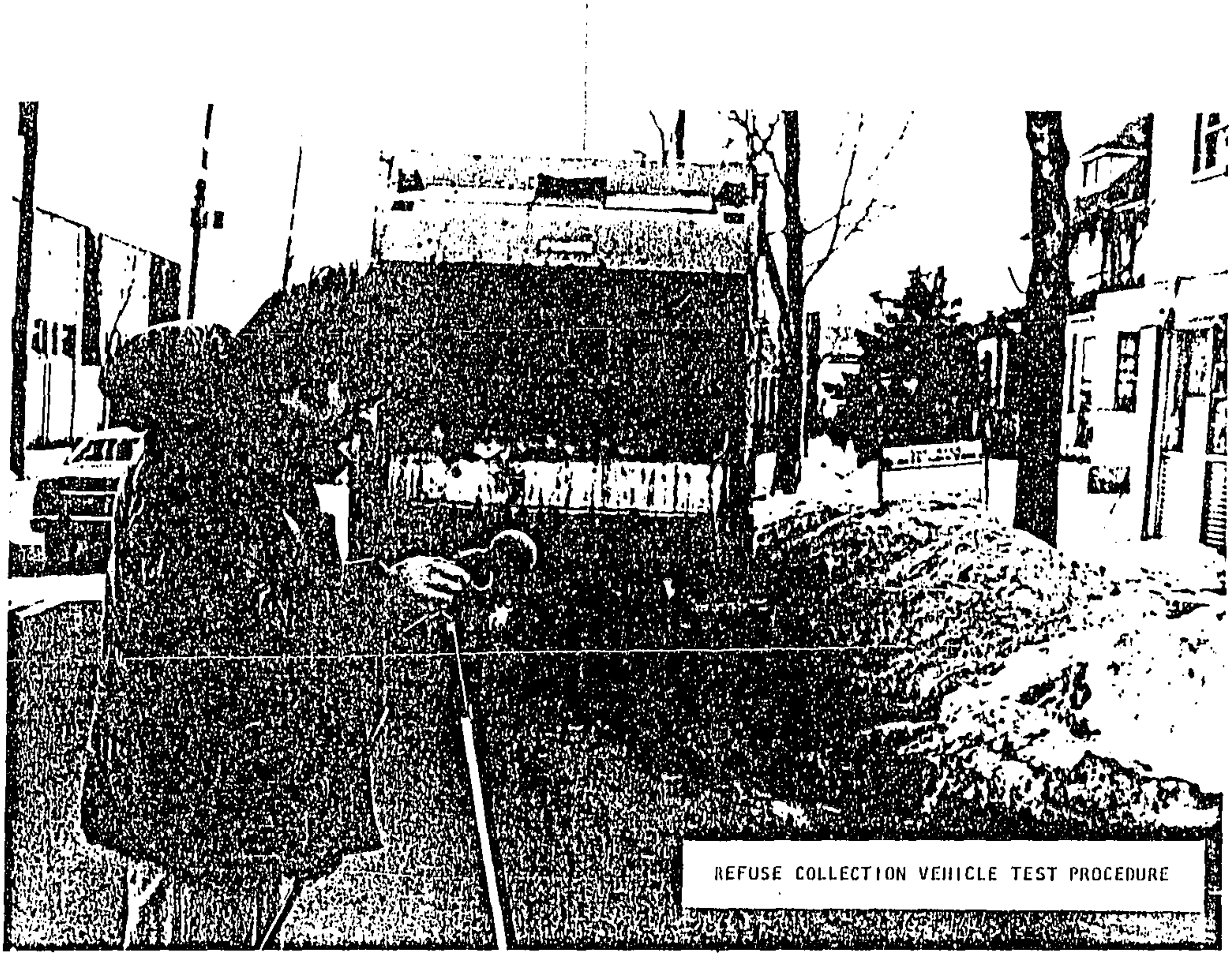
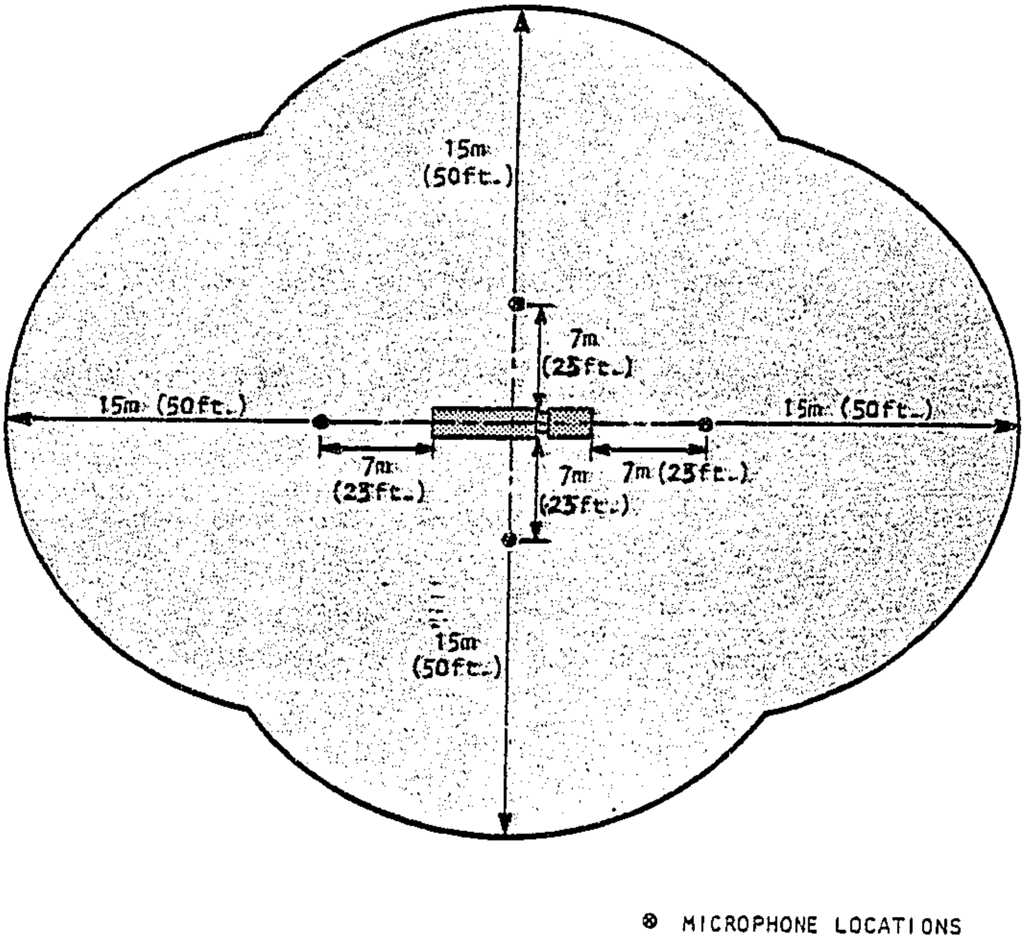


Figure 1. Refuse Collection Vehicle Test Procedure



TEST SITE REFUSE VEHICLE MEASUREMENT PROCEDURE

FIGURE 1

Figure 2: Example: Vehicle Noise Measurement Report Form

Examiner: ____________________ Date: __________ Time: __________

Vehicle: ____________________ Test Type: ____________________

Vehicle Make: __________ Vehicle Type: __________ License: __________ Model: __________ Year ______

Registered Owner: ____________________ Address: ____________________

Sound Level Meter Manuf: __________ Calibrator Manuf: __________ Micro. Manuf: __________
Type: __________ Type: __________ Type: __________
Serial #: __________ Serial #: __________ Serial #: __________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions __________ Wind Speed __________ m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

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TRUCKS 15

15.0 TRUCKS

15.1 INTRODUCTION

Two truck noise measurement methods are presented in support of Article IX, Section 9.1 Motor Vehicles and Motorcycles on Public Rights-of-Way of the Model Community Noise Control Ordinance. A stationary truck noise regulation is not provided in Article IX, Section 9.1, but an applicable enforcement method is presented here for communities desiring to adopt this type of regulation.

The two noise measurement methods presented here were selected after a thorough review and analysis of current available sound level test procedures for trucks. Figure 15.1 presents the evaluation matrix used in selecting these methods. In addition, the methods for automobiles (Figure 5.1) were also reviewed.

The passby and stationary noise test methods for trucks are similar to those for automobiles and buses. The height of the microphone and distance from the vehicle required for the stationary test is consistent with the position required by federal Department of Transportation procedures.

VEHICLE: HEAVY TRUCKS

EQUIPMENT

MEASUREMENT METHOD		Sound Level Meter	Microphone	Calibrator/ Calibration Procedure	Other Acoustical Equipment	Other Equipment	Special Test or In-Situ Site/Description Restrictions
Florida - Highway Vehicle Test Procedure	IN-SITU	Type 1,2, or S2A meeting applicable ANSI specifications		End-to-end with a minimum of every 2 hours Annual lab. Calibration	Windscreen (opt.)		a) Standard Site - no reflecting surface within 100' of microphone or microphone point. b) Restricted Site
Florida - New Vehicle Test Procedure	TEST SITE	Precision SLM as per ANSI specifications		Calibration before and after each use or every 2 hours as a minimum if instrument is used < 2 hours	Windscreen	Tachometer Anemometer	Flat Response. No reflecting surface within 100' of a) microphone, b) point 50' before microphone point, c) point 50' beyond microphone point. Ground Surface. Smooth asphalt or concrete in Δ area between microphone and two 50' points.
Metropolitan Washington	IN-SITU	Type 1 SLM ANSI S1.4-1971		Before and after each test	Windscreen	Tachometer Anemometer	Flat open space free of large reflecting surfaces from vehicle or microphone. Surface of ground free from snow, grass, loose soil or ashes.
Metropolitan Washington	STATIONARY	Type 1 SLM ANSI S1.4-1971		Before and after each test	Windscreen	Tachometer Anemometer	Flat open space free of large reflecting surfaces from vehicle or microphone. Surface of ground free from snow, grass, loose soil or ashes.
Chicago, Ill. - New Motor Vehicle Noise Measurements	TEST SITE	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour intervals			Normal concrete or asphalt; no reflective surfaces within 100' of microphone or 100' of centerline of vehicle path from throttle open to throttle closed point. Ground clear of standing water.
Chicago, Ill. - Motor Vehicle Operation Noise Measurement	IN-SITU	As per SAE J184 specifications	As per SAE J184 specifications	As per SAE J184 specifications. End to end and 1 hour intervals			Preferred location 100' clear area around microphone and microphone point. Surface of ground normal, highway without water.
Barrington, Ill. - Vehicle Noise Enforcement Procedure	IN-SITU	As per SAE	As per SAE	Before and after each test or every 2 hours as minimum	As per SAE		Highway - a) Standard sites: No reflecting surfaces within 100' radius of microphone and microphone point. b) Restricted sites: reflecting surfaces within 100'. All sites: concrete or asphalt; no tunnels or overpasses; no reflecting surfaces within 10'.
Minneapolis, Minn. - Measurement Procedure	IN-SITU	Any sound level meter No standard	Any microphone No standard		Windscreen "when appropriate"		Concrete or asphalt roadway surface: dry and free of bumps or cracks.
SAE J1096 - Meas. of Ext. Sound Levels for Heavy Trucks - Stationary	STATIONARY	Type 1 ANSI	SAE J184	Sound level calibrator ±0.5 dB "end-to-end"	Mag. Tape Recorder (opt.)	Windscreen opt. Engine Speed Tach.	Flat, open-free of reflecting surfaces for 100' - hard, non-porous surface
Grand Rapids, Mich. - Stationary Motor Vehicle Test	STATIONARY	Type 2 SLM ANSI S1.4-1971		Calibrated at 1000 Hz at start and end of each test series. Annual calibration of calibrator.	Windscreen with less than ±.5 dB affect on system sensitivity	Anemometer with ±10% accuracy. Tachometer ±2% accuracy. Data sheets.	Surface - dry, hard concrete level
Oregon - Dept. of Environmental Quality New Vehicle Test	TEST SITE			Calibration each time used. Yearly lab. calibration	Windscreen used	Standard form	Free of sound reflecting objects within 50' of microphone and 50' of vehicle.
Hawaii - Vehicle Noise Control Noise Level Measurement	IN-SITU	No specification	No specification	Calibrator meeting ANSI S1.4-1971	Windscreen "when appropriate"		Dry roadway. Concrete or asphalt, no loose material.

	SITE		INSTALLATION				VEHICLE OPERATION		
Meteorological Criteria/ Corrections	Reflecting Surfaces/ Criteria/ Corrections	Background Ambient Noise Criteria Corrections	Microphone Source Distance/ Correction	Microphone Orientation/ Movement	Stationary Engine Operation	Passby/ Operation	Auxiliary Equipment Operation	Personnel Required
Wind velocity must be < 12 mph	Nomograph for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point.	Ambient must be 10 dB below vehicle L_p	50' May be 26' to 118'. Corrections to 50' included	2'-6' above roadway surface; 3½' above surface on which microphone stands		Normal highway operation		Driver, technician. Tech. trained and certified by highway patrol.
Wind velocity < 12 mph		Ambient noise must be 10 dB lower than vehicle noise	50' ±1' from centerline of vehicle path	4' ±1'' above the roadway		Highest gear so that vehicle begins at < 2/3 max. rpm and ends at less than max. rpm and <35 mph, full throttle	With and without equipment	
Wind velocity < 10 mph		At least 10 dB lower than vehicle noise	50' (15 m) from centerline of lane of travel	4' above ground plane		30 mph at 25' from microphone point. Use lowest gear so that 25' past microphone point engine is at max. rated rpm.	Normal engine temp. Allow 1 min. cooling between runs	Observer and driver, allow one additional person within 50' of vehicle or microphone
Wind velocity < 10 mph		At least 10 dB lower than vehicle noise	50' (15 m) from centerline of lane of travel	4' above ground plane		30 mph at 25' from microphone point. Use lowest gear so that 25' past microphone point engine is at max. rated rpm.	Normal engine temp. Allow 1 min. cooling between runs	Observer and driver, allows one additional person within 50' of vehicle or microphone
Wind speed < 12 mph	No reflecting surfaces. 100'	10 dB below vehicle sound level	50' ±1' from centerline of vehicle travel	Microphone on 60' ext. cable on tripod. 4' ±½' above surface.		Auto. trans. (1st gear) Standard trans. (2nd gear), wide open throttle, 50' before microphone point.		Driver, technician, no closer than 50' from microphone or vehicle
	Correction table for large reflecting surface at least 20' x 20'	10 dB below vehicle sound level	50' from centerline of traffic	On tripod on ext. cable 50' from center of traffic lane, 4 ±½' above surface				Technician, no one within 50' to rear or side of microphone
Wind velocity <12 mph	Nomograph for corrections for parallel reflecting surfaces. Non-parallel surfaces must be 100' from microphone and passby point.	Ambient at least 10 dB lower than vehicle noise	50' Corrections for from 26' to 118'	2'-6' above roadway surface; 3.5' above microphone surface				Driver and technician, no other people within 50'
		Ambient + vehicle = ambient + 3 dB	Noise level criteria given at 20', 25' and 50'			Different limits for >35 mph and <35 mph		
Wind velocity ≤ 12 mph		Bystanders at least 50' behind reader. At least 10 dB lower than test vehicle	50' from centerline of vehicle 4' above ground perpendicular to centerline to rear of cab		Maximum engine acceleration and deceleration no ext. load. Normal engine temp. - Trans. neutral, full throttle to idle			Technician trained and experienced in the type of equipment test
No precipitation No wind > 12 mph		Free of reflecting surfaces	Record ambient noise and correct later - must be 8 dB below reading	≤4' above ground toward vehicle as per manufacturer	Trans. neutral accelerator from idle to max. governed speed - open throttle.		Turn off all auxiliary equipment	Not more than _ persons
Wind <10 mph Rain cannot be falling. Ground can be wet.			25' ±6'' from rear or either side of vehicle	Position is at max. L_p. 4.5' above the ground or orientation as per specs.	Open throttle to reach max. recom. rpm or max. governed rpm			
		Ambient cannot be greater than vehicle alone	20'-50'. Use spherical spreading law to normalize to code distance					

Figure 15.1

Heavy Truck Noise Measurement

MEASUREMENT

Sound Quantity Measured	Sound Quantity Reported	Measurement Statistical Measurements	Other Data Reported	References	Other Comments
A-wt L_p as vehicle passes	Highest L_p as vehicle passes		California Highway Patrol "Sound Measurement Procedures" HPM 83.3		
A-wt L_p fast response maximum as vehicle passes	Average of two highest readings within 2 dB of each other on each side	4 runs/side of vehicles		California Vehicle Sound Measurement Procedure	Deceleration test when warranted
Fast response A-wt. network Max. level noted	Average of two highest on each side (within 2 dB). Lowest of two averages is reported.	4 runs/side of vehicle or for side producing obviously higher levels			2 dB grace
Fast response A-wt. network Max. level noted	Average of two highest on each side (within 2 dB). Lowest of two averages is reported.	4 runs/side of vehicle or for side producing obviously higher levels			2 dB grace
A-wt fast response, max. level noted	Highest of two sides	4 runs/side. Average of 2 highest (within 2 dB) for each side		SAE Procedures	
A-wt fast response, max. level					Reflection correction factor is simpler to use yet most comprehensive. 1 dB grace given.
	Maximum A-wt level				
A-wt. fast response. Record highest reading. Average highest 2 readings each side	Report highest side average				
A-wt. fast response. Record max. reading of meter. Average highest two readings on each side	Measure readings on each exhaust outlet. Report highest side average				
Highest sound level A-wt fast response	Highest sound level which is no more than 1 dB above next highest level				
A-wt fast response, max. level					

15.2 TRUCK PASSBY: MEASUREMENT PROCEDURES

15.2.1 PURPOSE

A method for obtaining sound level measurements of trucks operating on thoroughfares is described below. It is difficult to control site conditions which affect the accuracy of sound level measurements at a road measurement site. If the preferred site cannot be established, adjustments to sound level measurements may be necessary. These adjustments are discussed in Section 2.3.

15.2.2 INSTRUMENTATION

The instrumentation necessary for the procedures includes a Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; and a windscreen recommended by the microphone manufacturer. The windscreen shall be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

15.2.3 PERSONNEL

Persons responsible for conducting sound level measurement procedures should be trained in the operation of sound level meters and familiar with the test procedure and corrections which may have to be applied.

15.2.4 MEASUREMENT SITE

The preferred site used for measurements shall be flat, open and free of reflecting surfaces such as parked vehicles, signboards, buildings, or hillsides, within a 30 meter (98.5 ft.) radius of the microphone and a 30 meter (98.5 ft.) radius of a passing truck (Figure 1) at the lane of traffic closest to the microphone. *Sites may be prequalified at various locations in the community.*

For those sites which do not meet the above specifications, adjustments to the measured noise level values are required. These adjustments are discussed in Section 2.3.

Within the area specified above, the highway shall be straight. The surface of the ground in the measurement area shall be hard, dry, and free from snow, standing water, soil, or other extraneous material.

15.2.5 VEHICLE OPERATION

Vehicles are observed during normal roadway operation. When measuring the noise level of a given vehicle, other vehicles on the same roadway shall be outside of the measurement area shown in Figure 1.

15.2.6 MEASUREMENT PROCEDURE

Mount the microphone (or sound level meter/ microphone combination) on a tripod at a height of 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground. Locate the microphone

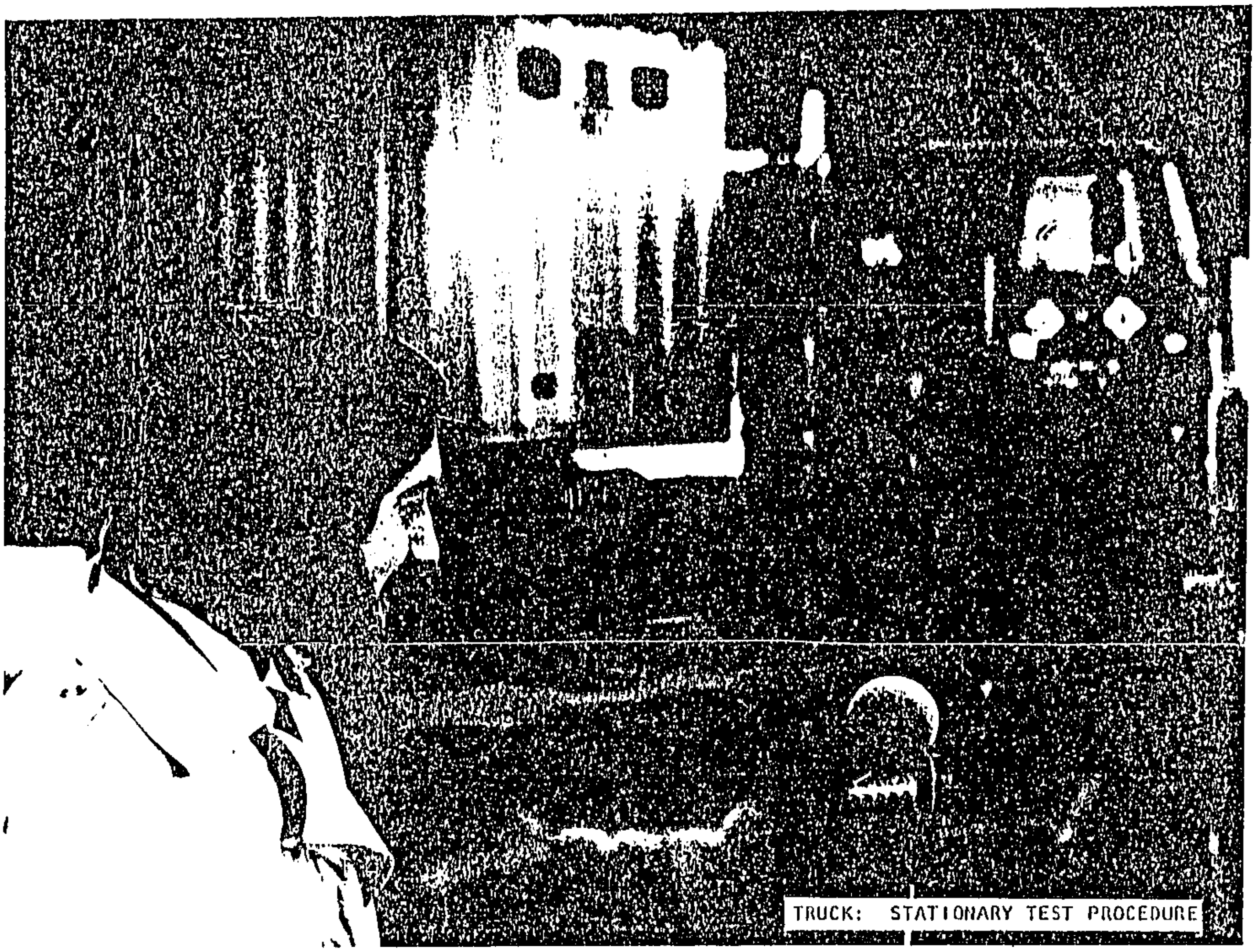

Figure 1. Truck: Stationary Test Procedure

at a distance of 15 meters (50 ft.) from the centerline of the lane of traffic. If the microphone cannot be located 15 meters (50 ft.) from the traffic lane, adjustments are then made to the sound level measurements to correct them to the standard distance. The adjustments are discussed in Section 2.3. The microphone shall be oriented per manufacturers' specifications.

Set the sound level meter to "fast" response and A-weighting. Observe the meter as the vehicle passes the microphone. Note the highest observed sound level on a data sheet (Figure 2).

Measurements shall be made only when the A-weighted sound level, including noise from wind and sources other than the vehicle being measured, is at least 10 decibels lower than the sound level of the vehicle. Background ambient sound measurements shall be made immediately before and after measurements or at regular intervals not to exceed 10 minutes.

Measurements shall not be made when it is raining or snowing, or when wind speed exceeds 20 km/hr (12 mph).

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturers deem unacceptable.

An external calibration of the sound level meter shall be made at regular intervals not to exceed 2 hours. If the calibration differs by more than 1 decibel, measurements taken between calibrations shall not be considered valid and the sound level meter shall be adjusted.

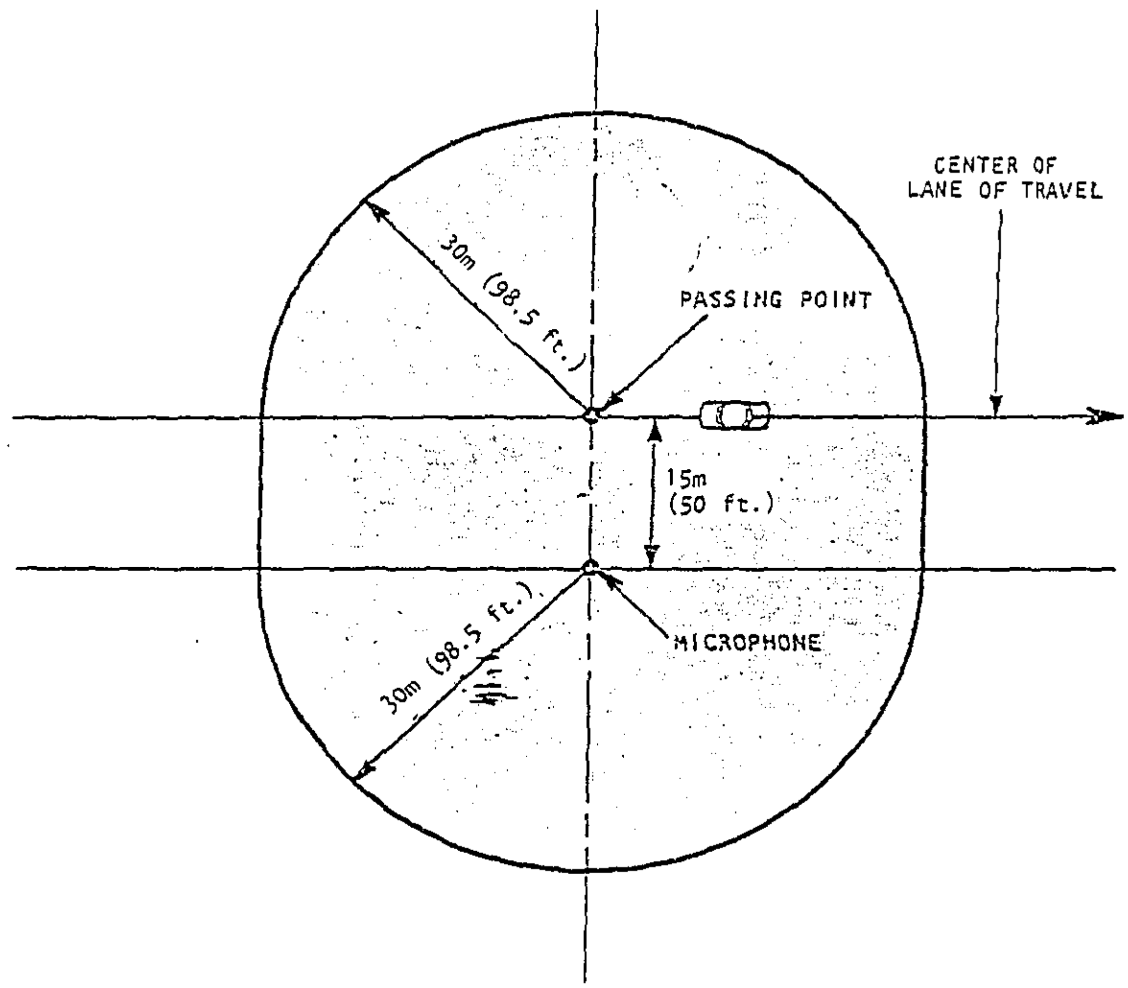

FIGURE 1. PREFERRED ROADSIDE TEST SITE

FIGURE 2. EXAMPLE: VEHICLE NOISE MEASUREMENT REPORT FORM

Examiner: ______________________ Date: __________ Time: __________

Vehicle: ______________________ Test Type: ______________________

Vehicle Make: __________ Vehicle Type: __________ License: __________ Model: __________ Year ______

Registered Owner: ______________________ Address: ______________________

Operator: ______________ License #: __________ Address: ______________

Sound Level Meter Manuf: __________ Calibrator Manuf: __________ Micro. Manuf: __________
Type: __________ Type: __________ Type: __________
Serial #: __________ Serial #: __________ Serial #: __________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____ dB Posttest ____ dB

Test Conditions General Weather Conditions ______________ Wind Speed __________ m/sec

Test No.	Measurement Location	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation __________

15.3 TRUCKS: STATIONARY TEST

15.3.1 PURPOSE

The purpose of this stationary noise test procedure is to provide a method to measure truck sound levels which is repeatable and defensible. The stationary test can be accomplished at a preferred site under desired operating conditions.

15.3.2 INSTRUMENTATION

A Type 2 (or better) sound level meter (per ANSI S1.4-1971 specifications); a sound level meter calibrator accurate to ±.5 decibel; an anemometer (wind speed indicator) accurate to ±10% at 20 km/hr; an engine speed tachometer* accurate to ±5% at full scale deflection; and a windscreen recommended by the microphone manufacturer are required. The windscreen should be used at all times. *Use of a windscreen reduces the influence of wind induced noise at the microphone and protects the microphone.*

The sound level measurement system shall be checked annually by its manufacturer or a certified laboratory to verify its accuracy.

15.3.3 PERSONNEL

Persons responsible for conducting sound level measurement tests should be trained in the operation of sound level meters and familiar with this test procedure.

*Two different tachometers may be required; one for spark ignition engines and one for diesel engines. See Section 3.7.

15.3.4 TEST SITE

The site shall be flat, open and free of reflecting surfaces, such as parked vehicles, signboards, buildings, or hillsides, within 15 meters (50 ft.) of the vehicle and the microphone. *An empty portion of a parking lot may be satisfactory.*

15.3.5 VEHICLE OPERATION

Turn off all auxiliary equipment which is installed on the motor vehicle and not associated with operation of the vehicle while in transit. The engine shall be at normal running temperature with the transmission in neutral or park. Attach the tachometer per manufacturer's instructions. A governed engine is accelerated to maximum governed speed with wide open throttle. If the engine is not governed, it is accelerated to engine speed corresponding to maximum horsepower.

15.3.6 MEASUREMENT PROCEDURE

Set the sound level meter on A-weighting and "fast" response. Place the microphone on a tripod 1.2 meters (4 ft.) ±8 cm (±3 in.) above the ground in the position shown in Figure 2. A point is established on the centerline of the lane in which the vehicle is parked and within 1 meter (3.3 ft.) of the longitudinal position of the vehicle's exhaust system outlet. The microphone shall be located 7 meters (23 ft.) from this point and along a perpendicular to the vehicle's side.

Observe the sound level meter as the truck is operated as described in Section 15.3.5. Measurements are valid when the background ambient A-weighted sound levels, including noise from wind and sources other than the vehicle under test, are at least 10 decibels lower than the noise from the vehicle under test. Observe the background ambient sound level before and after each test.

Note vehicle model, noise measurement results, and other pertinent data on a data sheet. (Figure 2 contains a suggested format.) For trucks with dual stack exhausts, repeat measurements on each side of the vehicle.

Measurements shall not be made when the wind speed exceeds 20 km/hr (12 mph) or when it is raining or snowing.

Measurements shall not be made during environmental conditions (temperature, humidity) which the instrument manufacturer deems unacceptable.

An external calibration of the sound level meter shall be made before and after each series of measurements. If the calibrations differ by more than one decibel, the measurements shall be repeated after the instrument is adjusted.

A stationary truck noise measurement is shown in the following photograph.

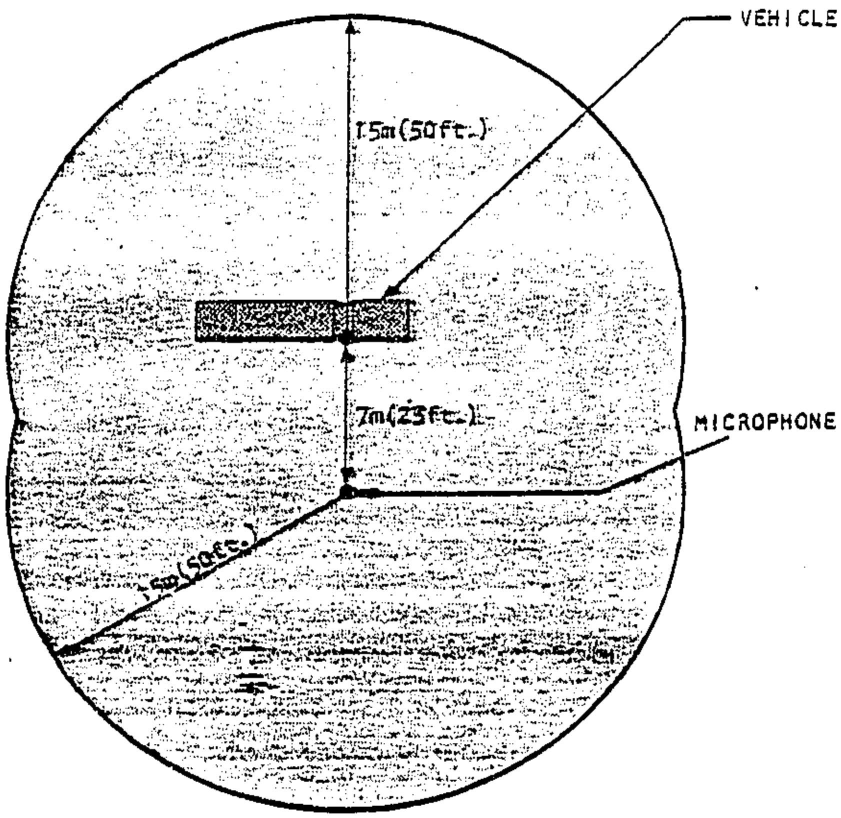

Figure 2. Stationary Truck Test Site

Figure 3. Example: Vehicle Noise Measurement Report Form

Examiner:________________________________ Date:____________ Time:____________

Vehicle:________________________________ Test Type:________________________________

Vehicle Make:________________ Vehicle Type:__________ License:__________ Model:__________ Year_____

Registered Owner:________________________________ Address:________________________________

Operator:________________________ License #:__________ Address:________________________

Sound Level Meter Manuf:________________ Calibrator Manuf:________________ Micro. Manuf:__________

Type:________________ Type:________________ Type:__________

Serial #:________________ Serial #:________________ Serial #:__________

Meter Check ☐ Batt. ☐ Windscreen ☐ "A" Weighting ☐ Fast ☐ Slow Response Calibration Pretest ____dB Posttest ____dB

Test Conditions General Weather Conditions ________________ Wind Speed ____________ m/sec

Test No.	Measurement Location	Engine Speed (rpm)	L_p, dB

Sketch of Test Site

If prequalified site, indicate site designation ____________

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