A guide to the measurement and analysis of noise

1. Introduction

This document will assist in the assessment of noise from industrial premises when using State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 or entertainment premises when using State Environment Protection Policy (Control of Music Noise from Public Premises) No. N-2.

This document does not prescribe rigid procedures for accurate noise measurement, nor should it limit the legitimate discretion of an expert in the field.

Recommendations in this document may not be appropriate in all circumstances and professional judgement and discretion should be employed.

2. Location of measurement point

2.1 Noise sensitive areas

The Policies normally specify noise limits for outdoor areas of noise sensitive areas. It is therefore preferable to choose a point outdoors to take measurements. It should be chosen so a maximum level of the noise source is obtained.

2.2 Indoor measurement

In some cases it is difficult to measure the noise outdoors, and an indoor measurement may be necessary. This situation is most likely to occur when an outdoor area, such as a front or back yard, doesn't exist such as where the noise sensitive area is an apartment in a high-rise building.

An indoor measurement is not preferred; it may be possible to use a microphone attached to a boom protruding from the window of the affected room instead of measuring indoors.

The Policies specify the circumstances in which measurements should be taken indoors.

2.3 Derived point

For practical reasons it may not be possible to take measurements in a noise sensitive area. In such cases an alternative point is chosen, called a derived point.

A derived point will normally be located out of doors and the general requirements of microphone placement are described in Section 3.1.

The Policies allow a derived point to be set at any point outside a noise sensitive area. They also specify under what circumstances a derived point may be used. These are discussed below.

(a) Multiple industries

A derived point may be appropriate when more than one premises contributes to the noise received at the noise sensitive area. In this case derived points should be selected so that the noise of an individual premises is measured at each point. Care should be taken in selecting a derived point so that the distance from the premises is sufficient for it to appear as a point source. Where there are a number of noise sources in the premises, it may be necessary to set multiple derived points to control individual pieces of equipment.

(b) Atmospheric effects

Weather conditions can markedly affect the noise level received at a noise sensitive area. This is particularly important when the level is low and the distance between the noise sensitive area and the source exceeds 200 metres. When it is believed that the noise received at the noise sensitive area is affected by weather conditions, then a derived point may be used. It is advisable to use this point in all cases where the noise source is more than 500 metres from the noise sensitive area because weather conditions are likely to be the major source of variability in the noise level at this distance.

Where a suitable derived point is not available, Policy N-l requires three measurements to be taken within a 30 day period at the noise sensitive area; this is used as an alternative to the derived point method to account for the variability in received noise caused by weather conditions.

Policy N-2 does not specify that a derived point may be used to take account of weather conditions for outdoor venues.

3. Measurement of the effective noise level

3.1 Microphone placement

Difficulties can arise in the measurement of noise due to the placement of microphone and tripod. For example, if a microphone is located too close to an acoustically reflecting surface, then reflections from that surface may artificially increase the noise level. Also, if the tripod is placed on a rigid surface then vibration through the legs of the tripod

may affect the measured level. Noise levels can vary from place to place because of shielding by buildings or other structures and also because of the presence of nodes and anti-nodes (especially indoors) resulting from tonal noises.

The microphone should be located so reflections from nearby surfaces are minimised and where a maximum noise level (unaffected by reflections) is obtained.

The following procedure is suggested.

(a) to be consistent with the procedures recommended in Australian and international standards, a microphone height of from 1.2 to 1.5 metres above the ground or floor should be used. The microphone may be located at a height greater than 1.5 metres in exceptional circumstances, such as when a measurement is made on a boom outside the window of a building to avoid making an indoor measurement;

(b) to avoid reflections from nearby acoustically reflecting surfaces, the microphone is best located at least 3.5 metres from such surfaces when located outdoors.

The Policies allow measurements to be taken closer than 3.5 metres from reflecting surfaces. Such measurements would only be made in exceptional circumstances, such as when a microphone is located outside a window to avoid an indoor measurement. In such cases a negative adjustment is made to the measured level as specified in the Policies;

(c) to avoid reflections affecting the measured level indoors, the microphone should be located at least 1.2 metres from any acoustically reflecting surface. A reflection adjustment is not made for indoor measurements;

(d) to avoid reflections from the body of a person when making direct reading measurements from the meter scale, the meter should be held at arm's length or placed on a tripod with the person taking the measurement at a suitable distance; and

(e) vibration being transmitted through the tripod legs from a hard rigid surface such as uncarpeted floor-boards or concrete may produce unwanted extraneous noise to be measured by the sound-level meter. This can be avoided by using vibration isolation, such as foam pads.

3.2 Equipment checkpoints

When measurements of noise are being made in the field, (from a factory premises, entertainment noise or background noise) certain procedures should be employed to ensure an accurate measurement is obtained. Some of these procedures also apply to analysis of tape-recordings in the laboratory.

Use of equipment should be generally in accordance with the manufacturer's recommendations.

In particular, the following points are important.

(a) some pieces of equipment require a minimum 'warm-up' time before their performance is optimum. The manufacturers' recommendations are the best guide.

(b) a battery check should be done on each piece of equipment used in the field before and after it is used.

(c) a calibration check should be made both before and after the measurement. Where a tape recorder is used, a calibration tone should be recorded at the start and end of the tape. Calibration checks may vary slightly, and may cause the measurement to be invalid if the difference is significant. The magnitude of the noise excess above the noise limit will play a part in this judgment.

(d) residual equipment noise can be a source of measurement error; all equipment including tape recorders and sound level meters have internally generated electrical noise. It is important that the signal being measured is significantly higher than this equipment noise. The margin will depend on the sound level meter range being used and the VU level recorded on a tape recorder.

If the measurement signal is 10 dB above the residual noise, then an error of approximately 0.4 dB will result. This is insignificant, and a margin of at least 10 dB is recommended. The residual noise may be estimated by placing a calibrator on the microphone of the sound level meter and observing the sound level indicated by the meter, without turning the calibrator on.

(e) The heads of a tape recorder should be kept clean using a suitable cleaning fluid.

3.3 Measurement methods

Two noise indices are used by the Policies to determine the effective noise level. These are discussed below.

(a) L_{Aeq}

The L_{Aeq} may be measured using any of the following methods:

(i) a tape recording of the noise which is analysed later to obtain an L_{Aeq}. This method should be used when a high level of accuracy is required, for example when some doubt exists about whether the noise is excessive;

(ii) an integrated L_{Aeq} using a suitable sound level meter in situ. This method can be used when the noise is clearly excessive; or,

(iii) the average of the meter deflections using a sound level meter. This method can also be used when the noise is clearly excessive, but should not be used if the noise is not steady (varies by more than 8 dB(A)).

In general, the L_{Aeq} may be determined using the equal energy principle:

$$L_{Aeq} = 10 \times \log_{10} \frac{1}{T} \int_0^T \left(\frac{P(t)}{P_0} \right)^2 dt$$

The appropriate SEPP should be consulted before selecting the measurement method. The method of measuring the noise will vary depending on the policy being used and the type of premises being assessed. For example, in the case of Policy N-l, a tape recording will usually be made for major premises and a short direct reading (hand-held) measurement will be taken for minor premises. A tape recording must be made for major premises if the noise is tonal or impulsive.

(b) L_{OCT10}

The measurement of L_{OCT10} may be made in any of the following methods:

(i) a tape recording of the noise that is analysed later using suitable equipment such as a real-time analyser. This method is preferred when a high level of accuracy is required or some doubt exists about whether the noise is excessive; or,

(ii) average of the maximum meter deflections of specified octave bands when using a sound level meter fitted with an octave filter set. This method can be used when the noise is clearly excessive.

The L_{OCT10} is measured when noise in the particular octave band correlates with the music. It may be necessary to analyse a recording a number of times where the contributions of the noise in the different octave bands are different. Extraneous noise should be excluded from the analysis. It is important to note that audible `extraneous' noise may not affect the measurement if its frequency is different from the music. For example, crickets generate noise around 3000 Hz, while music is commonly prominent below 250 Hz.

3.4 Measurement time

The time for which a measurement of the effective noise level is made will depend to a large degree on the variability of the noise source.

The following points should be noted when determining an appropriate measurement time.

(a) Policy N-l does not specify a measurement time, but it is recommended that the L_{Aeq} be measured so it represents the L_{Aeq} over a 30 minute period. Noise emissions need to be observed for at least 30 minutes for the purpose of assessing a duration adjustment; if the noise is steady over this period (that is, there is no observed rising or falling trend in the noise level either audibly or by sound-level meter inspection), a short measurement (say five minutes) should be adequate to represent the 30 minute L_{Aeq};

(b) if the noise varies in a cyclic or regular manner then the L_{Aeq} should be measured over a number of periods of the cycle. If the level fluctuates in a random manner, then a short measurement may be used as long as the measurement is carried out in an appropriate manner (see Section 3.1); and,

(c) Policy N-2 requires the measurement to be taken over at least fifteen cumulative minutes of audible music.

3.5 Analysis and adjustments

(a) Sampling rate

Where an L_{Aeq}, L_{OCT10}, L_{A90} or L_{OCT90} is determined using a sampling method, the sampling rate should be sufficient to give an adequate number of samples. The number of samples is a more important factor in general than the sample rate; a sample rate of at least one sample per second should be used.

Where the level is measured by taking a hand-held measurement of the average of the maximum, minimum or average meter deflections, then each sample should be recorded and at least 40 samples be made.

(b) Adjustments

Policy N-l requires adjustments to be made for the character of the noise. The requirements for making adjustments are clearly explained in the Policy.

The following may assist in making tonal and duration adjustments.

The tonal adjustment for major premises is made by using an A-weighted tape recording of the noise and determined by arithmetically averaging the adjustment for a number of samples. At least three samples should be made and the samples should be of equal duration. The Policy also requires that the sum of the durations of the samples be at least 24 seconds.

Where a tone falls between two 1/3 octave bands then the 1/3 octave analysis may not reveal the true tonal nature of the noise. In this case the speed of the play-back tape recorder may be varied to change the frequency of the tone so a maximum adjustment is obtained. The speed variation should not be greater in magnitude than 13 per cent of the normal speed.

The Policy requires that the samples be `representative of the tonal character of the noise'. It is important that the adjustment not be merely representative of the tonal character of the tape recording. That is, the **tape recording** needs to represent the tonal character of the noise.

The presence of a detectable tone on a tape recording may not mean that an adjustment is appropriate. It is necessary to consider, among other things, whether the tone is continuous and whether the tone is subjectively annoying.

The duration adjustment is determined from the time the noise is audible over a continuous 30 minute period. It should be noted that it is based on audibility at the measurement point and not on the total time the noise is emitted from the industry. For example, a noise may be continuously emitted from an industry but may only be audible for 50 per cent of the time at the measurement point because of the masking effect of traffic noise.

4. Noise limits

The method to determine noise limits is clearly set out in the Policies. The following additional points should be noted.

4.1 Policy N-l specifies a requirement to determine a zoning level. This level is based on the land-use zoning of the area as specified by the appropriate planning scheme. The Policy classifies land as Type 1, 2 or 3 depending on the zoning. Where a zone or reservation is undefined by the Policy then the Authority will designate the Type taking into consideration the nature of the uses permitted in the area. In most cases the Type given will be based on a similar land use. There may be cases where the uses permitted will have to be determined from the planning scheme ordinance before a suitable Type can be allocated.

4.2 Policies N-l and N-2 require a derived noise limit to be determined for a derived point. The derived noise limit is set so when the industrial or entertainment noise complies with this level, the noise limit at the noise sensitive area is not exceeded. To determine the derived noise limit, an adjustment must be made to noise limit conditions to allow for attenuation due to distance, weather conditions, barriers, etc.

Standard methods are available to determine the attenuation of noise over distance. If a derived point is used as an alternative point when the noise received at a noise sensitive area is affected by weather conditions, it is recommended that the derived noise limit calculation be based on weather conditions favouring propagation that occur for 20 per cent of the time.

5. Background noise measurements

The background level should represent the L_{90} (or L_{OCT90} if appropriate) level of the background noise at the noise sensitive area. The measurement should not include noise from the premises being investigated.

The measurement point should be located at the same point in the noise sensitive area where the L_{Aeq} was measured, or in the case of derived points the background level should be measured at a suitable place in the noise sensitive area.

Where the background level cannot be measured at the noise sensitive area because of the continuous operation of the industry, an alternative measurement point may be used. The alternative point should be carefully selected so the background level represents the background level at the noise sensitive area; in selecting the alternative point, consideration should be given to comparative contributions of the main sources of background noise at both sites, such as traffic (related in part to the proximity of main roads).

Different methods are used to measure the background level for Policies N-l and N-2, these are discussed in detail below.

5.1 Policy N-1

The background noise may be measured using one of the following methods.

(a) Direct reading measurement.

When a direct reading (hand-held) measurement is used, the average of the minimum meter deflections of a sound level meter may be used to represent the level. At least 40 samples of the level should be taken to determine the L_{A90}.

(b) A sound level meter and a chart recording.

When a chart recording is used, the background level may be read directly from the chart recording. The L_{A90} level for each hour may be estimated by measuring the level that is exceeded for 90 per cent of the time directly from the chart.

(c) A tape recording and a sound level meter.

The tape recording of the background noise may be analysed using a noise level analyser to obtain an L_{A90} level.

(d) Noise level monitoring equipment.

The background level may be measured by leaving noise level monitoring equipment in the field. The equipment should be capable of determining the L_{A90} level for each hour of the period investigated.

The Policy requires that the background be measured to determine if it is neutral. The background is neutral when it is neither high nor low (see Schedule B1.2 of the Policy). The Policy requires two measurements to be made of at least five minutes to determine if the background is neutral. It is recommended that short hand-held measurements be taken (as the average of the minimum meter deflections, see method 5.1(a)) at the start and finish of measuring the L_{Aeq} of the industry. Figure 1 can be used to check the L_{A90} represents the average background for the period of concern. This figure shows the average hourly levels for the 40 sites measured for the Melbourne noise survey. The figure can also be used to estimate what the average L_{A90} level is for the period of concern.

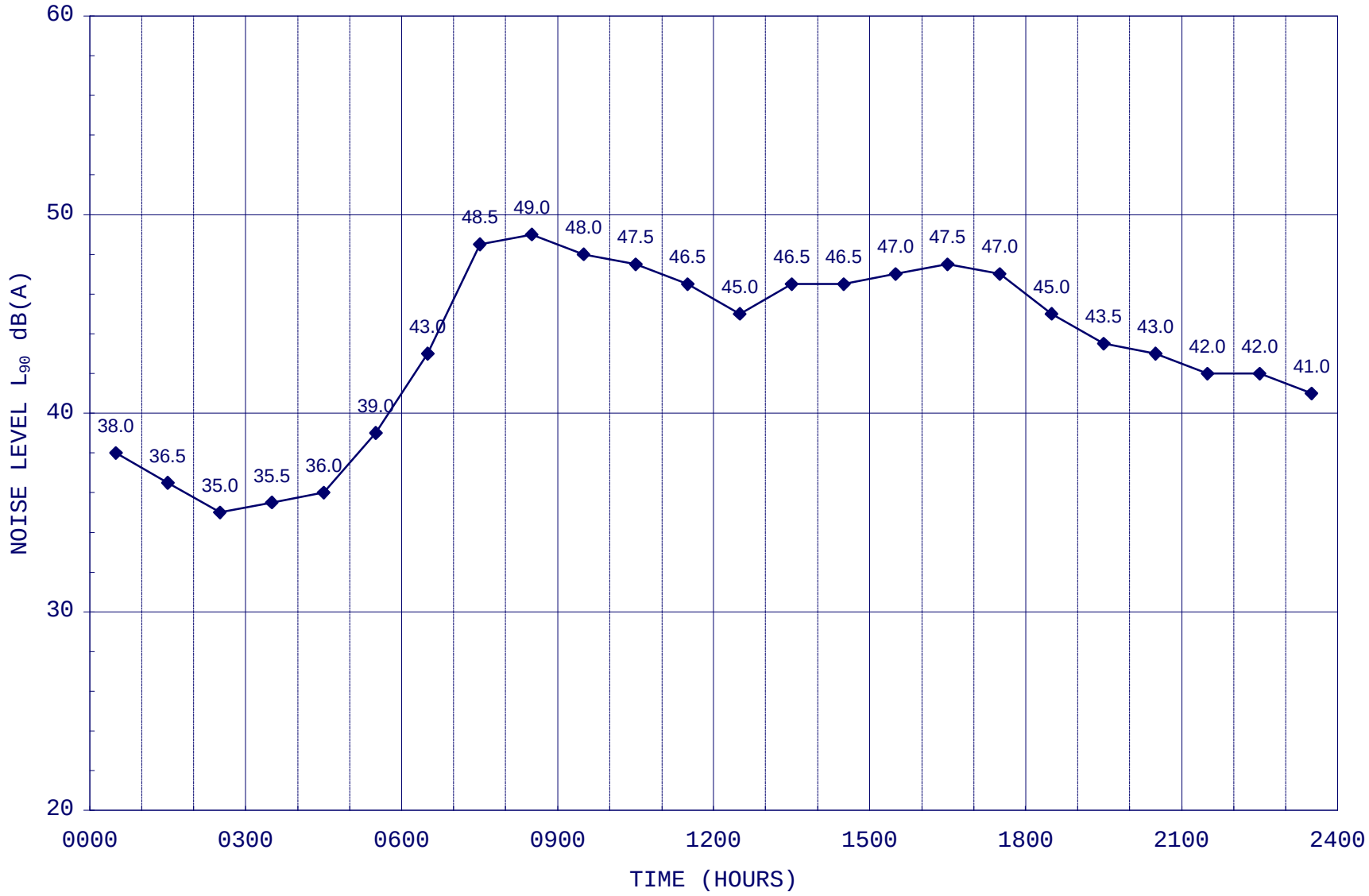
If the initial measurements of the background show it is neutral, then the noise limit is the zoning level. However, if the measurements indicate the background level is not neutral (or if any doubt exists about the results), then an accurate background level can be determined using a chart recording, from a tape recording or using noise monitoring equipment (methods 5.1 (b), (c) or (d)). It is recommended that the background be measured continuously for a minimum period of 24 hours, preferably for two to three days. The results can be used to determine if the background is high or low and, if appropriate, to determine the noise limit from the background level.

5.2 Policy N-2

The background level should be measured to obtain a L_{A90} or a L_{OCT90} level as specified by the Policy. The measurement should be made as close as possible to the time when the effective noise level is measured or at another time (at the same time on another day for example) so that the L_{A90} or L_{OCT90} represents the background when the noise level was measured. It is advisable to measure the background level for more than one day where noise emissions occur on several days of the week. For example, the background level may be different on a Monday night from a Saturday night.

It is recommended that the L_{A90} and L_{OCT90} be measured by taking a tape recording of noise and analysing it later or by using suitable noise analysing equipment in situ.

FIGURE 1
AVERAGE OF 40 SITES - MELBOURNE NOISE SURVEY



6. Equipment specifications

It is recommended that the following equipment specifications are used for Policies N-l and N-2.

6.1 Measurement and analysis equipment should have been calibrated within the previous 12 months by a laboratory equipped for the purpose.

6.2 A-weighting, 'F', 'S' and 'I' should conform to the requirements of *Australian Standard 1259-1982 - Sound Level Meters.*

6.3 Sound level meter

The meter shall conform to the requirements of sections 8 and 9 of *Australian Standard 1259-1982 -Sound Level Meters.*

A Type 0 or 1 meter should be used for major premises while a Type 0 or 1 or 2 should be used for minor premises.

For Policy N-2, Type 0,1 or 2 meters may be used generally, although, Type 0 or 1 is preferred for night period assessment of indoor venues.

6.4 Reference sound source (closed coupler calibrator)

The reference sound source should have an accuracy of $\pm$ 0.5 dB between 0 and 50^{o}C. It is preferred that the reference sound source has a frequency of 1 kHz $\pm$ 2%.

6.5 Tape recorder

The record and replay tape recorder(s) should conform to the following specifications:

(a) Speed accuracy - within $\pm$ 1% of the specified speed.

(b) Wow and flutter - less than 0.2% peak weighted (as per *German International Standard DIN 44507-1966 Measuring Apparatus for Frequency Variations in Sound Recording Equipment*).

(c) Frequency response - the response for different frequencies should comply with the following tolerances when compared to the level at 1 kHz:

35 Hz to 90Hz,	$\pm$ 3 dB
90 Hz to 7100 Hz,	$\pm$ 1.5 dB
7100 Hz to 14 KHz,	$\pm$ 3 dB.

In the case of the record/replay machines, a suitable test tape should be used to record standard tones from 35 Hz to 14 KHz at a level of -20 VU (when the tape recorder is calibrated to the manufacturer's specifications). When replayed the levels should comply with the above tolerances.

In the case of replay only machines, a suitable test tape should be played at a level of -20 VU (when the tape recorder is calibrated to the manufacturer's specifications) and the levels should comply with the above tolerances.

(d) Signal to noise ratio - greater than 45 dB(A) referenced to a 1 kHz tone recorded at 0 VU (when the tape recorder is calibrated to the manufacturer's specifications) and replayed.

(e) Distortion less than 2% total harmonic distortion for a 1 kHz tone recorded at 0 VU (when the tape recorder is calibrated to the manufacturer's specifications) and replayed.

(f) Separation between tracks - greater than 35 dB at 1 kHz.

6.6 **Octave and one-third octave measuring equipment**

The band pass filters should conform to the requirements of *Australian Standard Z41-1969 - Octave, Half Octave and One-third Octave Band Pass Filters intended for the analysis of sound and vibrations*.

6.7 **Noise level analysing equipment**

(a) The equipment should conform to the requirements of Type 0 or Type 1 sound level meters as specified in Section 8 and 9 of *Australian Standard 1259-1982 - Sound Level Meters*.

(b) The `Linear' weighting should have a flat frequency response between 20 Hz and 20 kHz with a tolerance of $\pm$ l dB.

6.8 **Noise level monitoring equipment**

The noise level monitoring equipment should conform to the requirements of Type 0, Type 1 or Type 2 sound level meters as specified in *Australian Standard 1259-1982 - Sound Level Meters*.

6.9 **Chart recorder**

The chart recorder should have an accuracy within + 3% of full scale deflection for any position on the chart and a writing speed equal to or greater than 50 mm/s. The paper speed of the chart recorder should be approximately 5 cm or more per hour.

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