Department of Environment and Heritage Protection

Noise Measurement Manual

Great state. Great opportunity.

Queensland Government

Prepared by: Environmental Performance and Coordination Branch, Department of Environment and Heritage Protection

Version	Date	Description of changes
2	1 March 1995	Major revision
3	1 March 2000	Major revision
4	22 August 2013	Major revision

August 2013

Contents

Purpose

This document prescribes the processes required to measure noise in accordance with the Environmental Protection Regulation 2008 (EP Reg) under section 71 and 72.

Noise measurements taken using these procedures can be used by Authorised Persons to make assessments under the *Environmental Protection Act 1994* (EP Act) and subordinate polices and guidelines. These laws are enforced by the Queensland Government, local governments and other administering authorities.

Information included in this document is applied by administering authorities to assist in the decision making process for applying enforcement provisions under the EP Act.

Guidance material in the appendices should be used in conjunction with other relevant legislation and standards referenced within this document.

Scope

This manual explains how to:

- Plan a noise measurement
- Take on-site source and background noise measurements.
- Determine component levels by removing ambient noise
- Make adjustments to account for tonal and impulsive characteristics
- Report noise measurements.

Activities listed in schedule 1 of the EP Act (and as cross-referenced in Clause 8 (4) (a) of the Environmental Protection Policy, EPP (Noise)) are not within the scope of this manual. Exclusions in the scope also cover any licensed or unlicensed activities and operations of facilities considered to be ancillary to those listed in Schedule 1 of the EP Act (e.g. maintenance depots that support transport infrastructure).

Limitations

This document does not include guidance for all situations. Noise measurement methodologies outside the scope of this manual may be required. In those circumstances, detailed assessment notes should be taken which specify why the measurements were taken in a different manner. This manual is intended for use by Authorised Persons and those with a basic understanding of acoustics.

Legislation

Relevant legislation and subordinate policies include, but are not limited to, the following:

- *Environmental Protection Act 1994*
- Environmental Protection Regulation 2008
- Environmental Protection (Noise) Policy 2008 (EPP Noise)

Responsibilities of “Authorised Persons”

All ‘authorised persons’ as defined under the EP Act who conduct noise measurements are responsible for performing their work in accordance with the procedures described in this manual. Authorised persons must prove that no deviation from the procedures has occurred during noise measurement, except in special circumstances. Where deviation has occurred, the authorised person must provide details including a statement of reasons.

Acronyms and terms

Some frequently used acronyms and terms are detailed in Table 1.

Table 1. Acronyms and Terms

Acronym/term	Meaning
AS	Australian Standard
CASA	Civil Aviation Safety Authority
DA	Development Approval
dB	Decibel
DTMR	Department of Transport and Main Roads
EA	Environmental Authority
EHP	Department of Environment and Heritage Protection
EP Act	*Environmental Protection Act 1994*
EP Reg	Environmental Protection Regulation 2008
EPP Noise	Environmental Protection (Noise) Policy 2008
EPO	Environmental Protection Order
ERA	Environmentally Relevant Activity
Hz	Hertz
L_p	Sound pressure level
NATA	National Australian Testing Authority
OLGR	Office of Liquor and Gaming Regulation
Pa	Pascal
Registered Operator	A person or company who is currently on the Register to operate an ERA under an Authority
SLM	Sound level meter
TEP	Transitional Environmental Program

Purpose of measurement

Authorised Persons assess noise levels to establish a level of compliance with the EP Act. The noise measurements collected during site inspections may be used as evidence for enforcement.

Confirm jurisdiction

The officer investigating the noise nuisance must confirm what jurisdiction the complaint falls within. Table 2 indicates the distribution of responsibility between government bodies for controlling common noisy activities at the time of publishing this document.

Table 2. Responsible authorities

Activity	Local Government	OLGR	EHP	DTMR	Police	Water Police	Airservices Australia	Commonwealth
Residential noise, ie air-conditioning units, pool pumps, animals.	■							
Devolved activities as listed in section 101 of the EP Reg 2008 *1	■							
Premises with liquor licence		■						
Activities described in Schedule 2 and not devolved to Local Government as listed in section 101 of the EP Reg 2008			■					
State owned or operated activities			■					
On road noisy vehicles and trail bikes				■				
Off road noisy vehicles and trail bikes					■			
Music, loud stereos, parties and rowdy behaviour and burglar alarms					■			
Boat noise, canals, rivers and creeks	■					■		
Aircraft in flight							■	
Helicopters							■	
Noise from Defence Force								■

Exceptions to devolution

An activity is not devolved to the relevant local government if:

a) the activity includes an environmentally relevant activity administered by the State at the same place (see r. 108 of the EP Reg)

b) the activity is carried out by a local government or the State (see r. 106 of the EP Reg)

c) the activity is carried out as a mobile and temporary activity in more than one local government area (see r. 107 of the EP Reg).

Complaint details and noise emission diary sheets

Prior to commencing a noise investigation it is suggested that the investigating officer request the complainant to complete noise emission diary sheets.

Refer Example Template – Noise Emission Diary Sheet (Appendix 1).

Investigation details and emission criteria

A noise assessment involves the examination of the nature and characteristic of a noise. The investigating officer must gather basic information relating to the complaint and noise source including, but not limited to:

- the type of noise
- the time the noise happens (noise may be a nuisance at any time of day or night)
- a subjective assessment of the source noise i.e. is the noise audible within the complainant's backyard and/or house; is the noise at a level that would preclude sleep or prevent the complainant from enjoying the confines of their own home; or impact upon the complainant's ability to watch television etc.
- the duration of the noise
- the frequency of the noise (both the tone/pitch and how often it occurs)
- notes of any other noise that can be heard, i.e. extraneous noises and any observation as to their relations in sound level (e.g. traffic noise is much louder than the noise under investigation, or the noise under investigation can be heard clearly over other noises etc.)

Before an Authorised Person can decide to issue a direction notice in relation to a contravention of section 440 of the EP Act involving an emission of noise, the Authorised Person must consider the general emission criteria as stated within section 363 of the EP Act.

Refer Appendix 5—Officer Checklist 1—Investigation Details/Emission Criteria.

Weather

A noise measurement should be taken on a day with a calm to gentle breeze and without rain. Some conditions to avoid are high wind (generally, do not conduct the assessment if the wind is higher than 5 meters/second (m/s)), or rain.

If it is necessary to measure in a wind-affected position, check the manufacturer's specification for the microphone and confirm that the windshield can be used in these conditions.

It may assist to check the Bureau of Meteorology website: http://www.bom.gov.au/ prior to conducting a site visit for the local weather forecast and wind conditions for the area.

The investigating officer must note the approximate wind speed using the Beaufort Scale as shown in Table 3.

Table 3. Beaufort Scale (Source AS 2221.1)

Wind force number	Explanatory notes	Specification of Beaufort scale for use on land	Mean wind speed m/s
0	Calm	Calm, smoke rises vertically	Less than 0.5
1	Light Air	Direction of wind indicated by smoke drift, but not by wind vanes	0.5-1.5
2	Slight Breeze	Wind felt on face, leaves rustle, ordinary vane moved by wind	1.5 - 3
3	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag	3 to 5
4	Moderate Breeze	Raises dust and loose paper; small branches moved	5 to 8
5	Fresh Breeze	Small trees in leaf begin to sway; wavelets from the inland waters	8 to 11
6	Strong Breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	11 to 14

Safety

If there are hazards in the general location of where the ideal measurement position is, find an alternative location or time with similar conditions, but without the hazard.

Refer Appendix 2—Personal Safety / Risk Reduction Measures.

Noise descriptors

A noise assessment may be completed for the following reasons:

- to determine if an environmental nuisance has been caused
- to verify if a noise standard has been contravened by emission of noise.

It is important to ensure the correct noise descriptor is assessed:

Time varying noise: $L_{Aeq,T}$ is used to quantify the noise where the L_p varies over time. In most situations, the $L_{Aeq,T}$ is the most appropriate descriptor used to investigate environmental noise complaints.

Steady noise: In cases where constant noise is present e.g. constant machine noise, the $L_{A90,T}$ can be used as an equivalent to $L_{Aeq,T}$. This generally has the advantage of removing extraneous ambient effects from the measurement. For example, noise from occasional traffic and birds won't be captured by the $L_{A90,T}$. The $L_{A90,T}$ descriptor is commonly used to assess noise emissions from sources including fan noise, domestic air-conditioners and pool pumps.

Short duration/non-steady noise: Impact, impulse and transient noise is measured with L_{Amax}. This noise descriptor is also used to assess sleep disturbance and awakening criteria as per WHO, 1999.

Frequency weighting

The frequency weighting, A, C and Z will be specified by the noise standard, guideline or licence condition. A-weighting is most common and should be used unless specified otherwise.

Time weighting

The Time Weighting (Fast, Slow or Impulse) will be specified by the noise standard, guideline or licence condition. Fast is the default unless otherwise specified.

Measurement time

The noise under investigation should be measured for sufficient time to establish that the measured value adequately represents the subject source noise. The source noise is measured over a time interval of at least 15 minutes or, if the noise continues for less than 15 minutes, the duration of the source noise.

Refer Appendix 3—Basic Acoustic Principles.

Measurement location

When an investigating officer is undertaking a noise assessment it is essential to make note of the following on a site map:

- location of noise source
- background noise measurement location
- source noise measurement location
- topography between noise source and sensitive receivers.

When assessing environmental nuisance or noise standards under the EP Act:

When assessing under the EP Act, select the location that is considered to best represent the most affected location. These measurements are typically conducted in or near buildings and are not required to be in a free field.

When assessing a licence condition under the EP Act:

The appropriate measurement location and descriptor should be referenced in the DA, licence conditions or notice/order i.e. at the nearest sensitive receiver, nearest commercial premises, nearest nuisance sensitive premises or boundary. These measurements are not required to be in a free field unless specified.

Measurement method

Handheld Quick Assessment

The handheld assessment method is useful to get an idea of noise levels, however a tripod should be used for a compliance inspection or to take enforcement action.

To obtain the most accurate data using this method, hold out the SLM at arm's length and hold it out to your side with the microphone pointed towards the source of the noise, to minimise sound reflecting off your body.

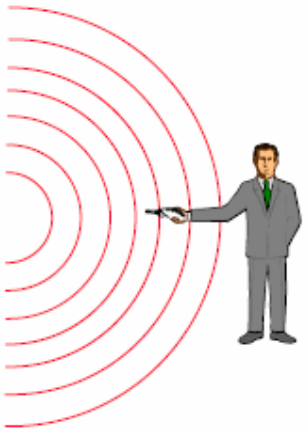

Figure 1. SLM handheld assessment method

Source Bruel & Kjaer

SLM (including microphone) mounted on tripod

SLM mounted on a tripod is the method used most commonly and is the standard methodology for most noise measurements where compliance/enforcement action may be taken as a result of the investigation.

Care should be taken not to make noises whilst observing the meter in this method and ensuring the least amount of reflective surface from your body is exposed to the meter.

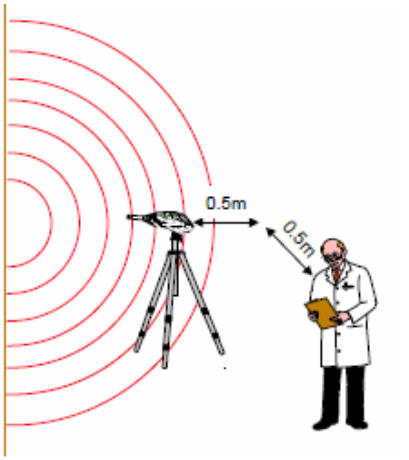

Figure 2. SLM mounted on tripod

Source Bruel & Kjaer

Affected height of the receptor

A noise reading should always be taken at the height of the receptor. If the receptor is at the ground level, take a measurement at the ground level (1.2–1.5m off the ground).

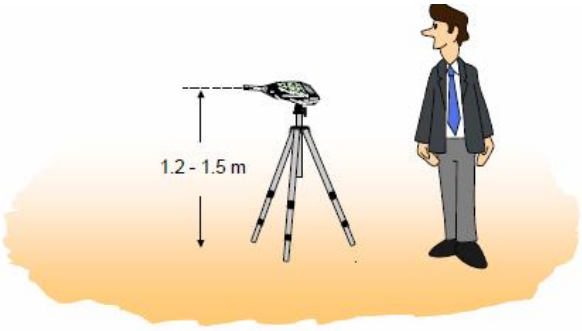

Figure 3. SLM measurement

Source Bruel & Kjaer

Microphone mounted on a tripod remotely from SLM

Sometimes situations and locations require setting up a microphone away from the location of the SLM mounted separately on a tripod. If the receptor is higher off the ground, raise the microphone to the level that is approximately at the middle of the window (or other opening to the dwelling) using an extendable tripod or position the meter in the plane of the window using an extension pole. The distance of the microphone from the façade of the building should be 3.5m.

Outside premises – free field measurements

Free field measurements are generally used to assess noise conditions set at property boundary or to assess a noise model calibration/validation point. Free field measurements are not required for measurements under the EP Act unless specified on the licence or approval conditions.

Any hard surface will reflect sound. If the microphone/SLM is placed too close to a reflective surface, the noise level will show up higher than the actual noise level. To avoid the reflection, take a reading more than 3.5m away from a reflective surface.

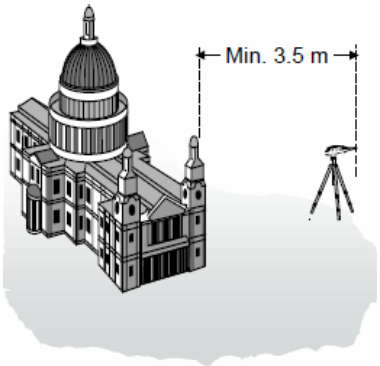

Figure 4. Minimum distance to nearest reflective surface outside premises

Source Bruel & Kjaer

Inside a room

Measurements inside buildings shall be carried out in those locations at which the noise of interest dominates. When investigating a sleep disturbance issue a noise assessment will be necessary in a bedroom, reference WHO 2009. The preferred positions are at least 1m from walls or other major reflecting surfaces, 1.2m to 1.5m above the floor, and 1.5m from windows. The presence of furnishings or other reflective surfaces, which may result in shielding or scattering of the noise, should also be considered.

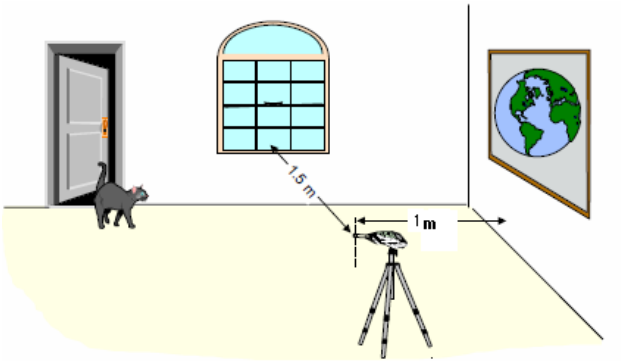

Figure 5. Minimum distance from nearest reflective surface inside room
Source Bruel & Kjaer

An outdoor location that is part of a building

(For example: under a veranda, porch, on a deck, balcony)

As per **Inside a room**. The same distances and considerations should be applied

Inside, at the façade of the building, in the plane or open window or open doorway

In many cases the intrusive noise will be most noticeable at the building opening most exposed to the source noise. In these cases, the part of the building of interest will be the open window or doorway.

The window or door should be open as wide as possible, with the microphone being located in the middle of that opening. For example see Figure 6 below:

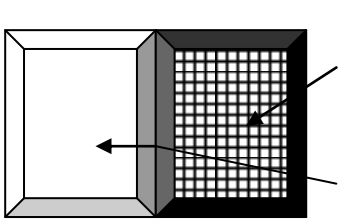

Figure 6. Measurement location with an open window

Where it is not possible to sufficiently open the window (e.g. awning window with limited opening as shown in Figure 7 below) then the measurement may be taken inside the room as discussed above.

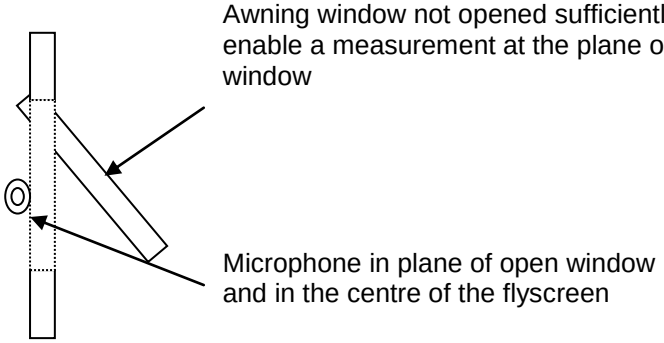

Figure 7. Measurement location with a window - limited opening

Measuring source noise and extrapolating back to the complainant's property.

An alternative method for measuring the noise under investigation is to move the sound level meter closer to the noise source to a point where the source clearly dominates, note this new position, and take a new reading. Measured levels may then need to be extrapolated back to the position of the affected resident.

Refer Appendix 4—Distance Attenuation.

Multiple noise sources

Many noise measurement situations require calculating the combined sound pressure level of multiple noise sources.

Refer Appendix 4—Multiple noise sources.

Long-term logging (unattended)

Noise logging can be useful in the following situations:

- When measuring irregular and infrequent noises, it is not always practical to measure the noise with an attended measurement.
- When it is difficult to determine the background noise during the attended period (e.g. the source doesn't stop during the attended period, or the background is known to be variable), noise logging can determine the background noise over a longer period of unattended measurement.

In these cases, the investigating officer may be able to conduct a 'logging', which allows monitoring of the noise for a longer period of time. In order to conduct outdoor logging of various durations, the SLM should be housed in an all-weather case and an outdoor all-weather microphone kit used to ensure damage to the meter/microphone does not occur. It is also important to ensure the security of the SLM, as the equipment is often very sensitive and expensive. The logger should be located using the same instructions indicated in the Measurement method section. Where an officer does perform unattended logging, it is suggested that attended measurements are also completed to calibrate the results of the unattended logging.

Calibration

There are two types of calibration necessary for noise monitoring equipment–laboratory calibration and field calibration.

Laboratory calibration

It is essential to ensure that the SLM and calibrator have been calibrated in a National Australian Testing Authority (NATA) certified calibration laboratory. The calibrators are required to be calibrated every year and the SLM must be calibrated as per the manufacturer's specifications. A sticker on the SLM and calibrator indicates the last recorded date of laboratory calibration

Field calibration

Calibration of the SLM is to be carried out before and after each set of noise measurements in accordance with AS IEC 61672.1-2004 (Standards Australia 2004a). The investigator should also recalibrate each time the SLM is moved to different locations.

The L_p shown on the meter should match the stated L_p for the calibrator being used. Standard calibration is generally 94 dB(A) but can vary slightly due to the microphone sensitivity e.g. 93.8 dB(A). The calibration level should be confirmed with the SLM manufacturer's specifications. The variation before and after the calibrations should be no more or less than 1 dB(A). If the deviation of the calibration is greater than 1 dB(A) then the results obtained during the assessment are invalid.

The background noise assessment

The background Lp is commonly referred to as the background noise level or LA90 in the absence of the source noise. Accurate measurement of the background level is important, as it is often one of the criteria used when assessing the impact or potential impact of intrusive noise.

Short term background measurements

For noise assessment purposes the short-term background noise level is generally taken as the L_{A90} level measured by the SLM, excluding all distinct extraneous noises. A minimum measurement time of 10 minutes is required to determine the background noise level under AS 1055.1. One of the most common extraneous noises encountered in Queensland whilst conducting a noise assessment is constant cicada noise. Cicadas only occur during certain periods of the day and it is advisable to postpone measurements until the insect noise stops, or return at another time. Extraneous noises which may contaminate a background noise measurement include insects, machinery and other long-duration noise sources that are not typical of the area and which can be easily distinguished and clearly identified during the measurement period. Most short-term extraneous noises will not be captured by the L_{A90}, however where this cannot be circumvented these must be reported. Ensure the background is representative of the worst-case scenario and the background noise level should be ideally measured immediately before or after the assessment of the source noise at the same location. If more than one background noise assessment is completed it is advisable to use the lowest result.

Long term background measurements

For more complex situations it may be necessary to complete long-term background monitoring. This involves measuring the L_{A90} for 8 hours or more using a SLM and is generally used for complex noise investigations.

The following time periods are generally used for background noise measurements:

- Day: 7am to 6 pm
- Evening: 6pm to 10pm
- Night: 10pm to 7am.

Comprehensive long term background noise methodology is described in the EHP Planning for Noise Control Guideline.

Remote background assessment

When the noise source cannot reasonably be turned off, a background noise level can be measured at a location which has the same background noise characteristics, but away from the impact of the source noise (i.e. in a remote location).

When selecting a site to conduct remote background noise measurement, care should be taken to note the noise characteristics of the affected premises, then ensure similar distances are maintained from the major sound sources such as main roads, railway lines, forest and industrial zones (other than the one under investigation), to ensure the site has the same background noise characteristics as the affected premises.

Taking a remote background noise assessment is a less preferred method, however, in the event that this method is the only option, Record detailed notes and complete a site sketch showing the location of assessment in relation to the sensitive receiver and location of source noise.

Calculation of component noise levels

The influence of ambient noise must always be removed from the source noise level measurements for the purposes of comparison with noise limits. The source noise level with ambient noise removed is referred to as the component level. The simplest method to ensure the ambient noise is removed from the source noise is to measure at a time when the ambient noise is sufficiently low [more than 10dB(A) below the source noise level] The noise assessment

may require a measurement during periods of low ambient noise, even if that does not correspond to the time of complaint, to get a definitive result. In this case the measured noise level and component level are effectively equal.

It is also possible to mathematically remove the influence of the ambient noise from the source noise by logarithmic subtraction. Care should be exercised using mathematical adjustment, which is generally only applicable where the ambient noise environment is reasonably steady.

Table 4 provides a method for mathematical subtraction, where:

A = the measured result on site of the noise source plus ambient noise (continuous)

B = the result of the ambient noise level (continuous) only measurement

C = the noise source component level (continuous) only with the influence of the ambient noise level (continuous) removed

Table 4. Calculation of component noise levels

NOTES: * Such a result indicates that it is unlikely that noise from the noise source is an issue due to the masking effect of the ambient noise.

*,† Care should be exercised with such results as it indicates a difficult measurement. The measurement should be repeated over a number of periods to give confidence in the result. It may require measurement during periods of low ambient, even if that does not correspond to the time of complaint, to get a definitive result.

A minus B	**C**	Where both the ambient noise and the source noise are reasonably steady, the L_{A90} descriptor can be used for the A minus B calculation above. This will often be the case for mechanical plant noise, such as air conditioning, refrigeration equipment and pump noise. In situations where the source noise varies with time, the L_{eq} descriptor should be used for the A minus B calculation. Alternatively, the A-B calculation can be performed directly with the following formula: Component Level =10 x LOG($10^{A/10}$ - $10^{B/10}$) This can be done in a spreadsheet, e.g. In MS Excel ®: (to subtract cell A1-B1) =10*LOG(10^(A1/10)-10^(B1/10)) Corrections are then applied to the ***component level*** in recognition of the annoyance generally associated with a noise which is dominated by tonal or impulsive characteristics. This is discussed in later sections.
0	At least A minus 10*	
1	At least A minus 5*	
2	A minus 4†	
3	A minus 3†	
4	A minus 2	
5	A minus 2	
6	A minus 1	
7	A minus 1	
8	A minus 1	
9	A minus 1	
10 or more	A	

Adjustments made to noise levels with annoying characteristics

If a noise has tonal characteristics (especially at high frequencies) or impulsive characteristics, it is generally perceived more annoying than a noise heard without these characteristics. Examples of tonal noise include, reversing beepers, alarms, bells, buzzers, the screeching of mechanical plant, grinding metal. Examples of impulse noises include, a metal press and hammering.

Tonality adjustments

Tonal noise can be defined as having a prominent frequency and characterised by a defined pitch. A tonal characteristic can be identified objectively in accordance with the method in Australian Standard AS1055.1−1997

Acoustics - Description and measurement of environmental noise. The method involves comparing noise levels in adjacent one-third octave bands.

The standard states:

> *If tonal components are clearly audible and they can be detected by a one third octave analysis the adjustment may be 5dB. If the components are only just detectable by the observer and demonstrated by narrow band analysis, an adjustment of 2-3dB may be appropriate.*

If the A-weighted 1/3rd octave analysis confirms that the tonal band exceeds both neighbouring bands by 5dB the user is permitted to subjectively adjust the level. The adjustment can be 0 to 5dB to the ***component level*** depending on the audibility of the tone.

Alternatively, this analysis and correction can be performed quantitatively by performing the following check.

- Confirm the A-weighted 1/3rd octave band exceeds the neighbouring bands by 5dB
- Add 5dB to the tonal 1/3rd octave band
- Logarithmically sum all A-weighted 1/3rd octave bands, including the adjusted band
- The arithmetic difference between the log sum determined in (3) and the original overall A-weighted level becomes the tonal correction

Example: An officer measures noise from a machine and notices an audible low frequency tone at 50Hz. The total level of the measurement was 58dB(A). In this case the ambient level was more than 10dB below the measured level, so the component level is 58dB(A). Subjectively the tone was just audible as it was masked somewhat by the overall machine noise. The 1/3rd octave band component level data was entered into a spreadsheet as shown below. A 5dB correction was added to the 50 Hz 1/3rd octave band level.

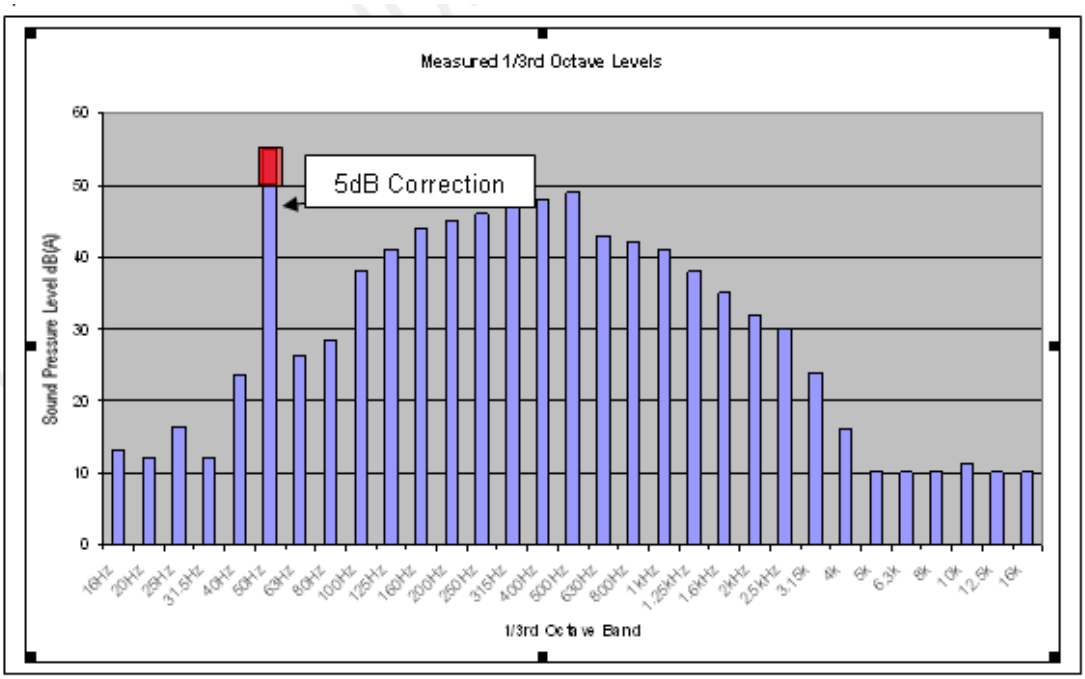

Figure 8. one-third octave band analysis

Logarithmically summing the one-third octave bands, including the corrected band gives a new total of 61dB(A). This is 3dB higher than the component level. The new corrected component level becomes 61dB(A), (i.e. a 3dB tonal correction).

Impulsive adjustments

Impulse noise can be defined as having a high peak of short duration or a sequence of such peaks (bangs, clicks, clatters, or thumps). To determine if an adjustment is necessary the investigating officer must measure the source noise using both A-weighted Fast response and Impulse response. If the difference in A-weighted maximum noise levels between Fast response and Impulse response is greater than 2dB then apply difference in measured levels as the correction up to a maximum of 5dB. The impulse adjustment should then be added to the component level (L_{Aeq} or L_{Amax}) and should not exceed 5dB. Combined adjustments for tonality and impulsive noise in total should not exceed 10dB.

Low frequency noise

Low frequency noise can be defined as noise that has a dominant content less than 200Hz. Noises below 20Hz are known as infrasound and are usually not audible but rather felt as a vibration, pulsating sensation or pressure on the ears or chest. Types or activities that may produce low frequency noise include pumps, fans, boilers, ventilation plant, electrical installations and wind turbines.

Refer Appendix 3—Basic Acoustic Principles.

Saving information and record keeping

To ensure data collected conforms to rules of evidence, detailed records of the investigation and methodology must be kept. The noise assessment must be completed in accordance with this manual however where special circumstances have lead to deviations, detailed notes and records must be provided explaining the reasons for deviation.

- Refer Appendix 5—Officer Checklists:
- Investigation Details / Emission Criteria
- Noise Assessment Equipment Checklist
- Noise Assessment Procedure
- Noise Assessment Field Notes.

Controls

First review to be made in 12 months and then every 3 years thereafter b y Environmental Performance and Coordination Branch.

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Standards Australia AS 1055-1997 Acoustics – Description and measurement of environmental noise.

Part 1: General procedures

Part 2: Application to specific situation

Part 3: Acquisition of data pertinent to land use

Standards Australia AS IEC61672.1-2004: Electroacoustics – Sound Level Meters – Specifications.

Standards Australia AS IEC 61672.2-2004: Electroacoustics - Sound level meters - Pattern evaluation tests.

Standards Australia AS 1633-1985 Acoustics – Glossary of terms and related symbols.

Standards Australia AS 2659 – Guide to the use of sound measuring equipment.

Part 1: Portable sound level meters

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WHO 2009 - Night noise guidelines for Europe. World Health Organisation 2009

Appendix 1

Noise emission diary sheets template

Day and time	Time started	Time finished	Description of noise	How did the noise affect you?

Appendix 2

Personal safety

Before embarking on any site inspection it is essential that officers are aware of their legislative responsibilities for *WorkPlace Health and Safety Act 2011*.

Some of the common risks encountered whilst conducting a noise assessment include

- vehicles on the road
- machinery on site
- people (especially when conducting noise assessment at night)
- overhead wires (especially if you are raising a microphone using an extendable tripod)
- animals (dogs, stinging insects and snakes are common in some places); and
- weather including cold, heat, humidity and the sun.

Officers should be aware of their surroundings and assess any potential dangers associated with conducting a site visit and noise assessment. Hearing protection may be required when conducting environmental noise assessments.

The primary criterion for selecting a hearing protector is that the level of noise entering ears must be reduced to below the legal limits of the Workplace Health and Safety Regulation 2008, which are:

a) an 8-hour equivalent continuous A-weighted sound pressure level of 85 dB(A), referenced to 20 μPa; or

b) a C-weighted peak sound pressure level of 140 dB(C), referenced to 20 μPa.

Risk reduction measures

Once the risks are identified, the officer should consider how to reduce the risks. In most cases, the risks to personal safety while conducting noise assessment can be eliminated altogether or reduced significantly by moving to an alternative location or wearing personal protective equipment (PPE).

Personal safety comes first. No task is so important that safety can be compromised.

Appendix 3

Basis acoustic principles

Sound and noise

Sound is the mechanical vibration of a gaseous, liquid or elastic medium through which energy is transferred away from the source by progressive sound waves. Hearing is simply fluctuations in air pressure detected by the ear. ***Noise*** has a subjective quality and is often defined as unwanted sound.

Measuring sound

Air or sound pressure is measured in Pascals (Pa) but is expressed as a sound pressure level (L_p) in decibels (dB), which is a logarithmic scale used to compress the range of audible sound pressure. The relationship between sound pressure and L_p is as follows:

$$Lp\ (dB) = 10\ log(\ p^2 / p_{ref}^2\ ) = 10\ log(\ p / p_{ref}\ )^2 = 20\ log\ (\ p / p_{ref}\ )$$

Where ***Lp = sound pressure level (dB)***

p = sound pressure (Pa)

$p_{ref} = 2 \times 10^{-5}$ ***- reference sound pressure (Pa)***

Some useful rules of thumb:

- Some typical sound pressure levels of common noise sources are detailed in Figure 8.
- Table 5 shows the subjective effect of changes in noise levels.

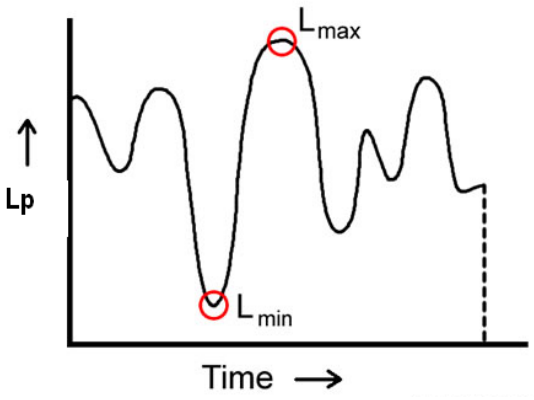
Noise descriptors used in impact assessment

The parameters frequently used for measuring noise include L_{Amin}, L_{Amax}, and L_{Aeq} and L_{A90}. Most contemporary SLMs record multiple noise parameters at the same time.

L_{Amin} and **L_{Amax}** refer to the equivalent minimum and maximum values recorded by the SLM during an assessment, see Graph 2. L_{max} is often compared to the L_{A90} (background) to describe the likely impact of non–steady noise such as fluctuating or impulsive noise.

L_{AmaxT} is the A-weighted L_p obtained by using 'fast' time response and arithmetically averaging the visual maximum levels of the noise under investigation, unaffected by extraneous noise, during the measurement period. This parameter is usually used for impact and/or intermittent noises, as this parameter does not account for a more constant noise.

L_{AmaxT} is generally only used where noise assessment is carried out using a non-integrating (analogue or digital) SLM and where the SLM does not have the capacity to calculate the statistical (i.e. **L%** sound pressure levels).

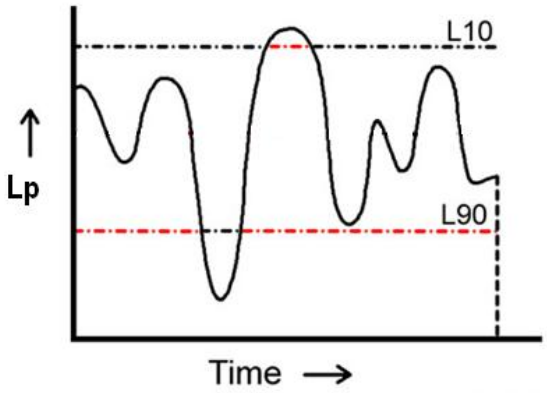


Graph 1. L_{Amin} and L_{Amax}

L_{AeqT} is the A-weighted equivalent continuous L_p of the sample time T. The **$L_{Aeq,T}$** is also known as the 'time average sound pressure level' or the 'level of noise equivalent to the energy average of noise levels occurring over a measurement period'. This is the current default descriptor for environmental noise measurement. It is used widely throughout the world for measuring noise sources and it is an extremely versatile parameter.

L_{peak} is not the same as the Maximum Sound Level. The Peak, referred to as the **L_{peak}** or sometimes L_{pk}, is the maximum value reached by the sound pressure. There is no time-constant applied. This is the true peak of the sound pressure wave. This parameter is commonly seen within the development conditions of mines and used to regulate blasting operations.

Percentile levels are commonly used when measuring environmental noise. This is represented by L_n, where n may be a value from 1 to 99. L_n represents that noise level exceeded for n% of the measurement time. Common percentiles used are shown in Graph 2.



Graph 2. Common percentiles

L_{A90} is the sound pressure level that has been exceeded for 90% of the time. This level is taken to be the background sound pressure level.

$L_{Abg,T}$ is also known as the 'background sound pressure level', (also known as the average minimum sound pressure level) and is the A-weighted L_p obtained using 'fast' time response and arithmetically averaging the visual minimum levels of the noise under investigation, unaffected by extraneous noise, during the measurement period.

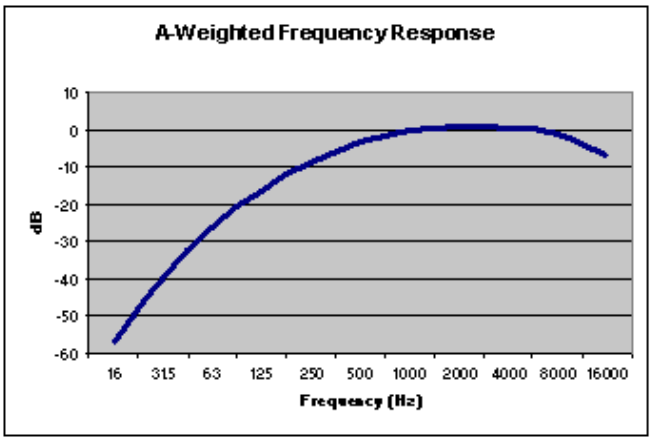
In cases where **$L_{Abg,T}$** has been referenced in development approvals or legislation, it is to be taken as **$L_{A90,T.}$** (**$L_{Abg,T}$** = **$L_{A90,T}$** (unaffected by extraneous noise)).

L_{A10} is the sound pressure level exceeded for 10 % of the time of the measurement duration.

Setting up of SLM and frequency weightings

A- weighting

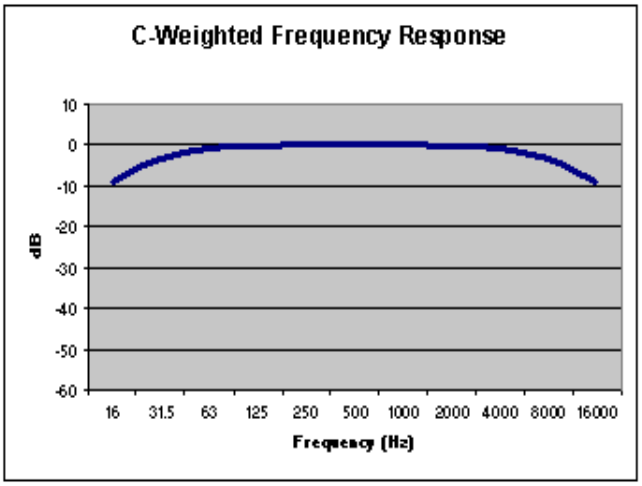
The most common weighting used in environmental noise measurement is A-weighting. The A-weighting represents the way the human ear is more sensitive to mid-range frequencies and less sensitive to high and low frequencies. Defined in the sound level meter standards (IEC 60651, IEC 60804, IEC 61672, ANSI S1.4), a graph of the frequency response can be seen to the right. A-weighted measurements are expressed as **dB(A)**, see Graph 3.



Graph 3. A-weighted Frequency Response

C-Weighting

The response of the human ear varies with the sound level. At higher sound pressure levels, the ear's response is flatter, as shown in the C-Weighted Response to the right. Although the A-Weighted response is used for most applications, C-weighting is also available on many SLMs. C-weighting can be used for Peak measurements and low frequency noise. It is often used in entertainment noise measurement, where high pressure low frequency noise is common. The C-weighting is also commonly used for sounds with impulsive characteristics such as fire-arms; shooting ranges; pile driving. C-weighted measurements are expressed as dB(C), see Graph 4.



Graph 4. C-weighted Frequency Response

Z-Weighting

Z-weighting is a flat frequency response of 0.5Hz to 20kHz ±1.5dB. This response replaces the older "Linear" or "Unweighted" responses. Z-weighted measurements are expressed as **dB(Z)**. Z-weighting has recently been used to measure explosive sounds and in the assessment of low frequency noise.

For most environmental assessments A-weighting will be used.

Time weighting

Sound level measurements using any grade of SLM can be **Fast**, **Slow**, or **Impulse** time weighted. The **Impulse** time weighting is about four times faster than **Fast**, with a short rising time constant but a slow falling one. **Fast** corresponds to a 125 ms time constant. **Slow** corresponds to a 1 second time constant. **Impulse** has a time constant of 35ms.

Ambient noise level

The ambient noise level is defined as the totally encompassing sound in a given situation at a given time, composed of sound from all sources near and far, measured using the equivalent continuous sound pressure level (L_{Aeq}) noise descriptor.

Rating level

The rating level can be defined as a specific noise level plus any adjustment for the character of the noise (tonal and/or impulsive) determined over the reference time interval.

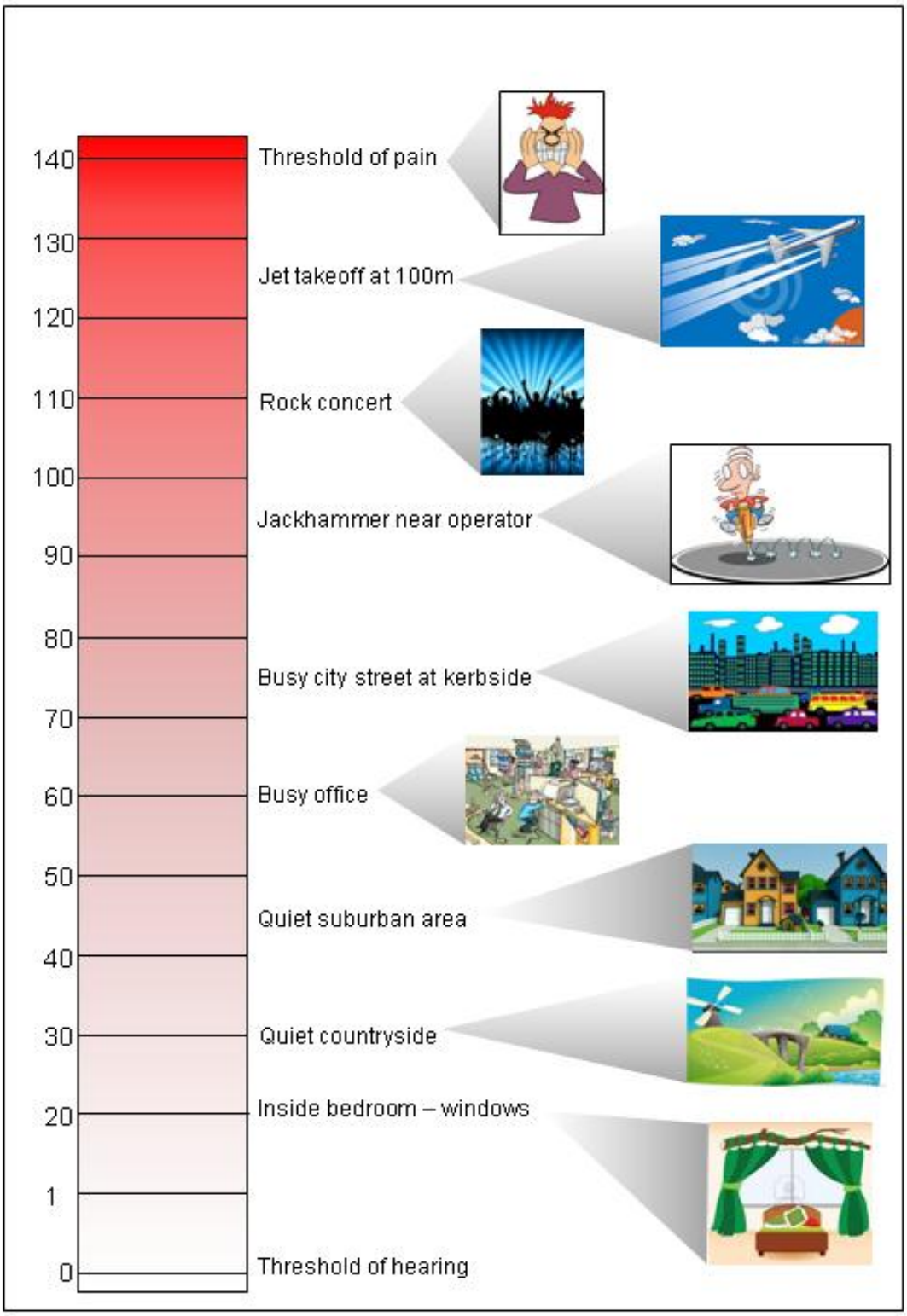


Figure 9. Common sound pressure levels dB(A)

The following tables are useful references when providing a qualitative description to related changes in sound pressure levels dB (A).

Table 5. Subjective effect of changes in noise levels

Change in level of dB	Subjective effect
3	just perceptible
5	clearly perceptible
10	twice as loud

Source Bruel & Kjaer

Table 6. Estimated community response

Amount in dB(A) by which the rating level exceeds the noise criterion	Estimated community response	
	Category	**Description**
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community action
20	Very strong	Vigorous community action

Source Bruel & Kjaer

Appendix 4

Distance attenuation

If the source noise is affected by extraneous noises another method to address this is to conduct a measurement where the SLM is moved closer to the source and measured levels need to be extrapolated back to the sensitive receiver/boundary. The new location must be selected where the source noise clearly dominates the area and clear notes must be taken regarding the new monitoring location. Once noise levels have been determined at this location it is possible to predict the noise level at the affected premises by extrapolating to the desired measuring location using the formulas relevant to distance attenuation.

Do not to measure too close to the source in the 'near field'. As a general rule, being at least one-third the length of the longest dimension of the source away will be outside the near field.

This method is only appropriate when terrain between source and receiver is flat and unobstructed, because effects of topography on attenuation are much reduced.

Distance attenuation is the reduction of L_p as a function of distance. As a general rule the L_p will decrease by 6 dB with a doubling of distance from a point source in the free field.

The following relationships can be used to quantify distance attenuation, reference Figure 9:

- **SPLx = SPLy – 20log(Dx/Dy) for a point source (e.g mechanical fan)**
- **SPLx = SPLy – 10log(Dx/Dy) for a line source (e.g heavy traffic along a road)**

  Where

  - SPLx = L_p at distance x from the source in metres (predicted)
  - SPLy = L_p at distance y from the source in metres (measured)
  - Dx = distance in metres to location x from the source
  - Dy = distance in metres to location y from the source

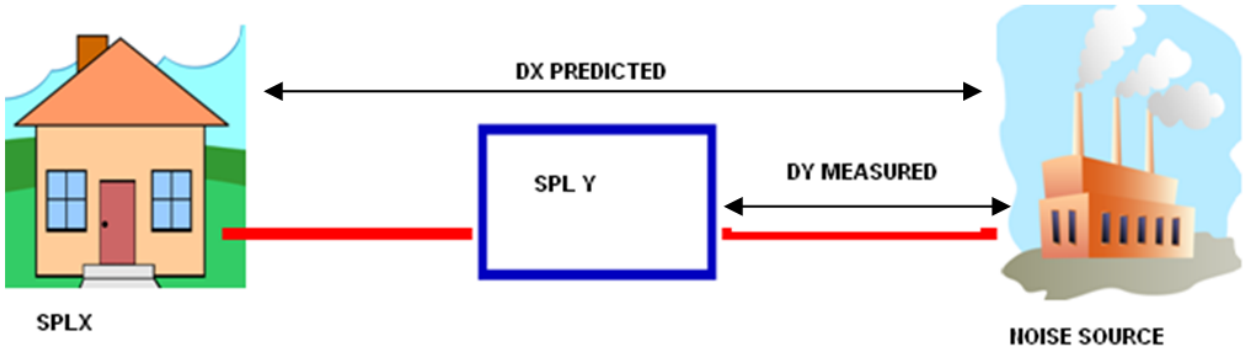


Figure 10. Pictorial representation of equation used for calculating distance attenuation

Note that the geometric distance attenuation method described above does not include several factors. Noise attenuation can often be affected by barriers, buildings, ground absorption, reflection from hard surfaces, air absorption and other atmospheric effects. These are beyond the scope of this document.

Further information is available in:

- ISO 9613:1996 Acoustics -- Attenuation of sound during propagation outdoors
- Engineering noise control : theory and practice / David A. Bies and Colin H. Hansen

Multiple noise sources

Many noise measurement situations require calculating the combined sound pressure level of multiple noise sources. As previously discussed sound pressure levels are expressed in a logarithmic scale and can therefore not be arithmetically added. For example, 40dB plus 40dB does not equal 80dB,

To add two or more noise levels reference Table 7.

Hence, 40 dB + 40 dB = 43 dB.

Sound power level difference between two Sound Sources (dB)	**Added decibel to the highest sound power level (dB)**
0	3
1	3
2	2
3	2
4	1
5	1
6	1
7	1
8	1
9	1
10 or more	0

Table 7. Multiple noise sources - addition of dB

Alternatively, an A+B calculation can be performed directly with the following formula:

Total Level =10 x LOG($10^{A/10} + 10^{B/10}$)

This can be done is a spread sheet, e.g. In MS Excel ®: (to add cell A1+B1)

=10*LOG(10^(A1/10)+10^(B1/10))

Appendix 5

Officer Checklist 1 – Investigation details / Emission criteria

Before conducting a noise assessment, contact the complainant to gather basic information required to start an investigation.

The information should include:

a) the emission's characteristics or qualities

b) the emission's amount or rate

c) the duration and time of the emission

d) whether the emission is continuous or fluctuating

e) the characteristics and qualities of the receiving environment, including the types of emissions that could reasonably be expected in the receiving environment

f) the emission's impact on the receiving environment

g) in relation to each affected person for the emission:

(i) any views of the affected person about the emission of which the authorised person is aware, including views about the degree of interference caused, or likely to be caused, by the emission to lawful activities at the place occupied by the affected person

(ii) the order of occupancy between the person causing the emission and the affected person

(iii) for the period during which the person causing the emission has occupied the place from which the emission is generated and the affected person has occupied the place affected by the emission—

- any structural or other changes to either of those places
- any change to the activities conducted at either of those places by the person causing the emission or affected person

h) any mitigating measures that have been taken or could reasonably have been taken by the person causing the emission.

The noise emission criteria are as follows—

a. if the authorised person has measured a sound pressure level for the noise—that level

b. the audibility of the noise

c. whether the noise is continuous at a steady level or whether it has a fluctuating, intermittent, tonal or impulsive nature

d. whether the noise has vibration components.

Officer Checklist 2–Noise assessment equipment checklist

Table 1 Equipment checklist

Equipment	Checked
SLM and calibrator - calibrated	
Protective case for SLM	
SLM battery life / charged	
Wind shield	
Tripod	
Outdoor weather equipment	
Outdoor battery pack charged	
Memory cards for SLM	
Camera	
Paper / record sheet / pen	
Personal protective equipment	

Officer Checklist 3–Noise assessment procedure

1. Select time when source noise is representative of the maximum level of noise from the activity.
2. Check settings of SLM:
    i. ‘Fast’ time weighting
    ii. ‘A’ frequency weighting
    iii. Audio recording on SLM – this can provide additional evidence.
    iv. Frontal incidence for microphone
3. Note the approximate wind speed using the Beaufort scale as shown in Table 3 of the NMM. Do not take measurements if raining or wind speed greater than 5 meters/second – (Leaves and small twigs in constant motion; wind extends light flag)
4. Calibrate the noise monitoring equipment before and after each set of noise measurements.
5. Set up the SLM up on the tripod.
6. Complete a background noise assessment-
    i. This is the $L_{A90,\ T}$
    ii. Ensure measurement taken in the absence of source noise
    iii. Measure continuously for a minimum time of 10 minutes
    iv. Ensure all extraneous noises are excluded – investigating officer to make detailed notes during the assessment.
7. Complete an assessment of the source noise –
    i. For time varying noise use the descriptor $L_{Aeq,T}$
    ii. The $L_{A90,T}$ descriptor is commonly used to assess noise emissions from sources including fan noise, domestic air-conditioners and pool pumps
    iii. Where source noise is affected by extraneous noises, move SLM closer to the source where it clearly dominates the area, note the new monitoring position and then these readings can be extrapolated back to the position of the complainant – see Appendix 3 ‘Distance Attenuation’ for further information.
8. Make notes of any audible tonal and impulsive characteristics of the noise and ensure use of appropriate correction factors.
9. Take photos of both background and source noise measurement locations.
10. Save data.
11. Re-calibrate the SLM. In the event that the deviation from the first calibration is greater than 1 dB(A) then the results obtained will not be valid and the assessment will have to be repeated.

Officer Checklist 4–Noise assessment field notes

Investigating officer: _____ Address:_____

Noise source: _____ Date: _____

Site Sketch:

- Location of nearest sensitive receiver
- Location of noise source
- Background noise measurement location
- Source noise measurement location
- Note of topography between source and sensitive receivers.

Notes

Weather, wind speed, audibility of noise, characteristic of noise, continuous or fluctuating, tonal, impulsive, extraneous noises in area, detail methodology of noise assessment and state where any deviations from procedures have occurred and why:

_____
_____
_____
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_____
_____

I _____(print name) certify that the noise assessment has been completed in accordance with the Noise Measurement Manual. Signature_____

Investigating officer: _____ Address:_____

Noise source: _____ Date: _____

Measurement: background / source	**Calibration start**	**Calibration end**	**Time started**	**Time finished**	**Notes: subjective assessment, extraneous noises, noise characteristics i.e high pitched / droning, impulsive, tonal.**