Noise Measurement Procedures Manual

Second Edition
July 2008

Environment Division
Department of Environment, Parks, Heritage and the Arts

Tasmania
Explore the possibilities

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Department of Environment, Parks, Heritage and the Arts
GPO Box 1751
Hobart Tasmania 7001
Australia

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PART A – INTRODUCTION

1 INTERFACE WITH STATUTORY INSTRUMENTS

1.1 Purpose of the Noise Measurement Procedures Manual

The Noise Measurement Procedures Manual is primarily for use in conjunction with the *Environmental Management and Pollution Control (Miscellaneous Noise) Regulations 2004,* as amended from time to time, which are referred to in this Manual as 'the Regulations'. The Regulations require that any measurement, calculation or estimate of noise or any test of a noise source for the purposes of the instrument must be made in accordance with the relevant requirements of the Manual.

This edition replaces the first edition of the Manual, which was issued by the then Director of Environmental Management in August 2004. It incorporates amendments notified in the Government Gazette of 13 July 2005 that were mainly related to vehicle operation and noise measurement and the chainsaw testing method. These amendments were previously only available in 'loose leaf' form. Several minor typographical errors have also been corrected.

The second edition has been issued by the Director of the Environment Protection Authority (EPA), as a consequence of the EPA taking effect on 1 July 2008.

Table 1 cross-references sections of this Manual with individual regulations in the Regulations. When making measurements of noise for the purposes of a regulation specified in column 1 of Table 1, the requirements of the corresponding section of the Manual specified in column 2 must be complied with, in addition to any relevant general requirements specified in Part A or Part B of the Manual.

Table 1 – Cross-reference of Regulations with sections of this Manual

Column 1 **Regulation number(s)**	Column 2 **Manual section number(s)**	Column 3 **Subject**
5	21, 22	Motor vehicles
17	22	Racing vehicles
6, 7	24	Specialised off-street vehicles
8	25	Motor vessels
17	25	Racing vessels
9	25	Outboard motors
10	26	Portable apparatus
11	27	Power lawnmowers
12	28	Chainsaws
13	29	Air-conditioners (including heat pumps)

1.2 Application of measurement procedures

The procedures in this Manual are presented as the definitive methods to be used for measuring, estimating, calculating and assessing sound pressure levels as required by the Regulations and any Environment Protection Policy on Noise.

1.3 Practical limitation to the correct execution of procedures

There are situations where variations to the procedures in this Manual may be desirable or necessary due to situations beyond the control of the person conducting the test or assessment. In such a situation the investigator is generally required to derive by appropriate measurement and calculation the results that the specified procedure would had produced. The regulatory authority must be consulted where such variations to procedures are considered necessary, and the approval of the Director Environment Protection Authority must be obtained.

The intention of such variations is to enable the assessment of compliance with a noise limit requirement in unusual situations where strict application of the measurement requirements may be difficult or impossible.

1.4 Supporting evidence – calculations and adjustment

In general, the noise measurement and assessment procedures result in sound pressure levels expressed in dB(A) or dB(A-adj). Calculations must be presented where required or used, and sufficient intermediate results should be provided to assist interpretation.

Adjustments, according to procedures presented in this Manual, may be required where the measured noise has intrusive or dominant characteristics. These adjustments and any other adjustments to basic results derived from field measurements or calculations must be quantified and clearly identified, and any supporting calculations and data must be presented.

1.5 Large data sets

Some measurements or assessments may require the presentation of the summary of large measurement data sets such as statistical distributions, frequency spectra or time series data. Where the measured data are critical to the final result, then the measured values should be provided in support of the result. If the data is used for descriptive purposes, then the data should be presented graphically or in some suitable summary form.

1.6 Organisation of this Manual

General requirements that relate to more than one measurement procedure are presented in Part B. Parts C to G provide methods and requirements that relate to particular noise sources and/or particular measurement situations.

2 STANDARDS USED IN MEASUREMENTS

2.1 Australian Standards

The following list of Australian Standards that relate to acoustics includes the Standards that are most likely to be relevant to environmental noise assessment and measurement. There are other Standards that may be relevant to particular situations.

- AS 1055 – *Acoustics - Description and measurement of environmental noise*
- AS 1217 – *Methods of measurement of airborne sound emitted by machines*
- AS 1259 – *Acoustics - Sound level meters*
- AS 1633 – *Acoustics - Glossary of terms and related symbols*
- AS 2012 – *Method for the measurement of airborne noise from agricultural tractors and earth moving machinery*
- AS 2021 – *Building siting and construction against aircraft noise intrusion*
- AS 2107 - *Acoustics - Recommended design sound levels and reverberation times for building interiors*
- AS 2187 – *Explosives – Storage, transport and use*
- AS 2363 – *Acoustics – Assessment of noise from helicopter landing sites*
- AS 2377 – *Acoustics – Methods for the measurement of railbound vehicle noise*
- AS 2436 – *Guide to noise control on construction, maintenance and demolition sites*
- AS 2659 – *Guide to the use of sound measuring equipment*
- AS 2702 – *Acoustics - Methods for the measurement of road traffic noise*
- AS 2900 – *Quantities and units of acoustics*
- AS 3671 – *Acoustics - Road traffic noise intrusion - Building siting and construction*
- AS/NZS 4476 – *Acoustics - Octave-band and fractional octave-band filters*

As Australian Standards are regularly reviewed, it is best practice to use the current Standard unless otherwise specified. Note that some useful information is contained in superseded Standards and is not necessarily carried over into subsequent revisions.

2.2 Other Standards

Other Standards that are referred to in this Manual are listed below.

- NZS 6808 - *Acoustics - The assessment and measurement of sound from wind turbine generators*
- ISO 9613 – *Acoustics – Attenuation of sound during propagation outdoors*

2.3 Manual takes precedence

For the purposes of the Regulations and any Environment Protection Policy on Noise, the requirements, notations and definitions in this Manual take precedence over any inconsistent requirement, notation or definition contained in any other document, including the Standards listed in sections 2.1 and 2.2.

PART B – GENERAL REQUIREMENTS AND PROCEDURES

3 FRAMEWORK

3.1 General

Ultimately, the noise measurement procedures presented in this Manual contribute to the control of acoustic energy at locations that are in some way sensitive to the level or quality of noise. To provide a consistent framework where various measurements at different locations can be inter-related, the following basic conceptual model of sound emission, propagation and potential annoyance is provided.

- Acoustic energy is emitted from specific items of equipment or machinery.
- The energy radiation pattern can generally be approximated by assuming that all sound energy from a particular item is emitted from a point source located at about the centre of the item. Some variation to this may be necessary for extended sources at close listening positions.
- The sound energy radiation pattern can generally be regarded as isotropic (i.e. the energy radiates equally in all directions) unless there is evidence to the contrary.
- The sound energy reduces with distance from the source in proportion to the inverse square of the distance between the effective point source and any listening position.
- The sound propagates through the air in relatively straight paths and can be subjected to various modifications such as atmospheric absorption and refraction, which become increasingly more significant with increasing distance from the source.
- The noise may be modified by the presence of sufficiently large objects that can reflect, absorb or screen sound. This can lead to associated increases or decreases in the sound pressure level at a particular listening position.
- Noise levels are measured with sound level meters that provide various signal averaging and analysis options. The measurement results are normally displayed in decibels (dB).
- The impact of environmental noise is likely to be greatest at locations where humans are associated with noise sensitive situations. Thus noise levels are generally reported in dB(A) which includes the A-weighting frequency response that corresponds to the sensitivity of the human ear.
- The main concerns of environmental noise generally relate to interference of such activities as sleep, relaxation and conversation.
- Various features of a particular noise, generally identified as tonality, impulsiveness, modulation and/or low frequency components, can increase its potential interference. These features tend to increase the information content of the particular noise and thus raise its audibility. The audibility of such a noise is also influenced by the level and characteristics of other ambient noise in the area.
- Non-acoustic factors that can influence the subjective audibility and annoyance potential of a particular noise include the subjective value of the activity generating the noise and the effectiveness or otherwise of any attempt to control the noise.
- Adaptation to the noise, past experience, individual differences and personality can influence the response of a particular listener.

3.2 Characterising the noise from a source

The measurement of noise from a specific source is normally carried out at positions near to the source where the sound pressure level of the noise from the source is significantly greater than the sound pressure level from all other noise. This is not a strict requirement as the contribution of this other noise can generally be calculated or measured. The sound measured at a sufficiently nearby position will generally provide a close representation of the sound actually emitted from the source. Any characteristics of the emitted sound, such as the presence of tonal components or variation in amplitude, can be quantified from these close measurements. Note that any adjustments must be consistent with subjective assessment at the measurement location.

Sometimes it is convenient to obtain or calculate the **sound power** (i.e. the rate of emission of acoustical energy) of a noise source so that sound pressure levels can be predicted at a variety of locations. Characteristics of the resulting sound pressure levels can be applied to the sound power of the corresponding noise source.

3.3 Varying noise levels and measurement options

If the amplitude of the sound power output of the source varies with time, then a suitable averaging technique or statistic that yields a concise and appropriate measure of the sound level is required. There are several alternatives that need to be considered when deciding on the appropriate statistic. If the sound level of the source in question varies, then the audibility is most likely controlled by the higher levels of noise which are best described by the higher percentile statistics such as the $\mathbf{L_{10}}$ (i.e. the noise level exceeded 10% of the time). On the other hand, if the noise from the source under investigation is virtually constant, any variation to the measured sound pressure level is likely to be from other sources and a low percentile statistic such as the $\mathbf{L_{90}}$ is appropriate. The majority of noise sources tend to fit between these two situations where there is some variation in the sound output. In these cases the $\mathbf{L_{eq}}$ (i.e. the equivalent continuous sound pressure level) is generally used for such measurements.

When making measurements of a particular source of noise, time periods when the noise source is not dominant at the measurement location may need to be excluded from the active measurement time. This is particularly true for L_{eq} measurements that can be influenced by other, louder noise because the logarithmic averaging used in the L_{eq} determination gives greater weight to the higher sound pressure levels. Most sound level meters that can measure the L_{eq} are equipped with a pause button for this purpose.

Impulsive noise is characterised by short duration, high sound pressure levels. These events are measured with an **impulse** sound level meter that detects the sound pressure level averaged with a time constant of 35 ms. To be able to record this short-duration level, the meter incorporates a maximum-hold circuit. Note that there is also a **peak** detector option on many meters which detects the sound pressure level averaged over 25 µs which also requires a maximum-hold circuit. Unfortunately the maximum-hold option is often referred to as peak-hold which can lead to some confusion.

Non-impulsive measurements are normally made using a meter that includes **fast** averaging with a time constant of 125 ms, although some measurements are made using **slow** averaging with a time constant of 1000 ms. Peak, impulse, fast and slow averaging options are generally regarded as non-integrating measurements.

Integrating sound level meters can average sound levels over much longer periods usually extending from minutes to hours and provides the final averaged result as the L_{eq}.

The short term averaging options of peak, impulse, fast and slow are also used in conjunction with the L_{eq} integration.

The terms *peak*, *impulse*, *fast* and *slow* have strict technical meanings when applied to the time response of a sound level meter, which are based on the historic and less formal use of the words on older sound level meters. In Australian Standard AS1259 the terms are replaced by the letters I, P, F and S to differentiate between the technical and historic use of these words. Both the words and the initials must be used in line with their technical meaning for matters that relate to the Regulations, and Environment Protection Policy on Noise, and this Manual.

Hand-held statistical sound level analysers are now quite common and, in the field of environmental noise measurement, the more historic sound level meters that provided only fast and slow averaging time constants have generally been replaced by combined integrating/statistical sound level meters. It is very important that the correct interpretation be attached to the various measurements made with any instrument and this is particularly true for statistical and integrating meters. When using a meter with a relatively short term averaging time constant the investigator can assess, on the run, the influence of extraneous noises on the sound pressure level result. If necessary, the investigator can wait for a suitably stable result to be displayed on the meter at a time when the source under investigation is clearly dominant. However, such influences may not be so obvious to the investigator where the results are presented by the meter at the end of an extended measurement period.

Field loggers that compute and record statistical values such as L_{max}, L_{10}, L_{50}, L_{90}, L_{min} and L_{eq} for consecutive measurement periods of the order of 10 minutes are also becoming a standard resource for environmental noise measurement. These units are fairly robust, can be left outdoors and have the capability to record for several weeks without attention. The problems alluded to above regarding the influence of extraneous sources of noise can be severe for a noise logger because there may be no valid identification of the actual noise sources that lead to any of the measured results.

Direct investigator observations are particularly important when assessing results from field measurements. The ability of direct observation to identify the significant sources of noise can greatly extend the potential use of the results and can assist the interpretation of unattended results from noise logging instrumentation. The use of audio recording equipment such as magnetic tape recorders may assist in associating particular measured results with particular noise sources.

Many of the issues of relating the measurement to a particular noise source as outlined above become more critical when the noise from a particular source is embedded in noise from a variety of other sources and is clearly not the dominant noise at the measurement location.

3.4 Sound pressure level versus sound power level

The sound level measured at a specific distance from a source can be used to calculate the sound power output of the source. In turn, the sound power of the source can be used to calculate the sound pressure level at other locations away from the source. This scheme can be very useful when quantifying the sound pressure level from a source at a particular location that is difficult to measure directly due to lack of easy access or due to the existence of other noise at the particular site. This scheme can be extended to calculate the resulting sound pressure levels over an area from one or more noise sources.

For simple isotropic acoustic radiators the relation between sound pressure level and sound power level is independent of radiation direction. For a particular listening area, the sound power level of a source should generally be considered as the sound power level that gives rise to the sound pressure levels in the area of interest. Where a sound source is unlikely to produce isotropic acoustic radiation, it is necessary to include directional or spatial details in any sound power level determinations.

If the source is moveable, then the sound power output should be taken as the maximum output from all applicable directions. If the source is fixed, then the sound power in a given direction should be used to calculate resulting sound pressure levels in that particular direction.

3.5 Noise attenuation with distance from the source

The relationship between the sound power of a noise source and the resulting sound pressure level at a particular location is influenced by a variety of physical processes. The relative importance of these processes is influenced by the source-receptor distance, topographic and ground-cover characteristics of the intervening land and the prevailing meteorological conditions.

For the purposes of the procedures and measurements detailed in this Manual, any calculation of the attenuation of sound with distance from the source should be as simple as possible and should always be conservative – i.e. tend to under-estimate attenuation particularly at ever increasing distance from the source where more complex propagation paths can occur.

In the absence of more detailed information, International Standard ISO 9613, Acoustics – *Attenuation of sound during propagation outdoors*, is to be used as a basis for the general interpretation and/or understanding of the attenuation of sound as it propagates away from the noise source. There are other schemes that can be used to estimate the attenuation of sound outdoors and there are some published papers that address various aspects of sound propagation that may be helpful for particular situations.

Where the source to receptor distance is relatively short, the relation between the sound output power of the noise source and the resulting sound pressure level at a particular location is essentially the sound power per unit cross-section area at the receptor position. For an isolated point source this is equivalent to the inverse square law for spherical dissipation. A common situation in environmental acoustics is the location of a source immediately above the ground. In this case, a relatively small amount of the emitted energy is absorbed by the ground and the majority of the emitted energy spreads out **hemispherically** into the air space around the source.

The atmospheric absorption of sound, measured in dB/km, is predominantly dependent on the frequency of the sound, air temperature and humidity, and air pressure to a lesser extent. Beyond some distance from the source, atmospheric absorption will become sufficiently large and will need to be included in the calculation of attenuation with distance.

At 15°C and 30% relative humidity, atmospheric absorption occurs in accordance with the following table (data from ISO 9613).

Frequency (Hz)	Absorption (dB/km)

50	0.14
100	0.44
315	1.5
1000	5.5
3150	41
10000	257

It can be seen from the table above that the attenuation due to atmospheric absorption increases rapidly with the frequency of the sound, thus the frequency of the sound has a critical influence on the distance beyond which air absorption must be included in sound power to sound pressure level or inverse calculations. Although the human ear tends to be more sensitive at frequencies above 1000 Hz, many sources of noise have greater sound output at lower frequencies, and both features must be considered when deciding whether to include atmospheric absorption in any calculations. As a guide, where the peak frequency is below 1000 Hz the inclusion of atmospheric absorption is not necessary for source to receptor distances less than 250 metres.

Other aspects that can influence the attenuation of sound include:

- ground effects that generally result from the interference between sound reflected by the ground and sound that propagates directly to the receiver;
- attenuation due to barriers such as topographic features or physical structures;
- attenuation due to propagation through spaced structures (foliage, industrial components and houses) where absorption, scattering and screening may occur; and
- the vertical air temperature profile and the vertical wind speed and direction profile that can influence the direction of propagation of sound rays.

Long distance predictions of sound propagation may have to include one or more of these influences, depending on the source to receptor distance and site specific considerations. The magnitude of some of these effects can be quite large and so some caution is needed in their use. Some effects exclude or modify other effects.

In general, calculations of sound pressure levels for long distance propagation should assume a downwind propagation direction and exclude other meteorological effects as indicated in ISO 9613.

3.6 Special terms

There are some descriptive terms that are often used in environmental noise measurement and assessment that have been given specific meanings in standards or legislation. Sometimes the use of these terms without some qualification can lead to ambiguity. For example, terms such as *ambient* and *background* should be used with care, and should be qualified where ambiguity could arise. Refer to the *Glossary of Terms* at the end of this Manual for the interpretation of technical terms.

4 INSTRUMENTATION REQUIREMENTS

4.1 Types of sound level meters

Sound level meters used for the procedures specified in this Manual must comply with either Type 1 or Type 2 precision as described in Australian Standard AS 1259. The 'Type' precision is normally indicated in the meter specification documentation. Sound level meters used for environmental noise measurements are normally Type 1 meters but this is not necessarily a strict requirement. Type 2 meters can be used provided that the requirements of the measurement are within the meter's specifications. In particular, the noise floor (i.e. the inherent noise of the instrument) of a Type 2 meter may be above the quiet ambient noise level in some areas. Type 1 meters generally exhibit lower noise floors than type 2 meters. In any case of dispute, measurements taken with a higher precision instrument will take precedence over measurements taken with a lower precision instrument, all else being equal.

It should be noted that Type 1 meters are generally intended for laboratory and precision use and Type 2 meters are intended for field use. It is likely that the precision of field measurements made with a Type 1 meter will be limited more by the environmental conditions than by the precision of the meter.

To ensure accuracy and stability of a sound level meter and to reduce to the practical minimum any differences in equivalent measurements taken with instruments of various makes and models, quality control and checking procedures must be included as part of normal operations.

4.2 Traceable measurement standards

All sound pressure level instrumentation used to determine noise levels in accordance with the procedures in this Manual must comply with the *National Measurement Act 1960*. The output level of a sound level calibrator must be traceable to an appropriate Australian measurement standard as defined in section 10 of the *National Measurement Act 1960*.

4.3 Calibration and Certification

The complete measuring system, including reference sound sources, sound level meters, octave sets, etc., must be calibrated over the full frequency and dynamic ranges in accordance with the appropriate Australian Standard where applicable. A comprehensive calibration by a certified calibration laboratory must be carried out at intervals appropriate to the long-term stability of the equipment. A one or two year interval is normally acceptable for sound level meters maintained in good working order. Sound level meters must have been calibrated within two years prior to their use in measurement procedures made in association with requirements of the Regulations and any Environment Protection Policy on Noise.

Where uncertified instrumentation is used for supportive measurements, procedures must include appropriate performance and reference checks against certified equipment. This would normally apply to chart recorders and tape recorders which are not an integral part of a measuring system.

4.4 Microphone Support

Unless otherwise stated, measuring microphones must, wherever practicable, be supported on suitable stands. For microphones located at or above 1.2 metres above ground level a conventional tripod of substantial construction is acceptable.

It is normally acceptable to have the microphone attached directly to the body of the sound level meter which is in turn attached to the stand. At particularly low sound levels it is advisable to mount the microphone directly on the stand and use a cable to connect the microphone to the body of the meter. This procedure is used to minimise the influence of the operator on the sound level measurement results.

The sound level meter and attached microphone may be hand-held for short term measurements of relatively high noise levels, such as vehicle exhaust sound level measurements.

4.5 Training

The officer taking sound pressure level measurements must be familiar with the use of the particular sound level measuring instrumentation and the relevant procedures in this Manual.

5 MEASUREMENT REQUIREMENTS

5.1 Scope

Measurement requirements that are applicable to a number of sections of this Manual are detailed in this section.

General requirements relating to the following are included:

- measurement sites;
- other noise including extraneous noise;
- local meteorological conditions;
- observer position;
- measurement; and
- dimension tolerances.

5.2 Measurement sites

Measurement site specifications for the individual procedures vary and are generally specified in each measurement procedure. In most cases the specified sites provide acoustic conditions closely approaching a free field above a reflecting ground plane. If a specific measurement situation is not indicated then free field above a reflecting ground plane is to be assumed (i.e. the microphone position is not influenced by any acoustically reflecting surfaces except the ground, which is assumed to be totally reflective).

Measurement sites must be located so that adjacent buildings and/or topographic features do not introduce acoustical focusing effects, unless such interference to free field propagation causes an increase in sound pressure levels at a receptor premises.

Unless otherwise specified, the measurement site must be located at least 3.5 m from any acoustically reflective surface other than the ground. If conditions limit the available measurement location to positions within 3.5 metres of such a surface then the measurement location should be positioned 1 metre from the surface. For the purposes of the procedures in this Manual and in the absence of other evidence, the sound pressure level at 1 metre from a single reflecting surface must be taken to exceed the value beyond 3.5 metre from the surface by 2.5 dB, and an adjustment of 2.5 dB must be subtracted from the measured results unless otherwise specified. This adjustment factor is provided as a straight-forward scheme to relate a measurement made away from a reflecting surface to a measurement made close to a surface. This adjustment should be used with caution and may not be appropriate when dominant tones are present.

Test sites used for the measurement of sound from discrete items of equipment must be located so that nearby obstacles, buildings and or topographic features do not introduce acoustic screening or focusing effects or result in the site being located between parallel vertical surfaces of significant area.

Unless otherwise specified, the measurement microphone must be located 1.2 metres above ground level.

If a measurement site is required on the boundary of a premises, but the microphone at its nominal height above the ground would be shielded by a fence, wall or dense hedge, then the microphone must be positioned 0.3 m to 0.5 m above the fence, wall or hedge, up to a maximum height of 2.5 m above the ground. Where it is not practicable to place the microphone on the boundary of the receptor premises, the microphone must be placed at a height of 1.2 metres above ground level and located at an appropriate position within the boundary of the receptor premises. Alternatively, it may be appropriate to locate the meter beyond 3.5 metres from the fence, wall or dense hedge at a position that is acoustically representative of the boundary of the premises. This may be appropriate where direct access to a private property is not available or needs to be avoided.

5.3 Other noise at the measurement location

Extraneous noise at a measurement site is regarded as noise that is not representative of the typical acoustic environment in the vicinity of the site. The most common example of extraneous noise at a measurement site located near a road is noise from cars that are travelling close to the microphone. Strictly speaking this noise is part of the acoustic environment but will be of less importance at measurement sites further away from the road, and may not be present if cars are not travelling on the road. Where possible, extraneous noise must be excluded from measurements.

Sound pressure level measurements of noise from a specified source should be made when the measured sound pressure level due to the source exceeds the measured sound pressure level due to all other noise by at least 10 dB(A). For equipment that can be stopped, this criteria is satisfied if the sound pressure level measured immediately before and after the item is tested, without the item contributing significantly to the measured noise level, is at least 10 dB(A) below the level measured during the test.

Where the difference is less than 10 dB(A) an adjustment should be made to the measurement following logarithmic dB(A) subtraction, or arithmetically from the following table.

Difference between the noise levels with and without the noise from the item of equipment	**Arithmetic adjustment subtracted from the measurement level**
>10 dB(A)	0 dB(A)
6 to 10 dB(A)	1 dB(A)
1 to 6 dB(A)	2 dB(A)
< 1 dB(A)	3 dB(A)

If the source under investigation cannot be stopped, the sound pressure level relating to all other sources of noise may have to be measured at a different location. If a different location is used when making such a reference measurement then a position must be chosen which suitably represents the acoustic environment at the main measurement position. Where the difference is less than 6 dB, it may be difficult to suitably differentiate the contribution from the noise source under consideration and an alternative measurement configuration should be considered where possible.

5.4 Local meteorological conditions

Noise measurements should not normally be made when the wind speed exceeds 5 metres/second (18 km/hour) due to the likely presence of excessive wind noise. The measurement of high noise levels, such as may occur for the in-service test for passenger cars and the test for chainsaws, may be acceptable under higher wind speed conditions.

Wherever practical, the effect of any wind influence on measured and averaged sound pressure levels must be minimised. These restrictions do not apply to the measurement of noise from wind farms.

A microphone windshield must be used for all outdoor measurements. Windshields must be of a type approved by the manufacturer of the sound level meter or microphone in use and any effect on the measured levels must be known. If this effect is significant, an appropriate correction to the results must be made.

Other meteorological conditions may influence the generation and propagation of noise. Appropriate observations should be noted where such an influence is possible. In general, temperature, wind speed, wind direction, cloud cover, relative humidity and rain condition should be noted.

Refer to section 10 for further procedures on meteorological matters.

5.5 Presence of people at a measurement site

The presence of a person near to a measuring microphone may significantly influence the sound pressure levels obtained. For critical measurements, it is recommended that an extension cable or remote control be used to allow the observer to be remote from the microphone. Where a cable, remote control or microphone extension is not available, the observer should stand to the side rather than behind the microphone. People, other than those critical to the measurement, should be excluded from the measurement site. Noise from talking, movement, noisy clothes etc. must be strictly excluded from any measurement.

5.6 Condition of an item of equipment under test.

Any item of equipment that is to be tested using the procedures in this Manual must be operating under normal conditions during the test. In particular, engines, gearboxes, transmission and hydraulic systems must have reached stable operating temperatures before measuring sound pressure levels. The person conducting the noise measurements must be satisfied that normal, stable operating conditions have been achieved. Where lubrication is required, the type and quantity of lubricant used must be as recommended by the equipment manufacturer.

5.7 Instrumentation

The complete measuring system must be in good working order and comply with the requirements of Section 4. A description of the equipment must be provided with sufficient detail so that another investigator could either duplicate the measurement system or construct a measurement system capable of duplicating the measurements.

5.8 Field checks

The performance of a sound level meter must be checked with a certified calibration source immediately before and after measurements are made, by following the recommended operating procedures for the sound level meter. Where the measurements are part of a survey that extends for many hours, it is recommended that the meter calibration should be checked more frequently. A discrepancy equal to or greater than 1 dB between consecutive checks may invalidate the results and should be investigated.

Normally, the calibration of a sound level meter is checked at about 94 dB(A) using a 1000 Hz acoustic calibrator. Any variation from this calibration method should be noted. Environmental noise levels are often significantly lower than 94 dB(A) and it should be appreciated that this single point calibration does not necessarily confirm correct operation at significantly lower sound pressure levels. It is important that the investigator is sufficiently skilled in the use of sound measurement equipment within the range of expected sound levels.

In general, long-term deployed noise loggers will not be able to be calibrated by an independent calibration system except at the beginning and the end of the deployment. Critical applications may require support measurements by a second, calibrated meter set up on regular occasions near the noise logger. Consistent measurement stability of a microphone system should not be assumed where the system is subject to variable weather conditions, rain, strong wind, high humidity or temperatures below about 4°C.

When a sound level chart recorder is used, it will normally be connected to the output of a pre-calibrated sound level meter. The calibration of a sound level chart recorder should include a recorded level on the chart that corresponds to the signal from an acoustic calibrator coupled to the microphone, such that the whole system is calibrated. It is likely that the dynamic range of the chart recorder will have to be changed after calibration by either adjusting the sensitivity of the sound level meter or the chart recorder. This must be done using pre-calibrated step attenuators, such as the range control on the meter. Correct operation of the attenuator should be confirmed by noting the change of the chart recorder output trace. The working range must be written on the chart. Several confirmatory levels, read from the display of the sound level meter, must be written on the corresponding section of the chart.

Tape recording systems can be calibrated in a similar way to chart recorders where suitable recording levels can be identified by the recorder's level display. Magnetic tape recorders must be used with caution as they generally have a limited dynamic range and may not have a particularly constant record-playback response. Digital recording techniques should provide a more stable response, but a suitable check should be made to confirm the dynamic range and frequency response.

5.9 Noise level readings

Controls of the sound level meter must be set as indicated by the relevant sections of this Manual. Where control settings are not given, the meter must be set to fast time response and A-weighted frequency response. The result must be read directly from the meter's display where averaging or statistical analysis is not required. If more complex measurement procedures are required, the measurements must be made for the required duration and the results must be recorded in a suitable form. All attended measurements should be accompanied by a written record of the measurement conditions and subjective notes.

5.10 Interpretation of meter reading

The types of measurements to be made under the procedures in this Manual and the types of sound level meters suitable for making these measurements are very diverse. In particular, meters fitted with analog displays will tend to require a different interpretation style than a meter fitted with a digital display.

When the output of the meter is steady the displayed value must be taken as the sound pressure level. If the output of an analogue meter indicates a fluctuating sound level the result must be taken as the mid-point of the maximum and minimum swing of the meter's readout. Alternatively, the meter must be set to measure the Leq and this value, integrated over a suitable period of not less than fifteen seconds, must be measured and reported.

Other values such as statistical L_n values are generally only produced by automated measurement systems and the results are presented directly on the meter's digital readout.

Sound pressure levels are to be reported in dB (decibels) relative to 20 micropascals.

Sound pressure levels must be reported to either the nearest whole dB or to the nearest one-tenth of a dB, consistent with the numerical or analog display of the meter. Many of the measurement protocols in this manual have specific averaging and rounding requirements.

5.11 Time measurements

The time of day of any measurement must be noted to an accuracy of +/- 5 minutes. The duration of measurement periods for statistical and/or integration measurements must be measured and noted to an accuracy of +/- 5% of the duration.

5.12 Dimension Tolerances

All linear distances, including the distance from a microphone to the ground and the distance from a microphone to a sound source, must have a tolerance of +/- 10%.

All radial angles must have a tolerance of +/- 10°.

5.13 Tachometers

Tachometers used to measure engine operating speeds must be accurate to ± 5% of the indicated reading.

A tachometer must have been calibrated using a suitable stable reference signal no longer than two years prior to its use.

6 ADJUSTMENT FOR INTRUSIVE OR DOMINANT CHARACTERISTICS

6.1 General

Where a sound contains intrusive or dominant characteristics, the measured sound pressure level must be adjusted where measurements are made for the purposes of any Environment Protection Policy on Noise. The individual adjustments for tonality, impulsiveness, modulation and low frequency are specified in the following sections.

If a sound contains more than one of the characteristics, then all applicable individual adjustments must be made and the adjustments are all linearly added to the measured level.

If the total adjustment exceeds 10dB, the total adjustment is to be regarded as 10dB.

The adjusted sound pressure level must be identified using the units dB(A-adj).

6.2 Tonality

Where a noise emission has a tonality characteristic, the following adjustment must be made to the measured sound pressure level.

With the sound level meter set to A-weighted frequency response, a one-third octave spectrum must be measured. The one-third octave spectrum should be measured over a period of at least 1 minute and less than 30 minutes. Several additional one-third octave spectra should be measured to confirm the temporal stability of the measurement.

A tonal band adjustment determined from the following formulae must be arithmetically added to the sound pressure level in each one-third octave band between the centre frequencies of 25 Hz and 16 kHz for which the sound pressure level exceeds the arithmetic average of the two adjacent one-third octave band sound pressure levels by more than 3 dB(A). Tonal band adjustments need not be applied to those bands for which the band level is 25 dB(A) or more below the highest band level.

For the range 1,000 to 5,000 Hz the following formula applies:

Tonal band adjustment (dB) = 0.35 x (Tonal band SPL minus average of adjacent band levels) + 4.31

For the ranges <1,000 Hz and >5,000 Hz the following formula applies:

Tonal band adjustment (dB) = 0.26 x (Tonal band SPL minus average of adjacent band levels) + 2.49

The overall A-weighted sound pressure level tonally adjusted (L_{Tadj}) must be calculated from the following equation:

$$L_{Tadj} = 10 Log \sum_{i} 10^{(Li/10)}$$

where *i* refers to the ith one-third octave band and *Li* is the adjusted sound pressure level in the ith one-third octave band.

The adjustment applied to the measured A-weighted sound pressure level is L_{Tadj} minus the measured A-weighted sound pressure level.

This adjustment scheme assumes that the tonality is due to one or several well separated peaks in the frequency spectrum. This scheme may not be applicable to sound that includes many spectral peaks (possibly from several unrelated items of equipment). Where the one-third octave scheme is not applicable or if the one-third octave spectrum can not be measured, an adjustment of 5 dB is to be added if the sound under investigation is audibly tonal.

6.3 Impulsiveness

A sound is considered to have an impulsiveness characteristic if it includes rapid, short changes in amplitude.

An impulsiveness adjustment is determined by taking a measurement when impulsive noise is observed using a sound level meter set initially to fast and then impulse time response. If it is found after taking measurements with these two time responses that the impulse level is greater than 2 dB above the fast response measurement, then the difference is the impulsiveness adjustment.

Where an impulse measurement cannot be made, perhaps due to the response time of the sound level meter, then the impulsiveness adjustment must be 2 dB if the impulsive noise is just detectable, and 5 dB if it is readily detectable.

6.4 Modulation

Modulation means a variation in the sound pressure level when measured with fast time response that is:

(a) more than 3 dB, or is more than 3 dB in any one-third octave band;
(b) present for at least 10% of the representative assessment period; and
(c) regular, cyclic, and audible.

If modulation is a characteristic of the sound within a measurement time interval, an adjustment must be made to the sound pressure level measured over that period.

The modulation adjustment must be equal to the magnitude of the variation in the sound level.

6.5 Low frequency

A noise has a low frequency characteristic if it contains significant energy within the frequency range 20 Hz to 250 Hz. If low frequency is a characteristic of the noise within a measurement time interval, an adjustment must be made to the sound pressure level measured over that period.

The adjustment must be based on the difference between the measured A-weighted sound pressure level and the C-weighted sound pressure level. If this difference is greater than 15 dB(A), then the low frequency adjustment is 5 dB.

7 STATISTICAL ANALYSIS

7.1 General

The sound pressure level at a particular outdoors location generally varies due to fluctuations in the noise levels from the various noise sources in the area. Features in the statistical distribution of noise levels can provide information on the duty-cycle of intermittent noise sources, the characteristics of moving noise sources and the magnitude of meteorological influences on sound attenuation. Statistical analysis of the noise levels can be used to identify the contribution of various sources and can be used to characterise the noise at the location.

The statistical analysis is carried out on a set of sequential sound level measurements, typically measured at a rate of 10 measurements per second. These measurements are accumulated for a total measurement period of typically between 5 minutes and one hour. The statistical distribution of noise levels is generally described using L_n values, which are the noise levels exceeded for the indicated proportion of the measurement period. Thus, the L_{10} level is the noise level that is exceeded 10% of the period.

7.2 Measurement

The general shape of the noise level distribution can be described by a limited set of L_n values. Normally this includes the L_{95}, L_{90}, L_{50}, L_{10} and L_5 values. Some sound level meters have the ability to measure this limited range of statistics, and measurement requirements are basically the same as for any other noise measurement with regard to meter location, calibration and use.

More detailed statistical distributions may be required to identify and measure the sound from a specific activity. These distributions can be measured with special purpose statistical analysers that have L_n -value resolutions down to 1 dB(A), i.e. L_{99}, L_{98} to L_1 can be measured simultaneously. It should be appreciated that sound level meters have a limited range of sound levels that can be measured without changing the sensitivity scale of the meter, sometimes referred to as the dynamic range. A statistical analyser can only classify sound pressure levels within the range of the instrument, thus the most appropriate range of the instrument should be selected prior to starting the measurement period. Other requirements for conventional sound level meters are generally applicable.

All analyser settings must be noted, including the duration of the measurement period and the sample frequency rate.

8 SPECTRAL ANALYSIS

8.1 General

Sometimes it is desirable to separate a noise into its component frequencies. Measurements and calculations that are required by sections of this Manual may require supportive spectral analysis measurements. In particular, the adjustment for tonality requires the measurement of one-third octave band spectra, and noise propagation calculations may require either one octave or one-third octave band sound power spectra. Source identification may require the measurement of one-third octave spectra and/or narrow-band spectra typically with a resolution of 1 Hz.

8.2 Measurement

A purpose built sound level meter with appropriate filter or analysis unit, or a sound level meter coupled to a signal frequency analyser, can be used for frequency analysis. Some systems can measure all spectral components concurrently and some measure them sequentially. When using a sequential filter system, measurements must be taken over sufficient time to ensure all frequencies are sampled – such as when using a single band-pass filter that is stepped across the frequency range of interest.

The measurement duration for frequency analysis needs to be carefully considered. This is influenced by the likelihood of extraneous signals disrupting the measurement of the noise under investigation. Narrow-band analysis may also be influenced by small temporal variations of the emitted noise. A particular narrow-band signal, such as the harmonic from a rotating fan, will not remain constant if the speed of the fan is changed. Thus, it is generally desirable to keep the measurement period of narrow-band analysis relatively short.

When measuring a one-third octave spectrum for tonality adjustment, the measurement period should be as long as reasonably possible, with due regard to possible disruptions. Typically this should be about two minutes, although shorter periods may be acceptable. Octave and one-third octave spectra measured with no weighting (i.e. linear frequency response) can be used for determining weighted noise levels, such as A-weighted and C-weighted sound pressure levels which can then be used for the assessment of low frequency adjustment.

Narrow-band frequency analysis should be used for source identification and investigative work. The spectral signals presented may not be directly indicative of annoyance.

9 SOUND POWER LEVELS

The majority of this manual addresses measurement of sound pressure levels. However, sound power levels are also sometimes required, for example for use in calculating and predicting sound pressure levels.

The calculation of sound power levels from measured sound pressure levels (or vice versa) is normally a matter for an acoustic specialist. Where such a calculation is necessary, the calculation procedure must be clearly stated, and must generally be consistent with International Standard ISO 9613, Acoustics – *Attenuation of sound during propagation outdoors*.

Sound power levels are to be reported in dB relative to 1 picowatt (i.e. 1×10^{-12} watts).

Equipment sound power levels can often be obtained from the equipment manufacturer. These data can be used for the prediction of sound pressure levels from one or more discrete items of equipment, in the absence of direct measurements.

The sound power emitted by a source can be expressed as a single number, such as the A-weighted sound power level, but sound power has spectral characteristics analogous to those of sound pressure and it is more common to express the sound power of a source as a power spectrum.

The total sound power of a collection of sound sources, such as an industrial facility, may be lower than the sum of the sound powers associated with the individual sources, due to factors such as acoustic screening and absorption within the facility.

10 METEOROLOGY

10.1 Introduction

Local meteorological conditions can influence both the level of the ambient noise in an area, due to such processes as wind turbulence, and the efficiency of propagation of noise from a particular noise source to particular listening position. These influences can be important but may not be identifiable for an investigator when working in the field. It is thus common practice to record local meteorological conditions when making outside sound pressure measurements.

The following sections provide suitable standards for meteorological measurements.

10.2 Wind

Wind speed should be measured using hand-held instrumentation, such as a hand held cup anemometer with an accuracy of +/- 1 m/s. Wind direction is generally determined with a conventional compass to the nearest of 8 compass sectors.

10.3 Temperature and relative humidity

Temperature and relative humidity should be measured with a suitable wet and dry bulb thermometer set or appropriate solid-state sensor instrumentation.

The atmospheric temperature should be measured using an instrument with an accuracy of ± 1º C, and the relative humidity should be measured using an instrument with an accuracy of ± 5%.

10.4 Rainfall

It is preferable to refrain from sound pressure level measurements during rainfall, as rain noise can increase the sound levels and high humidity and direct exposure to rain may damage sensitive equipment. The likelihood of rain should be noted.

10.5 Cloud cover

Cloud cover may provide an indication of the state of the lower atmosphere and should be noted in oktas (i.e. eighths) or tenths covered.

10.6 Barometric pressure

Barometric pressure has only a minor influence on noise. It should be measured with either an aneroid or solid-state barometer.

11 NOISE ATTENUATION CALCULATIONS

11.1 Introduction

The calculation of residual sound pressure levels from one or more discrete noise sources can be a useful tool for both the assessment of potential noise impact from new industrial and infrastructure proposals, or for investigating the propagation of noise from existing activities into nearby areas.

There are several schemes for calculating the sound pressure level at a distance from a source of known sound power output. The schemes range in complexity from basic source to receptor calculations to complex spatial models requiring detailed topographic, ground type and meteorological information. A noise propagation model is regarded as a calculation scheme that may or may not have been coded to run on a computer. The scheme can be based on theory or generalised empirical results.

11.2 Calculation considerations

The residual sound pressure at a receptor site is influenced by:

- geometrical spreading;
- atmospheric absorption;
- ground effects;
- meteorological effects;
- barriers; and
- near-source and near-receptor screening.

Geometrical spreading from a point source is the well-established attenuation due to energy divergence given by the equation:

$$\mathbf{A_{div} = 10 \log 4\pi d^2 \ dB}$$

where **d** is the source-receptor distance in metres. This tends to be the dominant attenuation for source-receptor distances less than about 250 metres and frequencies below 2000 Hz. Most close-range sound power to sound pressure level conversions can be based on this relationship.

The attenuation due to atmospheric absorption is due to several mechanisms and is principally a function of the frequency of the sound, air temperature and relative humidity. This attenuation is strongly dependent on frequency and its importance increases with increasing source-receptor distance.

The ground effect in its simplest form results in an increase of 3 dB for acoustically hard ground, and this is normally included in sound power to sound pressure conversion calculations by assuming all energy radiates hemispherically from the source. Various calculation schemes have different adjustments for different ground types.

Meteorological effects can modify the direction and divergence of sound energy radiating out from a source. The Calculation of meteorological effects is generally based on generalised empirical results, but the magnitude of these effects can be significantly influenced by specific local climatic features.

Barrier attenuation is generally calculated from diffraction theory. The influence of downward-curving sound ray trajectories due to temperature inversion conditions (i.e. an increase in temperature with increasing altitude) can significantly reduce barrier attenuation.

Near-source screening due to other objects, plant, equipment and/or buildings, and near-receptor screening due to vegetation can provide acoustic attenuation. Unless it can be shown that the attenuation due to screening is significant and is likely to remain unchanged, such attenuation would be regarded as unreliable.

11.3 Calculation requirements

For the purposes of any Environment Protection Policy on Noise, the procedures in International Standard ISO 9613 – *Acoustics – Attenuation of sound during propagation outdoors* are acceptable for predicting sound pressure levels. Any subset of these procedures that produce equivalent or higher sound level predictions are also acceptable. This option is provided so the assessment of less critical situations can be based on simpler modelling requirements.

There are several different treatments of the influence of meteorological conditions that can be used when calculating sound attenuation and predicting sound pressure levels. Calculations should assume downwind propagation as detailed in ISO 9613 unless sufficient information is available to justify an alternative approach.

Other calculation procedures must be approved by the Director.

12 RECORDS OF FIELD MEASUREMENTS

The procedures in this Manual cover a wide range of situations and measurement requirements. Some field measurements may be suitably recorded by a handwritten summary of actions and observations. More complex measurements that include the collection of frequency spectra and statistical distributions will have to rely on equipment with hardcopy print-outs and/or internal storage of recorded information for later transfer to computer. An audit trail for these measurements must be maintained for a period of 1 year after submission of any report of the results to a regulatory authority.

A sample record sheet for simple applications is supplied at Appendix 1. The report number on the sheet may be assigned by the testing authority for internal record keeping purposes.

It is vital that sufficient subjective notes be included with field records to place the measurements in their correct context.

13 NOISE SURVEYS RELATING TO A PARTICULAR ACTIVITY

13.1 General

The general purpose of noise measurements and surveys is to provide an objective description of the acoustic environment surrounding a particular activity that is emitting noise. Such activities can range from single items of machinery to entire industrial estates. Basic measurement requirements are provided in other sections of this Manual and this section provides additional requirements that are relevant to specific measurement situations and to noise surveys.

Any measurement of noise from a particular activity needs to address several basic requirements as discussed in the following section. It is important to remember that the results of sound pressure level measurements generally require a suitable subjective description of the sounds heard at the measurement location at the time if the measurement. A survey, consisting of multiple measurements at multiple sites, should be considered to be a set of individual measurements, each with supportive subjective notes.

A survey should be carried out in the course of a noise assessment of an activity or an acoustic conditions assessment of a development site. It is unlikely that an extensive noise survey will be required for the purposes of the Regulations.

It is normal practice to consult with the responsible regulatory authority regarding detailed studies and/or assessments.

13.2 Measurement of noise from an activity

The aim is to establish the sound pressure level, at a specific location, of the sound emanating from the activity under investigation. Some suitable procedure is required to remove or allow for other ambient sound at the measurement location. This is discussed in section 5.3, but more complex situations may require the use of statistical or frequency spectrum analysis.

Where the emitted sound is relatively constant and sufficiently dominant, the L_{90} statistic may provide the best indication of the sound pressure level of the sound under investigation. This is because the variations, and particularly the higher-level variations, are often due to other sources of noise (such as passing cars). Where the emitted sound is varying, it will be necessary to average the sound as the equivalent continuous sound pressure level (L_{eq}) over a suitable, representative time period. If this averaging period is not specified, measurements are normally averaged over 10 to 20 minutes. Measurement periods outside this range should be justified with reference to characteristics of the various sounds present at the measurement location.

13.3 Measurement site selection

Measurement sites should generally be chosen to represent free-field conditions, and should be located as discussed in section 5.2. Where the sound from an activity is to be measured at a parcel of land, the measurement site must be representative of the maximum level of sound from the activity under investigation as received anywhere on the parcel of land.

Measurement sites should be chosen to provide insight into the propagation of noise from the activity into surrounding areas, particularly those that may be sensitive to noise. It is not necessary to cover all noise sensitive areas, but the layout of chosen measurement sites should provide sufficient information for extrapolation into any noise sensitive premises likely to be impacted.

For a survey, most of the measurement sites should be chosen where the noise from the operation is clearly audible so that the noise level from the operation can be quantified. The distribution of measurement sites should extend sufficiently far away from the activity so that at least one measurement site is representative of the general ambient noise conditions, excluding any noise from the activity.

Where a noise survey is carried out around an activity that has been previously surveyed, it is often desirable to use the same measurement sites that were used in the previous survey so that a direct comparison of the results from the two surveys can be made. Although this is generally a reasonable method of selecting measurement sites, the investigator should carefully reconsider the merits of the original sites and be prepared to change locations if some of the original sites are not ideally located. If all the original sites are considered to be inappropriate then some limited measurements should be made at more than one of the original sites to provide some comparison with previous measurements.

13.4 Times of measurement

The time of the day when the measurements are made should be chosen carefully. The selection of measurement times needs to consider:

- the hours of operation of the activity;
- possible changes in the level of noise from the activity due to scheduled operations;
- the typical diurnal change in noise levels due to daily weather patterns and daily transport activities; and
- the possible need to assess noise levels during the day, evening and night time.

The influence of noises that are likely to change, such as wind, insect and traffic noise, should be considered during the survey as it may be appropriate to re-measure one or more of the sites at a later time. There are generally practical and economic constraints on survey work and it is possible that prevailing meteorological conditions may not be ideal at all times during a survey. The order in which measurement sites are visited should be scheduled to minimise undesirable acoustic interference where possible.

13.5 Types of measurement

The type of measurements employed will be dependent on the purpose of the survey. Inter-site comparison of results is often necessary to estimate the contribution of noise from specific sources, and it is thus desirable that similar measurements are carried out at each site. The use of statistical and frequency analysis for identifying sound from specific sources may be necessary, although careful subjective assessments generally provide a significant level of support to the objective measurements. Unless a particular noise source is dominant above the contributions of all other noise, the directly measured noise levels and characteristics cannot be assigned solely to the particular noise source.

Automated recording equipment can be very useful for measuring the temporal variations and statistical distributions of sound pressure levels. These types of measurement can provide very robust quantification of various types of sound pressure signals. It is important to support these types of measurement with a suitable level of interpretation to clearly identify the sound pressure level that can be ascribed to the activity under investigation.

The need for adjustment in accordance with section 6 should be considered at each measurement site.

13.6 Additional details to be recorded

Apart from actual noise measurements that are recorded at each site, it is important that some supportive notes are recorded to aid interpretation by somebody who is not directly aware of the noise conditions in the area under investigation.

The most important item to record is a subjective summary of the sounds heard at each measurement site at the time of measurement. The audible sources should be subjectively ranked to indicate how the noise from the activity under investigation compares to other noises as heard at the measurement site.

If the survey is likely to extend over several hours, some general meteorological observations should be recorded at each site. The purpose of these observations is to identify changes in conditions that may influence the propagation of sound or directly influence results. Temperature, wind conditions and cloud cover are generally sufficient for this purpose.

13.7 Influence of meteorological conditions

When measurements are being carried out to assess compliance with environmental noise limits, measurements should be made during conditions of downwind propagation. It is unlikely that all measurements of an extensive survey could be made under these conditions. In most cases, the atmospheric conditions that produce the most significant influences on sound propagation are beyond normal measurement capabilities. These include the vertical temperature profile and the vertical wind speed profile. The existence of particular meteorological conditions that lead to specific modes of acoustic propagation can often be judged from the observations suggested in section 13.6.

For critical situations where concerns about the acoustic environment have been expressed, it may be necessary to make compliance verification measurements within a specific range of meteorological conditions. For non-critical situations, it may be possible to provide suitable estimates of the sound pressure level by suitable calculations based on the measured results from other, suitable locations.

13.8 Reporting

In addition to the general requirements and the requirements of particular measurement procedures a report of a noise survey should include a clear, scaled map showing the locations of the activity, measurement sites and possible noise sensitive locations. It is expected that the report will include:

- survey details, including times, dates, locations;
- a location map;
- details of the source of noise under investigation where appropriate;
- details of subjective observations;
- a summary of the meteorological conditions;
- measurement results; and

- appropriate interpretation.

14 BACKGROUND NOISE LEVEL

14.1 Introduction

The background noise level is a reference level against which an intrusive noise is assessed. For the purposes of any Environment Protection Policy on Noise that is made, the background noise level is defined as the L_{90} statistic, in the absence of the noise under consideration.

Under normal circumstances, the background noise level will change with the time of day. Some alternative variation is also to be expected on weekends and public holidays. For the purposes of measuring the background noise level, the times of the day are regarded as being divided into the following periods:

(a) day - 7:00am to 6:00pm;

(b) evening - 6:00pm to 10:00pm; and

(c) night - 10:00pm to 7:00am the following day.

Sub-sections 14.4 and 14.5 provide two alternative measurement techniques. Only one of the measurement techniques is required.

14.2 Measurement site

A background measurement is intended to provide an indication of the quiet ambient conditions over an extended area. As such, the background noise level should not change significantly for modest changes in location.

The measurement position must be selected to be acoustically representative of the area under consideration. Locations that are subject to additional noise from nearby sources such as close traffic routes and wind in trees should not be used for background measurements, and locations that are shielded from the general noise in the area should also be excluded.

14.3 Microphone location

Where possible, the microphone must be located 1.2 metres above the ground on a suitable stand, and must be located at least 10 metres away from any building. The axis of maximum sensitivity can be directed in any horizontal direction or above. These requirements are expected to be difficult to meet in urban and suburban areas due to the proximity of buildings and so a more complex siting will need to be used. It may be necessary to raise the microphone to exclude screening from buildings and it may also be necessary to locate the microphone near buildings. Under such circumstances the considerations in section 5.2 should be considered and the chosen site should be carefully documented.

14.4 Short measurement procedure

A statistical sound level analyser capable of measuring the L_{90} level must be used. The meter must be set to A-weighted frequency response and fast time response. The sampling rate must be set to at least eight samples per second.

The total measurement period must be ten minutes or longer.

The measurements must be made under acoustic conditions that are common and typical of quieter periods for the area as judged from the expected prevailing weather conditions and expected level of human activity. Measurements are to be conducted for suitably representative times during day, evening and night periods. It is good practice to take several measurements for each period and the statistical distributions, where available, should be reviewed to support the results.

14.5 Extended measurement procedure

A statistical noise logger is to be used to record 10 minute L_{90} values over an extended, unattended period of about two weeks. Before subjecting the data to any additional analysis it should be checked to identify any extended or abnormal interference to the measured results.

The sequential L_{90} results are to be sorted into their associated day, evening and night periods. The representative background of each day, evening and night period of the each day is then calculated as the 10 percentile value of all the measured L_{90} results for each period. The background noise level for the day time will then be taken as the median value of all 10 percentile $L_{90,10\ min}$ values calculated for the day periods over the full two week measurement period, and similarly for the evening and the night period.

PART C – INDUSTRIAL AND COMMERCIAL ACTIVITIES

15 INDUSTRIAL AND COMMERCIAL ACTIVITIES

15.1 General

The procedures referred to in this section cover the measurement of sound pressure levels at receptor premises when measuring or assessing noise from industrial or commercial activities. The receptor premises can be noise sensitive, commercial or industrial premises.

The level of the general ambient noise, excluding noise from the source under investigation, is an integral part of the characteristics of the area under investigation. The ambient sound level must be measured in conjunction with any assessment of noise from a proposed activity, and should be measured for the purpose of compliance verification or complaint investigation depending on the circumstances.

15.2 Application of other procedures

The measurement of the sound pressure levels resulting from some particular items of equipment may have different measurement requirements than the requirements specified in this section. The requirements of this section do not exclude the requirements of other sections of this Manual. An example is the measurement of noise from heat pumps which requires a measurement location closer than 3.5 metres from a building containing a noise sensitive room.

15.3 Measurement locations – noise sensitive receptor premises

For noise sensitive receptors, there may be a set of noise limits applicable to areas of the premises that are generally within 25 metres of buildings on that premises that contain a noise sensitive room, and another set of noise limits for areas of the premises further away. It may not always be appropriate or possible to enter private property, so measurement locations may need to be selected on publicly accessible land at positions that are representative of the areas of the receptor premises under consideration. Noise measurement locations may be specified in the activity's operating approval.

15.4 Measurement locations - industrial and commercial receptor premises

Unless otherwise specified, measurements for commercial and industrial receptors can be made anywhere on or within the boundary of the receptor premises, as appropriate. Noise monitoring locations may be specified in the activity's operating approval.

15.5 Microphone position

Unless otherwise stated, the microphone must be mounted 1.2 m above the ground, and at least 3.5 m from any reflecting surface other than the ground. The microphone should be orientated so that it is most uniformly sensitive to the incident sound from the noise source. See section 5.2 for microphone locations near fences and the like.

15.6 Measurement interval

The basic sound pressure level values for comparison against noise limits or noise criteria are generally the L_{eq} and the L_{max} from the activity, which are to be determined over a specified measurement interval. This interval may be specified in an industrial activity's operating permit, or must be representative of the situation under consideration. In general, the measurement interval must be equal to or greater than 10 minutes. Intervals can be subdivided for measurement convenience with the composite result being derived by the appropriate calculations. Measurement intervals greater than 1 hour should always be subdivided into intervals of duration less than 1 hour.

15.7 Sound pressure level measurements

If the noise from the activity under consideration is totally dominant at a measurement site, then it is only necessary to measure the L_{eq} and the L_{max} over the nominated measurement interval. Where there is interference from other ambient noise, additional supportive measurements are often required to correctly quantify the sound pressure level of noise from the activity. These measurements may include other statistical measures such as the L_{90}, L_{50} and L_{10}, or a full statistical distribution of the sound pressure levels recorded over the measurement interval. It is often necessary to measure the contribution of the other ambient sound at a position that excludes the particular noise sources of interest.

If present, it is necessary to adjust the results for intrusive or dominant characteristics of the noise from the activity as heard at the measurement location. The adjustment requirements are detailed in section 6 of this Manual.

The potential annoyance impact of noise from a particular industrial/commercial activity is likely to be greatest where there is minimal other general sound to act as a mask and where relatively quiet pastimes are likely to occur. The most investigated receptor type is the domestic premises in the evening and at night, as it generally fits these two criteria and there are significantly more domestic premises than any other noise sensitive premises. Premises such as hospitals, offices and homes for aged care often have mechanical services such as air conditioning, plant rooms and water heaters which produce noise close to or within the building that may mask or interfere with external noise.

The sound being measured will generally be a mixture of the noise from the source under investigation, noise from human activity including traffic, and natural noises including wind noise and animal and insect sounds. It is important that the different components of the noise at the receptor premises or measurement site be identified and ranked to provide a comparative list of the audible sources of sound.

The response of the various measurement statistics, particularly the L_{eq}, to the various noises present should be considered during the measurement procedure. The main noise sources may have particular temporal behaviours that direct their signature noise levels to a specific range within the statistical distribution of noise levels. In such cases a complete statistical sound level distribution should be recorded over the full L_{eq} measurement period for later analysis.

The sound at a measurement site may contain a variety of different features in the frequency spectrum, due to both the source under investigation and other nearby sources. Once again, field observations and appropriate records are important in correctly assigning these spectral features to their appropriate source. There are several options to consider when addressing the measurement of frequency spectra, which generally relate to the ultimate use of the measurements. The main uses of one-third octave spectra include assessment for tonality and for identification of particular components of the ambient sound, including interferences such as insect noise. Identification of the source of noise or particular tonality components detected in one-third octave spectra can often be supported by narrow band spectral measurements.

16 BLASTING AT EXTRACTIVE INDUSTRIES

16.1 Instrumentation

Air blast measurements should preferably be performed with a sound level meter that has a low cut-off frequency of 2 Hz or less. The meter must be set on linear frequency response, fast time response and to record the maximum peak level.

A sound level meter with a low cut-off frequency between 2 Hz and 10 Hz may be used, but a correction of 5 dB must be added to the measured value.

A sound level meter with a low cut-off frequency above 10 Hz must not be used for the purpose of measuring air blast overpressure.

16.2 Measurement Locations

The microphone must be mounted on a tripod or other suitable stand with its nominal axis of maximum sensitivity horizontal, and directed toward the extractive industry under consideration.

The microphone must be placed at the boundary of the receptor premises, if possible, and must be placed at least 3.5 m from any acoustically reflecting surface, such as the wall of a building. The microphone must be placed at a height of 1.2 m above the ground.

16.3 Measurement

The maximum hold circuit on the noise meter must be reset just prior to the blast. The detection of the air blast noise is to be confirmed by the investigator on the basis of the meter response to the subjective detection of the blast noise. The response of the meter to all other ambient noise before and after the blast should be recorded to establish the noise level that wind and other noise contributed to the air blast level.

16.4 Ground vibration

Assessing vibration from blasting requires specialised equipment and data analysis methods, and should be carried out by an experienced specialist.

Site selection for the measurement transducer should follow the same general requirements as the site selection for air blast measurements. The vibration transducer must be firmly bound to the ground such that there is no horizontal or vertical slip between the ground and the transducer. A three-axis vibration transducer should be used and the results from each axis are to be used to calculate the maximum ground displacement velocity as the maximum of the square root of the sum of the squares of the three orthogonal axis velocities.

17 WIND FARMS

17.1 Introduction

This section addresses the measurement of sound from wind turbine generators, and assessment of the received sound. Procedures used for these measurements are, in general, drawn from New Zealand Standard NZS 6808 *Acoustics - The Assessment and Measurement of Sound from Wind Turbine Generators*.

Special considerations apply to the assessment of noise from wind farms because the noise from a wind turbine increases with wind speed and so it is necessary to consider noise determinations over a range of wind speeds. Normally, sound pressure level measurements would not be carried out at wind speeds above 5 m/s.

Measurements of installed wind farms indicate that the increase in noise from a wind farm with increasing wind speed is less that the corresponding increase in wind noise. Since ambient sound pressure levels are relatively constant up to wind speeds of about 5 m/s, the audibility of noise from the wind farm above the general wind noise tends to be a maximum at wind speeds of about 6 to 8 m/s measured at 10 m above the ground.

Assessment of noise from proposed wind farms and compliance testing for an established wind farm requires a detailed comparison of ambient noise and wind farm generated noise over all reasonably likely wind speed and direction conditions.

For assessment, predicted wind farm noise levels are compared to measured ambient noise levels over a range of wind conditions. Compliance testing is a comparison of ambient noise levels measured before and after construction of the wind farm, over a range of wind conditions.

17.2 Wind measurements

Wind speed and direction are to be measured at a location that is representative of the study area but is unlikely to be significantly influenced by any current or future wind turbines.

The wind measurements are used to estimate the sound output power of the wind farm and to provide a reference for the comparison of wind farm noise with other ambient noise that is generally dominated by wind noise. The sound power output of the turbines may only depend on the wind speed but the wind induced noise in the surrounding areas will generally depend on both wind speed and direction.

The wind speed and direction measurements must be taken under conditions that can provide a suitably accurate measurement or calculation of the wind speed at the nominal height of the wind turbines. Normally these measurements must be made at a height of 10 metres above the ground in an area that has similar ground cover to the wind farm site.

17.3 Sound pressure level calculation and prediction

Calculation of noise from a wind farm is required for assessment of a proposed wind farm development, but may also be useful during compliance testing of a constructed wind farm.

Calculations of noise from a wind farm must be based on sound power levels for the turbines under consideration. The sound power level data must be supplied by the wind turbine manufacturer or derived from measurements carried out on similar turbines. The sound power level data must include:

(a) the sound output power detailed over the complete range of wind conditions likely to occur at the site;
(b) frequency spectra suitable for the evaluation of tonality over the working range of the turbine;
(c) any tonality, impulsiveness, modulation or low frequency characteristics; and
(d) the variation of sound power output with horizontal direction relative to the incident wind direction.

When relating the sound output power from a turbine to the prevailing wind speed at a particular height, it is important to use consistent wind data. In particular, the relation between the wind speed and the sound power output of the turbines must be consistent with the expected vertical wind speed profile, the wind speed measurement height and the hub height of the turbines.

Where it is necessary to calculate or predict the sound level from a wind turbine or a wind farm, hemispherical propagation must be assumed and attenuation due to air absorption must be included taking due account of the sound output spectrum of the turbine(s). The general requirements of Section 11 are also applicable.

17.4 Sound level measurement sites

The locations selected for sound level measurements must be more than 5 m from any significant vertical reflecting surface, or other structures or objects. The measurement sites must normally be located within 15 metres of a building containing a noise sensitive room or representative of such a site. The microphone should not be shielded from noise from the wind farm direction by man-made structures.

The microphone must be located 1.2 metres above the ground and must be protected from extraneous wind sound by an appropriate windshield. Cables, tripods and any other equipment associated with the measurement system must be secured as to avoid extraneous sound generated in proximity to the microphone.

Where attended measurements are carried out, noise levels should be adjusted for intrusive or dominant characteristics.

The same measurement locations should be used for both the assessment measurements and post-commissioning compliance tests. The need to include additional measurement and compliance test sites may arise after the wind farm has been constructed. It this case it will be necessary to predict the pre-operation ambient noise levels at these sites.

17.5 Comparison with other ambient noise

The comparison of predicted or measured wind farm noise with other ambient noise including wind noise must use a correlation technique to quantify this other ambient noise with wind conditions. This correlation must be based on a suitable regression between measured wind speed, wind direction if necessary, and measured L_{90} noise levels measured in dB(A) in the absence of the wind farm. The data for this correlation must include L_{90} sound pressure levels and wind speed and direction recorded over a series of ten-minute periods that extend over all reasonably likely meteorological conditions in the vicinity of the wind farm location. The measured sound pressure levels should be correlated with wind speed using a least-squares regression to fit a third-order polynomial of the wind speed to the measured sound levels. A suitable survey data set is expected to require about 14 days of continuous monitoring.

Once the noise conditions in the absence of the wind farm have been established, the results can be used for assessment of a new wind farm by comparing the measured results with predicted levels.

17.6 Compliance verification

General compliance verification must be essentially a repeat of the wind correlation with measured L_{90} sound pressure levels with the wind farm in full operation, followed by a comparison of the two regression curves relating to before and after commissioning of the wind farm.

The same set of locations must be used for measurements of wind speed and direction prior to, and after, commissioning of the wind farm. The locations must be such that the wind turbine generators do not significantly affect the wind measurements. Monitored wind and sound pressure level data should cover the range of wind speeds and wind directions normally expected at the wind farm site.

PART D – TRANSPORT INFRASTRUCTURE

18 ROAD TRAFFIC

18.1 Introduction

The procedures in this section are to be used for the measurement and assessment of noise from road traffic.

18.2 Site selection

Site selection depends on the purpose for which the measurement is made. Factors that have a marked effect on the received noise level include:

- road geometry such as grades, freeway ramps, intersections;
- topographical features including the nature of the ground surface between the road and the measurement site, which may provide some degree of shielding; and
- the presence of buildings or other reflective surfaces which may result in shielding or scattering of sound.

Measurements will generally be carried out to assess the noise performance of a roadway at a critical noise sensitive receptor premises, or for assessing the traffic noise at the location of a potential noise sensitive development.

Where measurements are taken to determine noise levels adjacent to a proposed or existing road, measurement sites must be selected to be typical of as wide an area as possible.

18.3 Microphone location

The microphone must be located 1 metre from the façade of a building on a noise sensitive premises that contains a noise sensitive room. A façade adjustment in accordance with section 5.2 must not be made.

If such a building does not exist in the area being tested, the microphone must be located at least 15 metres from any wall, building or other reflecting surfaces on the opposite side of the roadway, and at least 3.5 metres from any wall, building or other reflecting surfaces on the same side of the roadway. An absence-of-façade adjustment of 2.5 dB(A) must be added to all results from such measurement locations.

The axis of maximum sensitivity of the microphone should be normal to the traffic stream and directed towards the road.

The microphone must be located 1.2 metres above the ground or 1.2 metres above the floor level of a verandah if present.

18.4 Measurement conditions

Measurements are to be made when the relevant sections of the road surface are dry, and when the peaks of wind noise at the microphone are 10 dB(A) or more below the measured L_{10} noise statistic. Traffic conditions should be assessed during the measurement period and should be typical for the road or roads under consideration. Weekends, public holidays and school holidays may influence traffic volume and speed which would be expected to result in modified sound pressure levels. Unless it is suspected that traffic noise is louder on weekends, public holidays or school holidays, measurements should be carried out on week-days that are neither public holidays nor school holidays.

18.5 Road traffic parameters

Traffic flow and composition should be measured where possible, and these measurements should be concurrent with the measurements of the traffic noise. Traffic speed, pavement type and pavement conditions should also be recorded.

18.6 Measuring equipment and sampling time

The instrumentation must consist of a statistical noise level analyser capable of measuring the L_{10}. Sound pressure levels must be measured with the instrument response set to A-weighting frequency response and fast time response. An integrating sound level meter must be used for measuring the L_{eq}.

18.7 Sampling time for L_{10} measurements

A series of L_{10} measurements, each representing 1 hour of traffic, are recorded and are then used to calculate the $L_{10(18hr)}$.

18.8 Normal $L_{10(18hr)}$ procedure

Eighteen hourly measurements covering the 18 hours from 0600 to 2400 hours must be measured and the $L_{10(18hr)}$ must be calculated as the arithmetic mean of the 18 one-hourly measurements.

18.9 Shortened $L_{10(18hr)}$ measurement procedure

A good estimate of the $L_{10(18hr)}$ can be derived from a shortened measurement period. For this shortened $L_{10(18hr)}$ procedure, one hourly L_{10} measurements must be made over any three consecutive hours between 1000 and 1700 hours. The $L_{10(3hr)}$ is calculated as the arithmetic mean of the three measured values and the $L_{10(18hr)}$ is calculated from the relation:

$$L_{10(18hr)} = L_{10(3hr)} - 1 \text{ dB(A)}$$

This procedure is preferred if attended measurements are required. The responsible regulatory authority may require either the shortened or normal procedure to be used in any particular case.

18.10 $L_{eq(1hr)}$ measurement

If the highest $L_{eq(1hr)}$ value between 2200 and 0700 hours is required, then a suitable integrating sound level meter must be used to measure the L_{eq} over each 1 hour period from 2200 to 0700 hours. The highest $L_{eq(1hr)}$ value must be reported as the maximum one-hourly measured L_{eq}.

18.11 Composite measurements

Where unattended measurements are acceptable, both hourly L_{10} and L_{eq} can be measured concurrently with a suitable statistical and integrating noise logger.

18.12 Calculation of road traffic noise

Where it is necessary to calculate or predict the noise from a particular traffic configuration, the procedures in the publication *Calculation of Road Traffic Noise* (Department of Transport, Welsh Office, HMSO 1988), or any software package that implements these procedures accurately, are acceptable.

Other calculation procedures must be approved by the Director.

19 RAILWAYS

19.1 Introduction

This section details the specific procedures required to measure noise from railways. These procedures are intended to be used for assessing the noise from trains at noise sensitive premises.

It may be convenient or necessary to take measurements of train noise without reference to a particular noise sensitive premises. The measurement results can then be used to calculate the train noise at particular locations near existing or proposed noise sensitive premises. These calculations should take due regard of any changes in conditions such as a variation in grade or acceleration.

19.2 Measurement site selection

The measurement site should be chosen in relatively flat terrain where there are no major reflective surfaces that could influence the measurements by more than 1 dB(A). If the measurement site is chosen to represent a particular noise sensitive premises, then the site should be chosen to represent the building containing a noise sensitive room that is likely to be subjected to the greatest noise level from a passing train.

19.3 Microphone position

The microphone position should be chosen such that the noise from the train is at least 10 dB(A) greater than the otherwise ambient noise level when the train is at its closest approach to the microphone position. The microphone should be 1.2 metres above the ground, and:

(a) for railways existing prior to the commencement of any Environment Protection Policy on Noise that is made, either 15 metres from the centre line of the railway or 1 metre from the façade of the building containing a noise sensitive room, whichever is at the greater distance from the track centre line; and

(b) for new railways or railways upgraded subsequent to the date of commencement of any Environment Protection Policy on Noise that is made, 15 metres from the centre line of the railway.

The axis of maximum sensitivity of the microphone should be normal to the railway line and directed towards the railway.

19.4 Train operations

It is assumed that the investigator has no influence over the operation of passing trains. In particular, the speed of the trains and throttle setting should not be varied from normal levels. In general, the type and number of trains that pass by the measurement site during the test period should be representative of the trains that normally travel on the particular section of railway. The power and number of locomotives, the total train load and the train length should be typical of the trains passing the measurement site.

19.5 Measurement procedure

The two criteria to be measured are:

(a) $L_{eq(24h)}$ - the 24 hour equivalent A-weighted sound pressure level, and

(b) L_{max} - the maximum A-weighted sound pressure level.

Where the number of trains passing a given receptor premises is unlikely to exceed ten per 24 hour period it is recommended that the L_{max} and L_{eq} for each train passing is measured separately and the 24 hour values are calculated as indicated below.

The L_{max} for the 24 hour period is the maximum of the individual recorded L_{max} values.

The L_{eq} for the 24 hour period is calculated as:

$$L_{eq(24hr)} = 10\log\{\frac{1}{T}(\sum_{i=1}^{n} t_i 10^{(Li/10)} + t_r 10^{(Lr/10)})\}$$

where *Li* is the L_{eq} of the i[th] event measured over time interval t_i, L_r is the otherwise Leq for the area, t_r is the time over which train noise is not audible and *T* is the sum of the measurement intervals including the otherwise Leq. Each train measurement interval should correspond to the time period that the train is audible above the otherwise ambient noise.

For general investigations relating to operating railways, it is usually only necessary to measure the L_{max} over a suitable representative period.

19.6 Calculation of train noise

Where it is necessary to calculate or predict the noise from a particular railway configuration, the procedures in the publication *Calculation of Railway Noise* (Department of Transport, HMSO 1995) are acceptable.

Other calculation procedures must be approved by the Director.

20 HELIPADS

20.1 General

The procedures in this section for assessment of the impact of noise from existing or proposed helipads are based on Australian Standard AS 2363 *Acoustics – Assessment of noise from helicopter landing sites*.

Measurements must be taken of the sound emissions from helicopter operations at the existing or proposed helipad site to determine:

(a) **$L_{Aeq,T}$ (Hel)** – the total encompassing measured or predicted sound at a given site over a period T, composed of sound from all sources near and far, including the helicopters using the site, measured as the equivalent continuous A-weighted sound pressure level; and

(b) **L_{Amax} (Hel)** – the logarithmic average of the L_{Amax} (Event) levels for each mode of operation for each flight path where L_{Amax} (Event) are measured as the maximum A-weighted sound pressure level using fast time response.

The measurements can relate to actual operational conditions or pre-arranged testing conditions. The measurements made during pre-arranged tests are referred to as **sample** measurements.

20.2 Measurement locations

Measurement locations should be chosen to represent the noise sensitive premises that are likely to receive the highest noise levels from the helipad. Since flight paths may differ due to consideration of weather, safety, and air traffic control requirements, a number of flight paths should be included to ensure that all potentially affected receptor premises are considered.

20.3 Microphone position

The microphone must be mounted 1.2 m above the ground in an area preferably with flat ground, no nearby obstacles, and at least 3.5 m from any reflecting surface other than the ground. The axis of maximum sensitivity of the microphone should be directed towards the closest point of approach of helicopter activities.

20.4 Measurement conditions

Measurements are to be carried out under relatively calm wind conditions with the wind speed less than 5 km/hr.

20.5 Determination of $L_{Aeq,T}$ (Hel) and L_{Amax} (Hel)

For an operational helipad, $L_{Aeq,T}$ (Hel) can be directly measured and L_{Amax} (Hel) can be calculated from L_{Amax} (Event) measurements over a daily operating period. Alternatively, $L_{Aeq,T}$ (Hel) and L_{Amax} (Hel) can be calculated from sample measurements of L_{AE} and L_{Amax} (Event) of flight operations at the site.

For a proposed helipad, $L_{Aeq,T}$ (Hel) and L_{Amax} (Hel) can be calculated from sample measurements of L_{AE} and L_{Amax} (Event) of flight operations at the site.

L_{AE} is the sound exposure level of a discrete noise event as defined in AS 1055.1 integrated over the time interval when the noise from the helicopter operation is within 10 dB(A) of the maximum noise level for the event. L_{AE} can be measured directly with suitable instrumentation or can be calculated from suitable measurements. If the L_{AE} values are calculated, the calculation method(s) must be provided.

20.6 Flight operations during measurements

For an operating helipad, the necessary measurements should be made during normal operations.

Where it is desirable to take sample measurements for either an operating or proposed helipad, noise measurements of a series of flight manoeuvres must be carried out using a test helicopter of a type that is likely to be used at the helipad.

20.7 Measurement of sample L_{Amax} (Event) and L_{AE}

Four modes of operation are to be evaluated to measure the above properties: landing; hover; idling on the ground; and take-off.

The test helicopter should be loaded as for the upper permitted limit of the proposed operations.

Rates of climb and descent must be according to usual commercial helicopter practice for the type of site under consideration. Similarly, the landing and take off operations must be along the centre-line of the flight path according to usual commercial practice.

Flight paths during a measurement program must, as far as practicable, be as follows.

(a) Approach on the first flight path and land on the pad site.
(b) Idle for 30 seconds.
(c) Hover about 3 m above ground level for 30 seconds, reorient the helicopter for the next flight path, then land.
(d) Idle for a few seconds.
(e) Take off on the second flight path.
(f) Turn.
(g) Approach on the second flight path and land.
(h) Idle for a few seconds.
(i) Hover about 3 m above ground level for 30 seconds, reorient helicopter for the next flight path, then land.
(j) Idle for a few seconds.
(k) Take off on the first flight path.
(l) Turn and repeat all the above steps at least three times.

The L_{AE} and L_{Amax} for each mode are calculated as the logarithmic averages of the corresponding L_{AE} and L_{Amax} (Event) values for the individual event measurements.

20.8 Determination of L_{Amax} (Hel)

During a program to measure L_{Amax} (Hel), each operational mode is measured as a discrete event. At least four measurements must be taken of each mode for each helicopter type likely to use the existing or proposed landing site.

The final value of L_{Amax} (Hel) reported is calculated as the logarithmic average of the L_{Amax} (Event) levels measured for each mode throughout the test series.

The value of L_{Amax} (Hel) is the same for operational and sample measurements.

20.9 Calculation of the time averaged A-weighted equivalent sound pressure level, $L_{Aeq,T}$ (Hel)

L_{AE} data are required for each mode of operation and each flight path for each helicopter type that will use the landing site. The number of times each operation will be performed by each helicopter type during the time period T is also required.

The equation for **$L_{Aeq,T}$ (Hel)** is:

$$L_{Aeq,T}\text{ (Hel)} = 10 \log_{10} \{ \Sigma_h \Sigma_p \Sigma_m Q_{hpm} \text{ antilog } (L_{AE,hpm}/10)\} - K$$

Where: **$K = 10 \log_{10}(3600T)$;**

h is the type of helicopter;

p is the flight path;

m is the mode of operation (landing, hover, idle, and take off);

$L_{AE,hpm}$ = L_{AE} for helicopter (h), on flight path (p), performing mode of operation (m);

Q_{hpm} = number of operations of helicopter (h), on flight path (p), performing mode of operation (m); and

T = number of hours in the measurement period.

The numbers of operations refers to the actual or proposed level of activity.

PART E – DISCRETE ITEMS OF EQUIPMENT

21 MOTOR VEHICLES (STATIONARY)

21.1 Introduction

The procedures in this section cover the measurement of sound pressure emission levels from stationary motor vehicles and are based on the document *National Stationary Exhaust Noise Test Procedures for In-Service Motor Vehicles* (National Road Transport Commission, 2000).

21.2 Petrol vehicles converted to run on LPG

Where an engine primarily designed to operate on petrol has been converted to run on liquid petroleum gas, the operating parameters under which sound pressure levels are measured must be those stated by the manufacturer for that engine in its original form, unless alternative operating parameters are specifically stated by the person or organisation responsible for converting the engine.

21.3 Ancillary Equipment

While the vehicle is being tested, any ancillary equipment, such as refrigeration units, or agitator drum drives, must be in operation except where that equipment would only be in operation whilst the vehicle is stationary or travelling on a road at a speed of less than 8 km/h.

21.4 Test site requirements

The measurements must be made in the open air where the ambient noise level is at least 10 dB(A) below the noise level being measured.

The test site may take the form of an open space or beneath a canopy if no part of the canopy or its supports is within 3 metres of the microphone.

The test site within 3 metres of the microphone must be substantially flat and may include kerbs, channels, gutter, poles or other objects not providing excessive acoustic reflection provided that no such object is within 1 metre of the microphone.

Whilst testing is in progress no person other than the testing officer and any occupants of the vehicle or, in the case of a motor cycle, the rider, must be within 1 metre of the microphone.

21.5 Sound level meter settings

The sound level meter is to be set to A-weighted frequency response and fast time response.

21.6 Test method for passenger cars and derivatives

21.6.1 Microphone position

The microphone must be directed towards the orifice of the exhaust, and the nominal axis of maximum sensitivity of the microphone must be substantially parallel to the test site surface and must make an angle of 45 degrees with the principal direction of gas flow from the exhaust.

In selecting the 45 degree alignment from the outlet of a motor vehicle fitted with two or more outlets, only the angle resulting in the microphone being farthest from any other outlet must be used.

The height of the microphone above the test site surface must be equal to that of the orifice of the exhaust outlet $\pm$25 mm but must not be less than 200 mm above the test site surface.

The distance of the microphone from the exhaust outlet orifice must be 525 mm.

For vehicles fitted with one exhaust outlet the microphone must be placed so that the greatest possible distance is achieved between it and the body of the vehicle.

For vehicles fitted with two or more exhaust outlets, each exhaust outlet must be treated separately as if it were the only one.

If a suitable position that conforms to the above requirements can not be selected, then an alternative position can be used. This alternative microphone arrangement should be as close as possible to the stated requirements.

21.6.2 Vehicle operation and noise measurement

The vehicle must be stationary with the transmission in “neutral” or, in the case of a vehicle with automatic transmission, with the gear selector in the “park” position if such a position is provided.

The engine of the vehicle under test must be operated in accordance with one of the following procedures, as applicable.

(a) Where the Engine Speed at Maximum Power (ESMP) for that engine has been determined by the testing authority the engine must be brought to and stabilised at a speed as close to 75 percent of ESMP as can be achieved.

(b) Where the ESMP for that engine has not been determined by the testing authority then the engine must be brought to and stabilised as close as can be achieved to the applicable speed shown in the following table.

Number of cylinders in engine	Speed (rpm)
5 or less	4000
6	3200
8	3300
More than 8	4300

Rotary engine	4500

(c) Where, in the opinion of the testing officer, the test speed determined by reference to (a) or (b) above is not attainable by the engine then the engine must be operated at the maximum speed that the testing officer believes that the engine can be safely tested.

A single noise level measurement must then be made.

The specified procedure must be repeated for as many times as the testing officer considers appropriate for the results to be valid.

21.6.3 Interpretation of Results

Where one microphone position is used the noise level of the vehicle must be the repeatable maximum level recorded.

Where more than one microphone position is used the noise level at each microphone position must be determined as if it were the only one. The noise level of the vehicle must be the higher or highest noise levels.

Non-integer results must be rounded down to the nearest whole decibel.

21.7 Test method for in-service goods vehicles, omnibuses and miscellaneous vehicles (Stationary)

21.7.1 Microphone Position

The microphone must be directed towards the orifice of the exhaust outlet, and the nominal axis of maximum sensitivity of the microphone must be substantially parallel to the test site surface.

The height of the microphone above the test site must be equal to that of the orifice of the exhaust outlet ±25 mm but must not be less than 200 mm above the test site surface.

The distance of the microphone from the orifice of the exhaust outlet must be 1050 mm.

For vehicles fitted with one exhaust outlet which is at a height above the test site surface of less than 1500 mm, the nominal axis of maximum sensitivity of the microphone must make an angle of 45 degrees with the principal direction of the gas flow from the exhaust outlet.

In selecting this microphone position the microphone must be placed so that the greatest distance is achieved between it and the body of the vehicle.

For vehicles fitted with one exhaust outlet which is at a height above the test site surface of at least 1500 mm, the nominal axis of maximum sensitivity of the microphone must make an angle of 90 degrees with the longitudinal centre-line of the vehicle. However, if positioning the microphone according to the preceding requirement would result in the microphone being placed in the gas flow from the exhaust outlet then the microphone location may be rotated, in a horizontal plane, no greater than 45 degrees.

In selecting this microphone position the microphone must be placed so that the greatest distance is achieved between it and the body of the vehicle.

For vehicles fitted with two or more exhaust outlets, each exhaust outlet must be treated separately as if it were the only one.

If a suitable position that conforms to the above requirements can not be selected, then an alternative position can be used. This alternative microphone arrangement should be as close as possible to the stated requirements.

21.7.2 Vehicle operation and noise measurement

The vehicle must be stationary with the transmission in “neutral” or, in the case of a vehicle with automatic transmission, with the gear selector in the “park” position if such a position is provided.

In the case of goods vehicles and omnibuses powered by a diesel engine, the engine must be operated in accordance with the following procedure:

With the engine at idling speed the accelerator pedal of the vehicle must be depressed as rapidly as possible and kept fully depressed until the speed of the engine is substantially stable at maximum (or governed) speed. The accelerator pedal must then be permitted to return to its original position as rapidly as possible and left in that position until the engine has returned to idling speed.

A single noise level measurement must be made for each microphone position in use by noting the maximum noise level indicated during this procedure.

In the case of goods vehicles and omnibuses powered by a spark ignition engine, the engine must be operated in accordance with one of the following procedures as applicable.

(a) Where the ESMP for that engine has been determined by the testing authority, the engine must be brought to and stabilised at a speed as close to 75 percent of ESMP as can achieved.

(b) Where the ESMP has not been determined for that engine by the testing authority, then the engine must be brought to and stabilised at as close as the testing officer can achieve to the applicable speed shown in the following table

Number of cylinders in engine	Date of manufacture	Speed (rpm)
5 or more	All	3000
4	Before 1970	2500
4	1970 or later	3500

(c) Where, in the opinion of the testing officer, the test speed determined by reference to (a) or (b) above is not attainable by the engine then the engine must be operated at the maximum speed that the testing officer believes that the engine can be safely tested.

A single noise level measurement must then be made.

The specified procedure must be repeated for as many times as the testing officer considers appropriate for the results to be valid.

21.7.3 Interpretation of results

Where one microphone position is used the noise level of the vehicle must be the repeatable maximum level recorded.

Where more than one microphone position is used the noise level at each microphone position must be determined as if it were the only one. The noise level of the vehicle must be the higher or highest noise levels.

Non-integer results must be rounded down to the nearest whole decibel.

21.8 Test method for in-service motor cycles (Stationary)

21.8.1 Microphone position

The microphone must be directed towards the orifice of the exhaust outlet and the nominal axis of maximum sensitivity of the microphone must be substantially parallel to the test site surface and must make an angle of 45 degrees with the principal direction of gas flow from the exhaust.

In selecting the 45 degree alignment from the outlet of a motor cycle fitted with two or more outlets, only the angle resulting in the microphone being farthest from any other outlet must be used.

The height of the microphone above the test site surface must be equal to that of the orifice of the exhaust outlet ±25 mm but must not be less than 200 mm above the test site surface.

The distance of the microphone from the exhaust outlet orifice must be 525 mm.

For motor cycles fitted with one exhaust outlet the microphone must be placed so that the greatest possible distance is achieved between it and the body of the motor cycle.

For motor cycles fitted with two or more exhaust outlets, each exhaust outlet must be treated separately as if it were the only one.

21.8.2 Vehicle operation and noise measurement

The motor cycle must be stationary and held in a substantially vertical position.

The engine of the motor cycle under test must be operated in accordance with one of the following procedures, as applicable.

(a) Where the ESMP for that engine has been determined by the testing authority, the engine must be held steady at a speed as close to 50 percent of ESMP as can be achieved.

(b) Where the ESMP for that engine has not been determined by the testing authority then the engine must be brought to and stabilised at a speed as close as can be achieved to one of the speeds shown in the following table.

Engine type	Speed (rpm)

Two-stroke	3750
Four-stroke	2500

(c) Where, in the opinion of the testing officer, the test speed determined by reference to (a) or (b) above is not attainable by the engine then the engine must be operated at the maximum speed that the testing officer believes that the engine can be safely tested.

The throttle must then be returned swiftly to the idle position.

The maximum noise level indicated during this procedure must be recorded.

The specified procedure must be repeated for as many times as the person making the tests considers appropriate for the results to be valid.

21.8.3 Interpretation of results.

Where one microphone position is used the noise level of the vehicle must be the repeatable maximum level recorded.

Where more than one microphone position is used the noise level at each microphone position must be determined as if it were the only one. The noise level of the vehicle must be the higher or highest noise levels.

Non-integer results must be rounded down to the nearest whole decibel.

22 MOTOR VEHICLES (DRIVEN)

22.1 General

This procedure is used for vehicles that must comply with a drive-by method of testing. The tests described in this section also apply to vehicles at racing events.

22.2 Petrol vehicles converted to run on LPG

Where an engine primarily designed to operate on petrol has been converted to run on liquid petroleum gas, the operating parameters under which sound pressure levels are measured must be those stated by the manufacturer for that engine in its original form, unless alternative operating parameters are specifically stated by the person or organisation responsible for converting the engine.

22.3 Ancillary Equipment

While the vehicle is being tested, any ancillary equipment, such as refrigeration units, or agitator drum drives, must be in operation except where that equipment would only be in operation whilst the vehicle is stationary or travelling on a road at a speed of less than 8 km/h.

22.4 Test site requirements

The measurements must be made at an open site where the ambient noise level is at least 10 dB(A) below the noise level being measured.

The site may take the form of an open space having a central part of at least 30 m radius, practically level, consisting of concrete, asphalt or similar material and not covered with powdery snow, tall grass, loose soil or the like. The surface of the test track must be dry and must not cause excessive tyre noise.

During the test no one must be in the measurement area except the testing officer and the driver. Their presence must have no influence on the meter reading.

22.5 Microphone position

The microphone must be located 1.2 metres above the test site surface and at a distance of –

(a) 7.5 metres for non-racing vehicles; or

(b) 30 metres for motor vehicles including motor cycles being used in racing competitions or speed or performance trials at a racing event –

from the path of the vehicle's centre-line, measured along a perpendicular (PP') to the path of the vehicle. Two lines AA' and BB', parallel to the line PP' and situated respectively 10.0 m forward and 10.0 m rearward of PP' must be marked out on the test site surface.

22.6 Sound level meter settings

The sound level meter is to be set to A-weighted frequency response and fast time response and set to record the maximum noise level during each drive-by event.

22.7 Vehicle condition

Measurements must be made on unladen vehicles.

The tyres of the vehicle must be the correct size and must be inflated to the correct pressure(s) for the vehicle in its unladen condition.

The engine must be brought to its normal operating conditions as regards temperatures, tuning, fuel, sparking plugs, carburettor(s), etc. as appropriate, prior to testing.

If the vehicle is fitted with more than two-wheel drive, it must be tested in the drive that is relevant to the purpose of the test.

If the vehicle is equipped with devices which are not necessary for its propulsion, but which are used whilst the vehicle is in service, those devices must be in operation in accordance with the specifications of the manufacturer.

22.8 Vehicle operation and noise measurement

The vehicle must approach line AA' at a steady speed as specified below. When the front of the vehicle reaches the line AA', the throttle must be fully opened as rapidly as practicable and held in the fully opened position until the rear of the vehicle crosses line BB' and then the throttle must then be closed again as rapidly as possible.

At least two measurements must be made on each side of the vehicle. The maximum of the sound levels recorded during this procedure must constitute the result of the test.

22.9 Interpretation of results for vehicles in motion

Non-integer decibel readings are to be rounded downwards to the nearest whole decibel.

The figure reported must be that corresponding to the highest sound level. Should that figure exceed by more than 1 dB(A) the maximum sound level authorised in the category of vehicle tested a second series of two measurements must be made. Three out of the four results so obtained must fall within the proscribed limits.

22.10 Approach speed

Vehicles with manual transmissions will approach the line AA' with uniform speed such that either the engine rotational speed is 75% of the Engine Speed at Maximum Power (ESMP) if the corresponding vehicle speed is less than 50 km/h, or at a speed of 50 km/h.

Vehicles with automatic transmissions without a manual selector must be tested by approaching the line AA' with uniform approach speeds of 30, 40 and 50 km/h, or at 75 percent of the ESMP if this value is lower. The condition giving the highest noise level must be reported.

22.11 Choice of gear ratio

Vehicles with two to four manually selected forward gears must be tested in second gear.

Vehicles fitted with a gearbox having more than four forward gears must be tested successively in second and third gear. The average values of sound levels recorded for these two conditions must be reported.

If the vehicle is fitted with an automatic gear box and has a manual selector then the test must be conducted with the selector in the position recommended by the manufacturer for normal driving. If an automatic down-shift occurs, the test must be repeated with the manual selector in the next lower gear position.

Motor cycles fitted with an engine having a cylinder capacity not exceeding 175 cc and a gearbox with five or more gears must be tested in third gear. Motor cycles fitted with an engine having a cylinder capacity exceeding 175 cc and a gearbox with five or more gears must be submitted to a test in second gear and a test in third gear; the average value of the two tests must be taken as the test result.

23 VEHICLE SECURITY ALARMS

23.1 Test site requirements

The measurements must be made in the open air where the ambient noise level is at least 10 dB(A) below the noise level being measured.

The test site may take the form of an open space or beneath a canopy if no part of the canopy or its supports is within 3 metres of the microphone.

The test site within 3 metres of the microphone must be substantially flat and may include kerbs, channels, gutter, poles or other objects not providing excessive acoustic reflection provided that no such object is within 1 metre of the microphone.

Whilst testing is in progress no person other than the testing officer and any occupants of the vehicle or, in the case of a motor cycle, the rider, must be within 1 metre of the microphone.

23.2 Measurement conditions

While the sound pressure level of a motor vehicle intruder alarm is being measured, only the following articles may be within the test site:

(a) the motor vehicle and its contents;

(b) any instruments and other objects used in connection with the measurement of the sound pressure level; and

(c) any other article which, in the opinion of the person making the measurement, will not substantially affect the measurement.

23.3 Sound level meter settings

The sound level meter is to be set to A-weighted frequency response and fast time response and set to record the maximum level.

23.4 Measurement Procedure

The microphone must be placed at a height of 1.2 m above the ground, and at a distance of 1.5 m from the vehicle.

The microphone must face towards, and have its nominal axis of sensitivity directed towards the alarm or device under test.

A motor vehicle intruder alarm under test must be, as far as practicable be:

(a) directed towards the microphone;

(b) operated for a period determined by the person making the measurements, being a period of at least 15 seconds; and

(c) operated by means of a power supply from the vehicle that normally supplies the power for the operation of the alarm or device.

The person making the measurement is to make as many sound pressure level measurements of the alarm or device as is appropriate.

The sound pressure level of the alarm or device must be considered to be the highest L_{Amax} sound pressure level obtained from the sound pressure level measurements on the alarm or device. If the reading of that measurement is not a whole number of decibels, it must be rounded down the next lowest whole number of decibels.

24 SPECIALISED OFF-STREET VEHICLES

24.1 Introduction

The basis for the procedures described in this section is Australian Standard AS 2012 – *Method for measurement of airborne noise from agricultural tractors and earthmoving machinery*.

The procedures detailed in this section cover the measurement of sound pressure emission levels from agricultural, industrial and earthmoving vehicles that are not travelling on public roads.

Tractor based power lawnmowers are to be tested in accordance with the requirements of this section.

24.2 Site requirements

The test site must be in the open air and must comprise a generally flat area of not less than 30 metres radius that is free from reflective planes (other than the ground plane) and any obstruction that could significantly affect the test results.

The central region of the test site must have a surface covered with concrete, asphalt, firm soil with a short grass covering, or other material appropriate to the equipment being tested. The outer region of the test site must have a surface covered with firm soil and or grass, essentially free from any loose acoustically absorbent material, ice or snow, and ponded water.

Only the vehicle being tested including the operator, the person carrying out the measurements and any instrumentation required to carry out the test shall remain within the test site whilst testing is in progress.

24.3 Microphone position

The microphone must be mounted on a tripod or stand with its nominal axis of maximum sensitivity directed horizontally toward the machine. The height of the microphone must be 1.2 metres above ground level and it must be positioned in turn at a distance of 7.5 metres from the front, rear and two sides of the machine.

In determining the distance from the vehicle no account should be taken of single projecting portions that have no significance in the generation of sound levels. The outer edge of the vehicle is that of the smallest imaginary rectangular box that would just fit over the machine, including all tyres or tracks, but which does not include attachment items such as buckets and booms. In the case of a crane or an excavator, the upper revolving super-structure should be in line with the lower section of the machine.

24.4 Machine operating conditions

The machine operating conditions specified are applicable only to compression ignition (diesel) engines. The maximum speed of a diesel engine is controlled by a governor and the engine can be safely run at its maximum speed. The maximum speed obtained from successive throttle depressions is repeatable, and therefore an acceptable test parameter. This is not the case with positive ignition engines.

Where a machine is fitted with a positive ignition (petrol or gas fuelled) engine, the engine should be operated in accordance with the requirements in this Manual dealing with motor vehicles in section 21.

Cabs, turbo-chargers, silencers and any other items of equipment fitted to the machine, which might influence the sound output of the machine, must be noted.

Full movement of the major components, such as front-end loader buckets or excavator booms, is required during the test. These cycling movements should be done as far as practical, taking into consideration all relevant safe practices. The blowing of relief valves should be avoided.

24.5 Test procedure

The sound level meter must be set to A-weighted frequency response and fast time response.

For agricultural and industrial tractors, stable sound pressure levels must be measured with the vehicle stationary in the centre of the test site, with the governor control level set in the fully open position so that the engine is running at the manufacturer's recommended high idling speed. The transmission must be in neutral and the clutch engaged.

For special purpose machines, i.e. vehicles with hydraulic or mechanical actuated components, maximum sound pressure levels must be measured with the machine stationary in the centre of the test site and with the engine or engines running in a stable condition at the manufacturer's recommended engine operating speed(s). The appropriate hydraulic circuits and mechanical, electrical, hydrostatic, or torque converter drive systems are to be activated to cycle the major component or components from the most retracted and/or lowered position to the fully extended and/or maximum height position and then back to the original position.

24.6 Number of measurements

Three sets of sound pressure level measurements, each comprising four measurements representing the front, rear and two sides of the machine must be obtained. Wherever possible the machine to microphone direction must be stepped 90^{o} between each set of measurements.

The three values at each measurement location are to be arithmetically averaged and the sound pressure level recorded must be the maximum of the four average sound pressure levels.

25 MOTOR VESSELS AND OUTBOARD MOTORS

25.1 Introduction

The procedure detailed in this section covers the measurement of sound pressure emission levels from motor vessels and outboard motors and includes tests for vessels used at aquatic carnivals.

The basis for the procedures described in this section is Australian Standard 1949 – *Method of measurement of airborne noise emitted by vessels in waterways, ports and harbours*.

25.2 Site requirements

The site must provide a free acoustic field above a reflecting plane consisting of water and/or ground.

This condition may be considered as fulfilled if the surroundings of the microphone up to 100 metre radius are free of large acoustically reflective objects like barriers, hills, rocks, dock walls, bridges or buildings. The area between the motor vessel being tested and the measuring microphone must be open water or land surface as free as possible from sound absorbing covering such as high grass, snow or ice.

Noise from waves splashing against the shoreline, jetty, or vessel if the measurements are made from another vessel must be included in the background noise assessment.

25.3 Microphone position

The microphone must be placed on a vessel, a jetty or the bank at a height of 1.2 metres above the mounting surface, and preferably between 3 metres and 6 metres above the water surface. The microphone must be directed perpendicular to the course of the motor vessel.

25.4 Arrangements and vessel condition

25.4.1 Outboard motors

The sound pressure level of an outboard motor must be determined with the motor fitted to a vessel which is suited to the outboard motor being tested. This vessel must be of a design that does not afford an abnormal degree of acoustic shielding to the motor. The person conducting the test shall determine the suitability of the vessel in relation to this requirement.

25.4.2 Motor vessels

For motor vessels, the main propulsion machinery must be run at 95% or more of its rated speed with controllable pitch propeller, if fitted, set at the normal power position. Where, in the opinion of the testing officer, the test speed determined by reference to the above is not attainable by the engine, then it must be tested at the maximum speed that the testing officer believes that the engine can be safely run.

All auxiliary machinery and equipment necessary for continuous service must be operating normally.

Where the position of doors and windows likely to be open during normal operation of the motor vessel influences the measured sound pressure level, measurements must be taken with doors and windows shut and also with doors and windows open. The higher sound pressure level measured must be taken as representative of the motor vessel.

25.5 Test procedure

The sound level meter must be set to A-weighted frequency response and fast time response.

The vessel must run on a straight course as close as practical to 25 metres from the measuring microphone. This distance must be in the range of 18 to 35 metres. This course must be of sufficient length to allow all motors and/or engines to attain stable operating conditions, and to permit a true course to be maintained across the line of measurement.

The maximum sound pressure level indicated during the passage of the motor vessel must be recorded.

The closest distance from the side of the vessel to the microphone shall be measured during each sound pressure level measurement.

Two sound pressure level and distance measurements must be made on each side of the vessel. Each measured sound pressure level must be adjusted to a standard measurement distance of 25 metres using the expression and/or table below.

$$\mathbf{L_{25m} = L_d + 20 \log(d/25) = L_d + \Delta L}$$

Values **ΔL** corresponding to rounded values of **d**

Distance **d** metres	18	20	22	25	28	32	35
ΔL dB(A)	-3	-2	-1	0	1	2	3

Where: **d** is the distance from the vessel to the microphone;
L_d is the measured sound pressure level;
ΔL is the adjustment associated with the nearest value of **d** listed in the table; and
L_{25m} is the sound pressure level adjusted to a standard measurement distance of 25 m.

The **L_{25m}** sound pressure levels representing each side of the vessel must be arithmetically averaged and the higher of the two values obtained must be taken as the sound pressure level from the vessel. If the spread of results on either side of the vessel exceeds 2dB(A) then the test should be repeated and the highest value of the two tests must be taken as the sound pressure level.

26 PORTABLE APPARATUS

26.1 Introduction

The procedures specified in this section are applicable to the measurement of sound pressure emission levels from apparatus of a portable nature, including:

- hand held power tools;
- free standing power tools;
- compressors and their drives;
- generators and their drives;
- pumps and their drives; and
- mixers and their drives.

A measurement distance of 3.0 metres is to be used for items that are smaller than 1.0 metre across their largest dimension and a measurement distance of 7.5 metres is to be used for all other items.

Lawnmowers and chainsaws are the subject of separate sections of this manual.

26.2 Test site

The site must be in the open air and must comprise a generally flat area that is free from reflective planes (other than the ground plane) and any obstruction that could significantly affect the test results.

If acceptable to the person conducting the test, sites having more reflective acoustic characteristics are permissible. Higher observed sound pressure levels can be expected from such sites. The nature of the test site must be noted.

Where a sound source to microphone distance of 7.5 metres is to be used, the minimum radius of the test site should be 30 metres. Where a sound source to microphone distance of 3 metres is to be used, the minimum radius of the test site should be 15 metres.

The central region of the test site must have a surface covered with concrete, asphalt, firm soil with a short grass covering, or other material appropriate to the equipment being tested. The outer region of the test site must have a surface covered with firm soil and or grass, essentially free from any loose acoustically absorbent material, ice or snow, and ponded water.

Only the apparatus being tested including an operator if necessary, the person carrying out the measurements and any instrumentation required to carry out the test shall remain within the test site whilst testing is in progress.

26.3 Microphone position

The microphone height for all measurements must be 1.2 metres above ground level. The microphone must be positioned so that its nominal axis of maximum sensitivity is horizontal and directed toward the machine being tested.

The microphone must be positioned 3.0 or 7.5 metres, as appropriate, from the outer casing of the machine if it is enclosed, or from the outer surface of the major components if it not enclosed. Measurements must be made at four locations perpendicular to the front, rear and two sides of the apparatus.

26.4 Operating Conditions

The apparatus must be adjusted in accordance with the manufacturer's instructions so that it is operating normally. Compliance with this requirement shall be as decided by the person carrying out the test.

Manual power tools which are designed to be normally hand held in operation must be held by hand in the centre of the test site so that the motor or engine casing is at it normal height above the ground surface.

Apparatus that is designed to operate in a free standing position (e.g. a bench grinder or concrete mixer) must be set up in its normal operating mode, on a bench if appropriate, or on the ground surface of the test site.

Where shields, guards or other similar components are supplied with the machine, these must be properly positioned whilst the test is in progress. Where such components are supplied as optional accessories, the machine must be tested without these components, unless they have been obtained for the particular machine in question.

The engine governor, where fitted, must be set so that at the maximum throttle setting the engine speed is within the manufacturer's stated maximum speed tolerance. Where a governor is not fitted the engine must be operated at a speed that is greater than 95% of the manufacturer's recommended maximum operating speed.

Apparatus powered by electric motors must be operated:

(a) at normal operating speed where this is fixed; or
(b) at the fastest speed where two or more fixed speeds are available; or
(c) at a speed that is greater than 95% of the manufacturer's recommended maximum operating speed where the speed is variable over a range.

Pneumatically powered apparatus that includes an impact or percussive component must be operated at or greater than 95% of its maximum operating speed or rate.

Rock drills must be tested whilst the drill is drilling in concrete or granite. The drill rod is to be drilled at least 0.5 metre into the material until between 0.5 and 2.0 metres of the drill remain exposed. The feeding force shall be that which gives maximum drilling performance. Details of the mounting and feeding device used shall be recorded.

Paving breakers, picks and spades must be operated vertically with a standard steel tool-bit embedded in a concrete block. The exposed length of steel with the machine in place should be between 0.2 and 0.3 metres. The machine must be held down firmly.

Pneumatically powered apparatus must be operated at the manufacturer's recommended working pressure. The machine must be operating normally and restriction of the exhaust by freezing must be avoided.

Compressors must be operated under load, so that the machine is running at its design full speed with the compressor on load, delivering its rated output and pressure.

Pumps and generators must be operated under load, so that the machine is running at its normal operating speed, and the pump or generator is delivering at least 75% of its rated output.

Mixers must be operated with the mixing bowl or chamber empty, or the impeller running in air.

Where the apparatus is hand held, or requires an operator to be adjacent, the operator must, whilst measurements are being taken, stand in a position where the effect of his presence on the measured sound pressure levels is minimal. In particular, he must not stand between the machine and the measuring microphone.

26.5 Sound Pressure Level Measurement

The sound pressure level for apparatus other than impact or percussive tools must be measured with the instrumentation set to A-weighting frequency response and slow time response. The sound pressure level for impact and percussive tools must be measured with the instrumentation set to A-weighting frequency response and fast time response.

With the apparatus positioned in the centre of the test site and operating as appropriate, three sets of sound pressure level measurements must be taken. Each set of measurements must comprise measurements representing the front, rear and two side aspects of the apparatus.

The three measurements representing each aspect of the apparatus must be arithmetically averaged, and the highest mean value must be taken as representative of the apparatus being tested.

27 VEGETATION CUTTING EQUIPMENT

27.1 Introduction

The procedures detailed in this section cover the measurement of sound pressure emission levels from power lawnmowers and other vegetation cutting equipment.

Larger lawnmowers, which are based on a general purpose tractor, must be tested in accordance with the procedure for off-road vehicles specified in this manual.

Other types of lawnmowers such as ride-on mowers must be tested in accordance with tests for motor vehicles as presented in this manual if the machinery is classified as a motor vehicle as defined by the Regulations.

27.2 Requirements

The site at which the noise level of the cutting machine is measured must be in the open air and have at its perimeter at least 30 m from any part of the grass cutting machine under test. The site must be covered with grass not more than 80mm high.

While the noise level of a grass cutting machine is being measured, only the person operating the grass cutting machine and the person making the measurements must be within the test site.

While the noise of a grass cutting machine is being measured, only the grass cutting machine and the instrumentation necessary for the measurement of the noise level of the grass cutting machine must be within the test site.

27.3 Position of microphone

The microphone must:

(a) be placed at the height of 1.2 m above the ground; and
(b) be placed at a distance of 7.5m from the centre of the test site; and
(c) face towards and have its nominal axis of maximum sensitivity (as indicated by the manufacturer of the microphone) directed towards the centre of the test site.

27.4 Condition of grass cutting machine

(a) A lawnmower or a ride on mower must be fitted with an empty grass-catcher if such a catcher is normally supplied with the mower.
(b) Where a catcher is not normally supplied, or is supplied as an optional accessory, the mower must be fitted with a safety discharge chute if such a chute is supplied.
(c) Immediately before each series of measurements the grass-cutting machine must be operated for a period of not less than 5 minutes at its maximum governed or ungoverned speed.
(d) The height adjustment position of a rotary mower must be determined by the person making the measurements as being the position approximately midway between the maximum and minimum adjustable height position (where fitted).
(e) For edge-cutters, the lower edge cutting tip of the blade or cord must be more than 30mm but not more than 200 mm above the ground.

(f) A lawnmower or ride-on mower, and in particular the underside of the base plate and the cutting disc and the blade assembly of a rotary mower, must be generally clean and free of all grass and dirt.
(g) Where applicable, the engine oil level must be within the manufacturer's allowable tolerances.
(h) For string trimmers and brush cutters, the lower edge of the cutting system must be not more than 200 mm above the test site.

27.5 Test Procedure

The lawnmower or cutter must be positioned at the centre of the test site.

The lawnmower or cutter must be cleaned and adjusted as necessary. The engine must then be started, allowed to reach its normal operating temperature, and checked to determine its operating speed. The engine speed must be adjusted if necessary.

Whilst the engine and the cutters are operating at the specified speed(s) sound pressure level measurements must be taken at four positions perpendicular to the front, rear and two sides of the lawnmower or cutter.

After each set, the lawnmower or cutter and the microphone must be re-oriented relative to the test site, so that a 90^{o} shift in orientation of each aspect is achieved. The orientation must be different for each set of measurements with at least one set of measurements comprising a reading from each aspect of the lawnmower must be made.

The sound level at each aspect of the lawnmower or cutter must be determined using the A-weighting network, and with the measuring instrument set on slow response. The arithmetic mean of those sound pressure levels obtained from the aspect showing the highest sound pressure levels must be taken as the sound pressure level of that lawnmower or cutter.

28 CHAINSAWS

28.1 Introduction

This section specifies two separate methods for the measurement of sound pressure emission levels from electric, internal combustion engined and hydraulic drive chainsaws.

A chainsaw to be tested for the purpose of checking compliance with the Regulations must first be tested in accordance with the method specified in subsection 28.2. If the results from that test indicate that the chainsaw does not comply with the relevant noise limit prescribed in the Regulations, the owner of the chainsaw may elect to have the chainsaw tested in accordance with the method specified in subsection 28.3. The results from the method which produces the lowest noise level results must be used for regulatory purposes.

The method specified in subsection 28.2 was drawn from Part 7 of Schedule 2 of the New South Wales *Protection of the Environment Operations (Noise Control) Regulation 2000*.

28.2 First chainsaw test method

28.2.1 Site requirements

(1) The site at which the noise level of a chainsaw is measured:

(a) must have its perimeter at least 30 metres from any part of the chainsaw under test, and

(b) must be in the open air, and

(c) must be covered with grass not more than 80 mm high or with concrete, asphalt or any other approved material or with a mixture of those coverings.

(2) While the noise level of a chainsaw is being measured, the following people only may be within the test site:

(a) the person operating the chainsaw,

(b) the person making the measurements,

(c) one observer, standing in the position specified by that person.

(3) While the noise level of the chainsaw is being measured, the following articles only may be within the test site:

(a) the chainsaw,

(b) the timber to be cut,

(c) the timber stands,

(d) the instrumentation and other objects necessary for the measurement of the noise level of the chainsaw,

(e) any other article which, in the opinion of the person making the measurements, will not substantially affect the measurements.

(4) The measurements must be made at each of the positions marked A, B, C and D in Figure 1 at the end of this section.

28.2.2 Position of microphone

(1) The microphone used to measure the noise level of a chainsaw:

(a) must be placed at a height of 1.5 metres (± 0.1 m) above the ground, and

(b) must be placed at a distance of 7.5 metres (± 0.2 m) from the nearest point of the motor of the chainsaw under test to the microphone, and

(c) must face towards the motor of the chainsaw, and

(d) must have its nominal axis of maximum sensitivity (as indicated by the manufacturer of the microphone) directed towards the motor of the chainsaw.

(2) Figure 2 at the end of this section shows the position of the microphone relative to the noise source.

28.2.3 Operation of chainsaw during measurement

(1) Noise measurements must be taken while the chainsaw is cutting a log.

(2) The noise level measurement must be taken at the engine speed which corresponds to the manufacturer's stated maximum power rating.

(3) Immediately before the noise level of a chainsaw is measured, the motor of the chainsaw must be operated for not less than 5 minutes.

(4) The position of the log and chainsaw during cutting must be as shown in Figure 2 at the end of this section.

(5) When the noise level of a chainsaw is being measured:

(a) the chainsaw must be held in a horizontal position by the operator and operated in a manner appropriate to normal cross-cutting, and

(b) the guide bar must be fed into the log and the load applied so that the engine speed is the same as, or within 300 rpm of, the speed at which maximum power is developed according to the manufacturer's specification, and

(c) the slices of timber cut must not be more than 25 mm thick, and

(d) full throttle must be maintained during the cutting operation.

28.2.4 Determination of noise level

(1) The person making the measurements is to make as many noise level measurements of the chainsaw as are reasonably appropriate.

(2) The maximum noise level (LpA) of a chainsaw is to be the average of the greatest noise level readings obtained from the positions A, B, C and D (shown in Figure 1 at the end of this section), as calculated in accordance with this item. If the average reading is not a whole number of decibels, it must be rounded down to the next lower whole number of decibels.

(3) An A-weighted sound pressure level must be calculated from the measured values of the A-weighted sound pressure levels (LpAi) from the following equation:

$$LpA = \frac{10\log_{10}}{N}\sum_{i=1}^{N}10^{0.1LpA_{i}}$$

Where:

"LpA" = A-weighted sound pressure level.

"LpAi" = A-weighted sound pressure level at the i’th measured position, in decibels.

"N" = Total number of measured points.

(4) If the range of values of LpAi does not exceed 5 dB(A), the A-weighted sound pressure level is to be the arithmetical mean of those values.

28.3 Second chainsaw test method

28.3.1 Site requirements

The test site must be in the open air and must comprise a flat area of 30 metres radius free from reflective surfaces (other than the ground plane) and obstructions.

The central area of the test site must comprise firm soil with a short grass covering, or a similar surface providing generally reflective characteristics.

The surface of the test site must be essentially free from any loose acoustically absorbent material, ice or snow, and ponded water.

Only the chainsaw being tested, its operator, the person carrying out the measurements and any instrumentation required to carry out the test shall remain within the test site whilst testing is in progress.

28.3.2 Microphone position

The microphone must be positioned at four positions each 7.5 metres from the chainsaw motor/engine casing, and perpendicular to the front, rear and two sides of the chainsaw.

The microphone must be at a height of 1.2 metres above the ground surface.

28.3.3 Chainsaw operating conditions

The chainsaw must be adjusted for best cutting performance in accordance with the chainsaw manufacturer’s recommendations.

The chainsaw must be positioned at the centre of the test site and held so that the blade is generally horizontal and the saw positioned 0.5 to 1.0 metres above the ground surface.

The saw must be operated at its full “no load” speed whilst sound pressure level measurements are being taken.

The chainsaw operator must always stand in a position that does not place him between the chainsaw and the measuring microphone.

28.3.4 Sound pressure level measurement

The sound pressure level must be measured with the instrumentation set to A-weighting frequency response and slow time response.

Whilst the chainsaw is operating at its full "no load" speed with the cutting chain being driven, sound pressure level measurements must be taken perpendicular to the front, rear and two sides of the chainsaw.

Three measurements must be taken at each aspect of the chainsaw. Between each measurement the throttle of an internal combustion engine chainsaw must be released and the engine allowed to idle or the on-off switch of an electrically powered chainsaw must be released.

The arithmetic mean of those sound pressure levels obtained from the aspect of the chainsaw showing the highest sound pressure levels must be taken as the sound pressure level of that chainsaw.

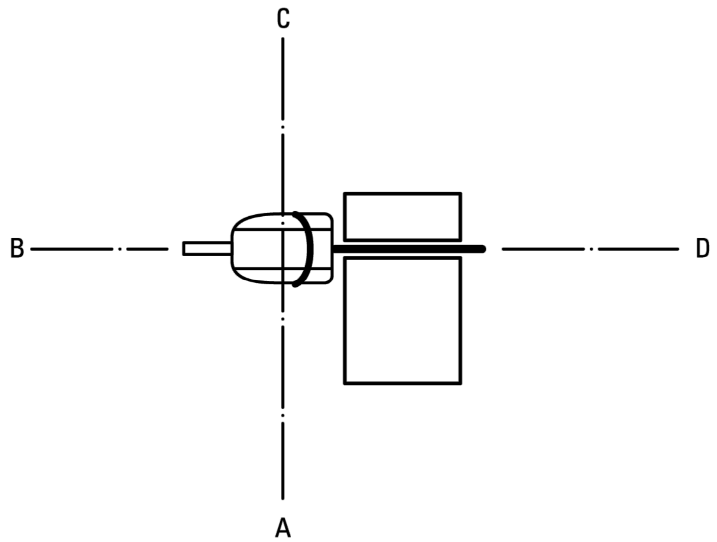

Figure 1

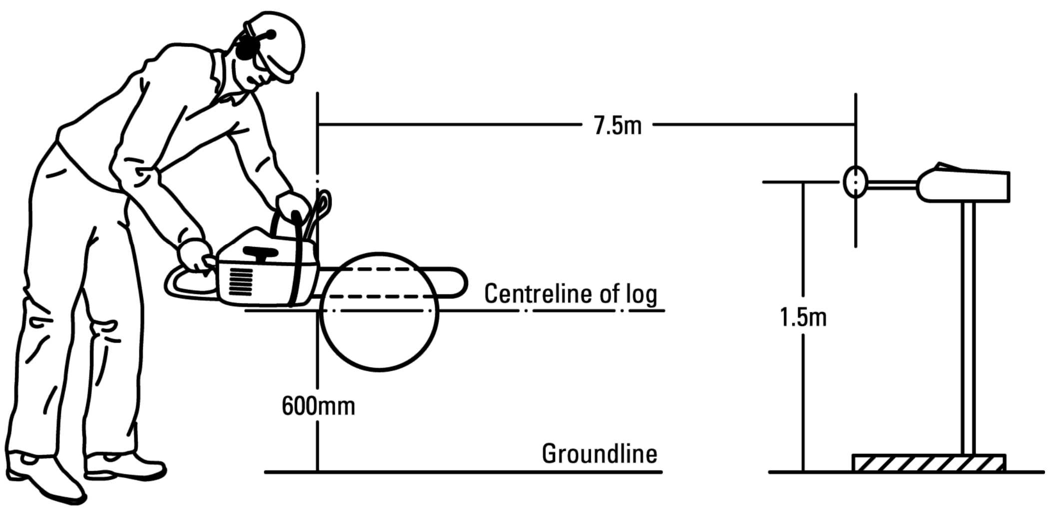

Figure 2

29 AIR CONDITIONERS (INCLUDING HEAT PUMPS)

29.1 Meter setting

The sound level meter must be set to A-weighted frequency response and fast time response.

29.2 Microphone location

The microphone must be located 1.2 metres above the ground and one metre from the external wall of the relevant area of a domestic premises on which the air conditioner is not situated. If this measurement location is outside the boundary of the premises at which the measurement is being made, then the measurement location must be on the boundary. See section 5.2 for suitable microphone height adjustments where there is a fence, wall or dense hedge shielding the microphone position.

29.3 Measurement procedure

One or more L_{eq} measurements of at least 5 minutes duration are to be taken when the air conditioner is under maximum load. A reference L_{eq} measurement of at least 5 minutes duration is to be taken that is representative of the ambient noise environment in the absence of noise from the air conditioner. Ideally, this should be taken at the same location as the initial measurement of the noise from the air conditioner but at a time when the air conditioner is not operating. This may not be appropriate if the air conditioner is operating continuously, in which case the reference measurement location should be moved to position where the air conditioner is unlikely to influence the ambient sound pressure level.

29.4 Adjustments to measurement

In taking a measurement, adjustments are to be applied to the time average A-weighted sound pressure level as follows:

(a) an adjustment of +5 dB(A) is to be applied if the noise emitted by an air-conditioner is audibly tonal;
(b) an adjustment of +2 dB(A) is to be applied if the noise emitted by an air-conditioner is audibly impulsive.

Audibility for the purposes of these adjustments is to be assessed at the measurement location.

The results of the air conditioner measurements, both before and after adjustments, and the reference measurements are to be reported.

A façade adjustment in accordance with section 5.2 must not be made.

PART F – SPORT AND ENTERTAINMENT

30 OUTDOOR CONCERTS

30.1 Measurement Location

Measurement locations are to be selected in accordance with the general considerations of section 13.3 and are to be representative of the most effected section of the noise sensitive premises under investigation.

30.2 Measurement procedures

Noise measurements must be taken during a time when activities at the outdoor concert venue are typical of the particular entertainment style. Measurement times must coincide with performances at the concert and are not to include times dominated by crowd noise, lulls between performances, arrival and departure of patrons and set-up and removal of services and equipment. Other ambient noise in the area must be measured during a lull in the noise from the concert under investigation or before and after the event.

The sound level meter must be set to A-weighted frequency response and slow time response. The measurement must consist of 15 cumulative minutes of music audible at the measurement site, measured as the L_{eq}. Significant extraneous noise and periods when music from the concert is not audible at the measurement location must be excluded for the measurement.

PART G – INDOOR MEASUREMENTS

31 INDOOR MEASUREMENTS

31.1 General

These requirements relate to the measurement of internal noise levels specified in any Environment Protection Policy that is made, and for other purposes where exceptional measurement of internal noise levels may be required.

31.2 Microphone position

The microphone must be located at least 1 m from walls and other major reflecting surfaces, 1.2 metres above the floor and at least 1.5 metres from any windows. If these distance conditions cannot be met, variations are to be noted.

The presence of discrete frequencies or narrow band signals may cause the sound pressure level inside a building to vary spatially within a particular area. Where this occurs, the sound level must be determined as the highest level measured in the occupied location(s).

31.3 Condition of the building

Where the space is naturally ventilated, at least half of the area of ventilation openings must be open during measurements. All neighbouring spaces in the building must be occupied with normal activities in progress.

Any building services such as ventilation systems, air conditioning systems, lifts, plumbing and lighting must be operating normally.

31.4 Adjustment for intrusive or dominant characteristics

Indoor measurements must be adjusted for intrusive or dominant characteristics if present, unless the characteristics result solely from the influence of the building.

GLOSSARY OF ACOUSTIC TECHNICAL TERMS

In this Manual —

"**air blast overpressure**" means the maximum air pressure at a specified point caused by the shock wave generated by an explosion and transmitted through the air;

"**ambient sound**" has the same meaning as in Australian Standard AS1633-1985 *Acoustics - Glossary of terms and related symbols*;

"**ANEF**" means Australian Noise Exposure Forecast and has the same meaning as in Australian Standard AS2021 *Acoustics - Aircraft noise intrusion – Building siting and construction*;

"**A-weighted sound pressure level**" has the same meaning as in Australian Standard AS1055.1-1997 *Acoustics - Description and measurement of environmental noise - General procedures*;

"**background level**", for a specified time interval T, means the $L_{A90,T}$ sound pressure level for that time interval;

"**C-weighted sound pressure level**" has the same meaning as A-weighted sound pressure level except that the level is calculated using the r.m.s. sound pressure determined by use of the frequency-weighting network "C" in Australian Standard AS1259.1 *Sound level meters Part 1: Non-integrating*;

"**dB**" means decibel, which has the same meaning as in Australian Standard AS1633-1985 *Acoustics - Glossary of terms and related symbols*;

"**dB(A)**" means decibel when stating A-weighted sound pressure level;

"**impulsiveness**" means a variation in the emission of noise where the difference in noise levels between the level obtained using the "F" time-weighting characteristic and the level obtained using the "I" time-weighting characteristic (the time-weighting characteristics defined in Australian Standard AS1259.1) is greater than 2 dB;

"$\mathbf{L_{A10,T}}$", for a specified time interval T, means the A-weighted sound pressure level that is equalled or exceeded for 10% of that time interval;

"$\mathbf{L_{A10(18hr)}}$" means the arithmetic average of the 18 $L_{A10(1hr)}$ levels for the period between 0600 hours and 2400 hours on any day;

"$\mathbf{L_{A90,T}}$", for a specified time interval T, means the A-weighted sound pressure level that is equalled or exceeded for 90% of that time interval;

"$\mathbf{L_{AE}}$" has the same meaning as in Australian Standard AS2363 *Acoustics – Measurement of noise from helicopter operations*;

"$\mathbf{L_{Aeq,T}}$", for a specified time interval T, means the time average A-weighted sound pressure level, within the meaning given by Australian Standard AS1055.1, for that time interval;

"$\mathbf{L_{Aeq,T}}$ **(Hel)**" has the same meaning as in Australian Standard AS2363 *Acoustics – Measurement of noise from helicopter operations*;

"$L_{Amax,T}$" means the maximum r.m.s. A-weighted sound pressure level during a specified time interval T, as measured using the F time-weighting characteristic as specified in Australian Standard AS1259.1 *Acoustics - Sound level meters - Non-integrating*;

"L_{Amax} (Event)" has the same meaning as in Australian Standard AS2363 *Acoustics – Measurement of noise from helicopter operations*;

"L_{Amax} (Hel)" has the same meaning as in Australian Standard AS2363 *Acoustics – Measurement of noise from helicopter operations*.

"L_{Apeak}" means the peak A-weighted sound pressure level;

"low frequency", as characteristic of a noise emission, means a difference of more than 15 dB in the A-weighted sound pressure level and C-weighted sound pressure level over the same time interval;

"L_{pA}" has the same meaning as in Australian Standard AS1055.1;

"$L_{p,peak}$" means the peak sound pressure level measured on a linear scale;

"modulation" means a variation in the emission of noise that –

(a) is more than 3 dB assessed as the L_{pA} level;
(b) is present for at least 10% of the representative assessment period; and
(c) is regular, cyclic and audible;

"sound pressure level" has the same meaning as in AS1055.1 *Acoustics - Description and measurement of environmental noise - General procedures*; and

"tonality" means the presence in the noise emission of tonal characteristics where the difference between –

(a) the A-weighted sound pressure level in any one-third octave band, and
(b) the arithmetic average of the A-weighted sound pressure levels in the two adjacent one-third octave bands

is greater than 3 dB when sound pressure levels are assessed as the $L_{Aeq,T}$ levels, where the time period T must be not less than one minute and not more than one hour.

APPENDIX 1 – RECORD SHEET

SOUND PRESSURE LEVEL MEASUREMENT RECORD SHEET						
***Report No.*…………………………**						
Test site:……………………..…………………………………………………………………………..						
Noise source…………………………………………………………………………………………………..						
Date		**Monitoring time period**		**Map reference**		
Sound level meter identification						
Make:		**Model:**		**Serial No.:**		
Pre-test calibration:		**Post-test calibration:**		**Date of last NATA calibration:**		
Meteorology						
Wind speed	**Wind direction***	**Temperature* (dry bulb/wet bulb)**		**% Humidity***	**Barometric pressure***	
Cloud*	**Rainfall***	**Other observations:**				
Results						
Property	**Test 1 ( )**		**Test 2 ( )**		**Test 3 ( )**	
dB						
Frequency weighting						
Time constant						
Characteristics (tonal, impulsive, etc)						
Start/end time						
Sample period						
Meter range						
Comments (the reverse of this sheet may be used for additional information and diagrams):						

Testing Officer:	**Position:**
Testing Authority:	

*** Data marked with asterisk not essential for measurement of minor sources in near field.***

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Environment Division
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GPO Box 1751
HOBART TASMANIA 7001
Ph: 1800 001 377
Visit: www.environment.tas.gov.au