Average Maximum Sound Level: A Complementary Metric for Environmental Noise Assessment

Ben Hall[1]

[1] Instralabs Pty Ltd
Unit 5, 15 Quarryville Road
Torrington, Qld

ABSTRACT

Many existing environmental approvals and licence conditions in Australia specify noise limits as an A-weighted 'average maximum' or '$L_{Amax,adj,T}$'. These descriptors originated in an era when analogue sound level meters were used and compliance was assessed by observing and informally averaging meter needle peak excursions. Modern digital sound level meters do not reproduce that observational process directly, and practitioners have commonly adopted the L_{A10} despite it being a time-exceedance percentile rather than an average of maxima. This paper presents the Average Maximum Sound Level ($L_{AFmax,T}$), a repeatable empirical method for calculating the arithmetic mean of maximum levels over consecutive time intervals. The method provides a practical and repeatable approximation of the historical "average maximum" concept, reduces subjective variability, and offers a more appropriate legacy-assessment descriptor than L_{A10} in environments characterised by recurring maxima. A formal technical specification, ILTS-AC-001:2025, has been developed to support consistent implementation.

1. INTRODUCTION

Many environmental approvals, development conditions, and licence requirements issued in Australia over past decades specify noise limits in terms of A-weighted 'average maximum' or '$L_{Amax,adj,T}$' (adjusted maximum sound level). These limits were established when analogue sound level meters were standard instrumentation, and assessment was performed by observing the meter needle and subjectively estimating the average of its peak excursions over a measurement period—typically 15 minutes.

With the widespread adoption of digital integrating sound level meters, this subjective needle-observation method is no longer practicable. Digital meters do not have needles to observe, and while they log L_{Amax} values, they do not inherently calculate an 'average maximum' as historically understood.

In response, practitioners have commonly adopted the L_{A10} (or L_{10}) statistical level as a substitute for the average maximum. While L_{A10} is objective and repeatable, it is a time-exceedance percentile and not an average of maxima, so its relationship to the historical intent of "average maximum" varies with the temporal characteristics of the sound environment.

This paper proposes the Average Maximum Sound Level, LAFmax,T, as a practical and repeatable method for interpreting such legacy conditions using modern digital instrumentation. The method is based on the arithmetic mean of consecutive interval maxima and is intended primarily as an approximation of the historical observational concept, rather than as a universal replacement for established modern noise descriptors. A formal technical specification (ILTS-AC-001:2025) has been developed [3] for consistent implementation.

2. THE LEGACY INTERPRETATION

2.1. Historical Assessment Method

Prior to digital instrumentation, the 'average maximum' was assessed by an operator observing an analogue meter with a needle that tracked the Fast time-weighted sound level. Over a measurement period (typically 15 minutes), the operator would mentally note the peak excursions of the needle and estimate their average. This subjective method was accepted practice but had inherent variability between operators and measurements.

Modern digital sound level meters replaced the analogue needle with numerical displays and data logging. While digital meters provide precise, logged values of L_{AFmax} for any specified interval they do not reproduce the historical observational process on which these legacy “average maximum” conditions were based.

2.2. L_{A10} as a Substitute

In the absence of a standardised method, practitioners commonly adopted L_{A10} as a substitute for the average maximum. The L_{A10} is the level exceeded for 10% of the measurement time—for a 15-minute measurement, this represents the level exceeded for 90 seconds.

While L_{A10} provides a repeatable and objective metric, its limitations as a surrogate descriptor may be summarised as follows:

- L_{A10} is a time-exceedance percentile, rather than an average of observed maxima
- Its relationship to the historical ‘average maximum’ depends on source duty cycle, event duration, and ambient noise levels
- For sources with different temporal patterns, LA10 may over- or under-estimate the typical maximum behaviour that would historically have been observed on an analogue meter

Consider a 15-minute measurement of an industrial site at which conveyors operate continuously, valves release periodically, forklifts and other site vehicles pass intermittently, and occasional chainsaw trimming produces the highest short-duration peaks. In this example, the chainsaw event forms part of the normal operation and should therefore remain included in the assessment. The L_{A10} is influenced by the cumulative proportion of time for which the combined source levels remain elevated, and therefore does not directly represent an average of the observed maxima. Conversely, the single L_{AFmax} is determined by the highest individual event within the period, which may not be representative of the typical peak behaviour observed across the full assessment period. By comparison, the arithmetic mean of consecutive interval maxima allows the occasional higher operational event to contribute appropriately as part of the overall average, while avoiding the result being determined solely by that one event.

2.3. The Average Maximum Approach

By dividing the measurement period into consecutive intervals (e.g., 10 seconds) and calculating the arithmetic mean of the maximum level in each interval, we provide a practical and repeatable approximation of the historical 'average maximum'. Arithmetic averaging is intentional, as the method seeks to reproduce the historical observational averaging of displayed maximum sound levels, rather than derive an energy-equivalent descriptor.

- Each interval's maximum represents a peak level that may have contributed to the historical observational impression of recurring maxima
- The arithmetic mean corresponds to the observer's informal averaging of displayed peak levels over the assessment period

– The result is objective, repeatable, and more closely aligns with historical concept of the "average maximum"

This method also has the advantage of being robust to single anomalous events.

3. MATHEMATICAL FORMULATION

3.1 Definition

The Average Maximum Sound Level is defined as the arithmetic mean of maximum time-weighted sound levels determined over N consecutive, non-overlapping averaging intervals of duration Δt with total measurement period of T:

$$L_{AFmax,T} = (1/N) \times \Sigma_{i=1}{}^{N} L_{AFmax},i \quad (1)$$

where L_{AFmax},i is the A-weighted Fast time-weighted maximum sound level in the i-th interval, and N is the number of valid complete intervals in the measurement period. The notation follows IEC 61672-1 conventions where subscripts indicate frequency weighting (A), time weighting (F), and the descriptor (max). Here, T denotes the total measurement period and Δt denotes the duration of the consecutive intervals used to derive the sequence of interval maxima.

3.2 Time Weighting

The maximum level in each interval is determined using Fast time weighting (τ = 125 ms) as defined in IEC 61672-1 [2]. The present formulation adopts Fast time weighting to align with the historical analogue meter response relevant to legacy "average maximum" assessment. Alternative time weightings (such as slow weighting (τ = 1s)) could be defined in an analogous manner, but are not considered further here.

3.3 Selection of Averaging Interval

The averaging interval Δt should be selected having regard to the temporal characteristics of the sound environment and the purpose of the assessment. Shorter intervals will increase the number of sampled maxima, while longer intervals will tend to reduce the influence of short-term fluctuations and yield fewer interval maxima over a fixed measurement period. For legacy environmental noise assessment, a fixed interval provides a practical and repeatable approximation of the historical observational process, even though a human observer would not have applied strictly uniform interval lengths. In the absence of source-specific justification or an applicable regulatory convention, Δt = 10 s may be adopted as a practical default for legacy environmental assessment, provided the chosen interval is reported with the result. Where the acoustic environment is strongly event-driven or irregular, the sensitivity of the result to interval selection should be considered. Δt should be reported with the measurement.

3.4 Arithmetic vs. Logarithmic Averaging

A key design decision is whether to average in the decibel domain (arithmetic mean) or the energy domain (logarithmic mean). This metric deliberately uses arithmetic averaging in the decibel domain for the following reasons:

– it is intended to approximate the historical observational averaging of displayed maximum sound levels
– it is intended to characterise typical maximum levels rather than cumulative energy exposure
– arithmetic averaging yields a result that remains directly interpretable as an average of the observed interval maxima
– the resulting value lies within the range bounded by the individual interval maxima, which assists practical interpretation

For reference, the logarithmic (energy) mean of maximum levels would be calculated as:

$$L_{AFmax,T(energy)} = 10 \log_{10}\left[(1/N) \times \Sigma_{i=1}^{N} 10^{(L_{AFmax,i}/10)}\right] \quad (3)$$

This formulation would weight higher values more heavily and may be preferred where energy exposure from peak events is the primary concern. For legacy amenity assessment based on historical "average maximum" concepts, arithmetic averaging is therefore recommended.

4. IMPLEMENTATION

4.1 Continuous Monitoring

For integrating-averaging sound level meters with logging capability, implementation is straightforward:

1. Configure the meter to log L_{AFmax} values at intervals equal to Δt
2. Calculate the arithmetic mean of valid logged L_{AFmax} values for the measurement period T
3. Report the number of intervals N and Δt alongside the result

Many commercial sound level meters already provide L_{AFmax} logging at selectable intervals, enabling post-processing calculation of $L_{AFmax,T}$.

4.2 Digital Signal Processing

For software implementations processing audio recordings, the following approach is recommended:

1. Apply the required frequency weighting, such as A-weighting, using filters compliant with IEC 61672-1
2. Apply the required time weighting, such as Fast weighting, to derive the weighted sound level time history
3. Sample the weighted time history at a temporal resolution sufficient to identify the interval maxima reliably
4. Divide the resulting time series into consecutive Δt-second windows spanning the assessment period T
5. For each window, find the maximum sampled value to obtain $L_{AFmax,i}$
6. Exclude invalid intervals in accordance with appropriate regulatory framework
7. Calculate the arithmetic mean of remaining $L_{AFmax,i}$ values

4.3 Extraneous Events and Adjustments

When calculating the Average Maximum Sound Level for compliance assessment, extraneous noise events shall be identified and excluded in accordance with the applicable measurement standard (e.g., ISO 1996-2, AS 1055, or the relevant jurisdictional noise measurement manual).

Where the applicable regulatory framework requires adjustments for annoying characteristics, these shall be applied to the calculated Average Maximum Sound Level. Such adjustments may include tonality, impulsiveness, or modulation, depending on the applicable framework. The adjusted level is reported as $L_{AFmax,adj,T}$ with the adjustment method and values documented.

4.4 Interval Validity

If an interval contains excluded data that could affect identification of the interval maximum, that interval shall be treated as invalid and excluded from the count N. Where excluded data are demonstrably immaterial to the interval maximum, the interval may be retained, provided the adopted treatment is documented.

5. APPLICATIONS

5.1 Industrial Noise Assessment

In industrial environments characterised by recurring operational cycles, the Average Maximum Sound Level may provide a more representative descriptor of typical peak behaviour than either L_{A10} or a single L_{AFmax} value. For example, where a manufacturing facility operates equipment on an approximately 45-second cycle producing repeated maxima at the nearest residence, assessment using $L_{AFmax,T}$ with a reported interval duration may characterise the recurring operational peaks while limiting the influence of occasional unrelated higher events. This is particularly relevant where legacy approval conditions are intended to reflect typical maximum site noise rather than the single highest event occurring during the measurement period.

5.2 Mixed Source Environments

In mixed-source environments, the Average Maximum Sound Level may still be useful when interpreted alongside supporting time-history review and source identification. Intervals affected by identifiable extraneous or non-target events, such as aircraft overflights, may be excluded or separately examined in accordance with the applicable measurement framework. The descriptor is therefore most useful where the target source produces recurring maxima that can be distinguished from the broader acoustic environment.

6. RELATIONSHIP TO ESTABLISHED METRICS

The Average Maximum Sound Level is not intended to replace established environmental noise descriptors. Rather, it fills a specific interpretive gap where legacy approval conditions refer to an historical “average maximum” concept that is not directly reproduced by modern digital instrumentation. The comparison between $L_{AFmax,T}$ and commonly used descriptors is summarised in Table 1.

Table 1: Comparison of metrics

Metric	Primary descriptor purpose	Limitation relative to legacy “average maximum” interpretation
L_{Aeq}	Total energy-average sound exposure	Does not directly represent peak behaviour or recurring maxima
L_{AFmax}	Single highest time-weighted maximum	May be dominated by one short-duration event
L_{A10}	Upper statistical level exceeded for 10% of the time	Depends on source duty cycle and event duration rather than an average of maxima
$L_{AFmax,T}$	Arithmetic mean of interval maxima over the assessment period	As the value of $L_{AFmax,T}$ depends on the selected interval duration Δt, the adopted value of Δt should always be reported alongside the result

The following relationship always holds: $L_{AFmax,T} \leq L_{AFmax}$. The difference ($L_{AFmax}$ - $L_{AFmax,T}$) provides an indication of the extent to which the single maximum exceeds the average of the recurring interval maxima over the measurement period.

7. CONCLUSIONS

The Average Maximum Sound Level ($L_{AFmax,T}$) addresses a practical problem facing acoustical practitioners: how to assess legacy noise conditions specified as 'average maximum' or '$L_{Amax,adj,T}$' using modern digital instrumentation.

The method provides a repeatable empirical alternative to subjective needle observation, yields results more closely aligned with the historical “average maximum” concept, and offers an objective alternative to the use of LA10 as a surrogate descriptor. The metric is straightforward to implement using existing sound level meters with L_{AFmax} logging capability, or through post-processing of calibrated audio recordings. A formal technical specification (ILTS-AC-001:2025) has been developed to ensure consistent implementation [3].

The method is principally intended for the interpretation of legacy conditions based on historical ‘average maximum’ assessment concepts, rather than as a universal replacement for other modern noise descriptors. Beyond legacy compliance, the method may find use in characterising cyclic noise sources, as it provides robustness to single anomalous events while representing typical maximum levels.

Where the applicable regulatory framework requires exclusion of extraneous events or adjustment for characteristics such as tonality, impulsiveness, or modulation, these should be applied in accordance with the relevant standard or jurisdictional method. Future work may investigate adaptive interval selection, including data-driven or AI-assisted approaches, to better approximate the variable manner in which a human observer may historically have grouped recurring maxima.

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