Attachment C

DCP Entertainment Sound Study (Acoustic Directions and PKA Acoustic Consulting)

ACOUSTIC DIRECTIONS

WHEN SOUND MATTERS

PKA ACOUSTIC CONSULTING

ACOUSTIC REPORT

DCP ENTERTAINMENT SOUND STUDY

Prepared for: City of Sydney

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Issue: v1.1

Report Ref.: 240927 DCPEntSnd v1.1

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DOCUMENT MANAGEMENT

Document:	240927 DCP Entertainment Sound Study v1.1
Ref	240927 DCPEntSnd v1.1
Date	27th September 2024
Authors	Glenn Leembruggen, Joel Parry-Jones
Reviewers	Glenn Leembruggen , Joel Parry-Jones

Document History			
Version	**Issue Date**	**Details**	**Authorisation**
D1	14/06/2024	Draft for comment	Glenn Leembruggen
V1	18/09/2024	Final	Glenn Leembruggen
V1.1	27/09/2024	Final -typos	Glenn Leembruggen

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1. INTRODUCTION

The association of Acoustic Directions (AD) and PKA Acoustic Consulting (PKA) has been engaged by the City of Sydney (City) to undertake a study that will inform the development of an Entertainment Sound Criteria for the amended Sydney Development Control Plan (DCP). This study (hereon referred to as '2024 Entertainment DCP') also provides guidance and supporting acoustic information to support our recommendations, and support discussions in relation to criteria for the City's public DCP exhibition.

This is the first draft of this report, and in some respects, the report is open ended as there are a number of directions that could be undertaken from these findings and further discussion with Council.

The City has provided a framework and guidance for our work to prepare this study, for which we are grateful.

1.1. Abbreviations and definitions

The following abbreviations and definitions are used in this report.

A weighting	A-weighting is a form of frequency weighting which is applied to measured sound levels in an effort to account for the relative loudness perceived by the human ear, as the ear is less sensitive to low audio frequencies.
Ambient noise	Ambient noise is the noise in an environment due to all sound sources other than entertainment.
ADG	Apartment Design Guide issued by NSW Govt.
AD	Acoustic Directions
Airborne sound	Sound that emanates from a source via the air, and travels to a receiver either directly through the air, or by transmission through building structures to the receiver room where is it is converted to airborne sound heard by the listener.
Background	The typical lowest level of ambient noise that is present in the environment.
DA	Development Application
dB	decibel – i) a unit of sound pressure level ii) a difference between sound levels and a reference level.
Council	The Council of the City of Sydney
The City	The City of Sydney
LGA	The City of Sydney Local Government Area
DCP	Development Control Plan
EHO	City's Environmental Health Officer
HVAC	Heating, ventilation, and air-conditioning system
Hz	Hertz – the unit of frequency in sound, equivalent to cycles per second.
L&GNSW	Liquor & Gaming NSW for licenced premises
LGA	The City of Sydney Local Government Area
NPfI	Noise Policy for Industry issued by the NSW Environmental Protection Authority.
Octave	An octave is the interval between one musical pitch and another with double or half its frequency, producing a frequency ratio of 2. E.g. if a note has a frequency of 440 Hz, the note one octave above is at 880 Hz, and the note one octave below is at 220 Hz.
Phon	Phon is a logarithmic unit of loudness level for tones and complex sounds; the logarithmic scale is similar to the Richter scale used to measure earthquakes. A doubling of the perceived level. Is generally associated with an increase in the level of 10 phons.
PKA	PKA Acoustic Consulting
RFQ	Request for Quotation issued by the City for this study.
SEP	Special Entertainment Precinct
SPL	Sound pressure level
Sound level	Sound pressure level
Structure-borne sound	Sound that commences as a vibration that is directly imposed on the building structure and travels via the structure to the receiver room where the structural vibration is converted to airborne sound travels to a listener through the air.

1.2. Structure of This Report

This report is structured as follows:

Section 1 presents details of our approach to preparation of this report, and the scope of the RFQ.

Section 2 provides a context for the proposed entertainment noise DCP and identifies some key goals for the DCP.

Section 3 presents a detailed discussion of numerous factors that we have considered in the process of preparing our recommendations for receiver and venue noise controls. This section considers issues ranging from psychoacoustics through to properties of contemporary music and different criteria.

Section 4 discusses the City's current entertainment noise conditions and identifies weaknesses in those conditions. In addition, a primary problem that has always existed is identified and discussed.

Section 5 outlines the rationale we have used to develop our proposed residential and venue controls (i.e. noise criteria).

Section 6 describes our proposed residential noise controls and illustrates the process by which they were developed. Some new concepts are also introduced.

Section 7 presents our proposed venue noise controls and provides examples to illustrate their use. Separate controls are recommended for new and existing residential buildings.

Section 8 is provides information that is intended to assist the city with assessing DA's submitted under the new DCP. This section should be expanded after discussions with the City.

Section 9 provides some guidance for venues to assist control of their noise emissions. This section should be expanded after discussions with the City

Section 10 provides a glossary of acoustic terminology.

1.3. Our Approach to this Report

Undertaking the 2024 Entertainment DCP to inform the preparation of an Entertainment Noise Criteria was a complex parcel of work, and involved consideration of a wide range of acoustic topics, encompassing:

- sound creation and noise sources within venues
- sound egress paths from venues
- sound propagation in the built environment
- sound transmission into residences
- internal room acoustics
- human perception of sound
- acoustic measurement theory and practice
- ambient noise levels in residential areas near entertainment venues

Our guiding principle for this study has been the City's desire to foster night life and music entertainment whilst maintaining satisfactory residential amenity. Another key component of the City's approach is the "agent of change" principle.

1.4. Scope of the City's RFQ

A. Venue Controls

a) Review the suitability of and suggest any refinements to the intrusive criteria used in the existing condition of consent for new entertainment venues, in order to translate them to DCP controls.

b) Provide advice on the potential use of external and internal amenity criteria for venues, as measured from the sensitive receiver, in the absence of special entertainment precincts. Note - Developing external amenity criteria is not in scope.

c) Provide high level, summarised guidance and approaches for proponents to plan for compliance with the criteria. For example, standardised approaches to estimating internal background noise levels, and for identifying typical sound transfer pathways to sensitive receivers.

B. Receiver Controls

a) Sensitive receivers for this DCP consist of residential accommodation and tourist and visitor accommodation, on mapped sites being late night trading areas and sites within close proximity to existing venues.

b) Attend two workshops with the City's urban design team to discuss design solutions for mitigating noise impacts to dwellings, and interactions between noise and other amenity considerations such as cross ventilation and daylight access.

c) Provide a summary of the key design considerations and assumptions for mitigating entertainment sound transfer, and identifying typical sound transfer pathways, from venues in:

   i. a nearby building

   ii. the same building as the sensitive receiver

d) Recommend criteria for residential accommodation and tourist and visitor accommodation (which may be different), which account for the special characteristics of entertainment sound, using consistent measurement metrics and time periods as the venue controls if possible.

e) Consider the use of intrusive criteria, amenity criteria, or a combination.

f) Consider the interaction with the proposed venue criteria, as they apply to inside sensitive receivers. Also consider Liquor & Gaming NSW (L&GNSW) L_{A10} criteria used in enforcement of noise complaints.

g) High level advice and considerations for Special Entertainment Precincts (SEPs) and the research and road map would be required to adopt SEPs.

h) If we consider that an internal amenity criterion is required, then specify a suitable criterion with limits and situations where it should be applied (structure-borne transfer etc.). Propose methodology to derive an internal amenity criterion taking account of parameters such as traffic noise ingress, hearing threshold etc.

C. Deliverables

a) Critique of the existing condition of consent for entertainment venues

b) If a different set of sound criteria for venue controls where tourist and visitor accommodation is the sensitive receiver is recommended, provide those criteria with a brief justification.

c) Justification for recommending or not recommending internal and external amenity criteria for the venue controls.

d) Guidance to inform a DCP schedule for easily and cost effectively establishing and demonstrating compliance with the venue controls.

e) Entertainment sound criteria for new sensitive development in mapped areas, with brief justification.

f) Content to inform a DCP schedule or separate design guidelines for new sensitive receivers near existing venues, explaining the special characteristics of entertainment sound, and guidance for how to identify typical sound transfer pathways and limit entertainment sound transfer.

1.5. Items Not Considered

Our brief from the City was not to consider:

- Architectural, urban design or apartment layout guidance.
- Amenity criteria for the venue controls however, this may be required to provide a useable set of criteria.

2. A CONTEXT FOR THE NEW DCP

2.1. Introduction

A. The Tension

When entertainment venues featuring contemporary music played at moderate to loud sound levels are located close to residential areas, there can be considerable tension between the requirements to foster that entertainment and the requirement to provided suitable noise amenity for residents. Complicating this tension is the need to provide natural ventilation for residential buildings.

Considering and addressing this tension is the primary endeavour of this study.

Part of the tension is the requirement to provide acoustic certainly for developers of residential apartments and venue proponents. A suitable compromise must be found between advancing the cause of residential amenity with SPL limits and the need for venues to implement acoustic treatments that are practical and feasible.

Venues often "push back" on recommendations by acoustic consultants for expensive upgrades, with the stance of "feasibility" being what the venue prefers to do, rather than what is necessary.

In contrast, with other industries such as manufacturing and mining, noise mitigation is often necessary and expensive, but it enables the long-term viability of these industries. Live music venues that have adopted this perspective have survived for many years.

Although hospitality and music venues often have shorter life spans than some industrial sectors, it is still the venues' responsibility for managing their noise impacts even though this may impact their short-term financial returns.

B. Comparison of Draft DCP with the Current Entertainment Noise Condition

In 2020 Council exhibited a draft Entertainment Sound DCP. In 2023, we were commissioned by Council to undertake an analysis and review of the exhibited DCP. Arising from this work was our 2023 study of Entertainment Noise (hereon called '2023 Entertainment Noise Study' *(Ref: 230531 CoSEntNse v1.2')* which concluded that the draft DCP criteria needed to be adjusted to achieve similar outcomes to the current Entertainment Noise Condition.

We considered that the benefits of this adjustment would be:

- Better match with the perceptual impressions of the entertainment noise.
- Less difficulty with site measurements to determine compliance.
- Elimination of conflicting requirements for a number of receiver types.

We also concluded that the post-midnight internal entertainment noise criterion of L_{Aeq} 30 dB proposed in the draft DCP was inappropriate for the construction of a new residential noise-sensitive receivers that are potentially affected by an existing venue, as it does not provide sufficient masking of entertainment noise at low frequencies.

C. Certainty for Venues and New Residents

The benefit of embedding acoustic criteria in the DCP to inform the design and construction of new buildings is:

- Existing entertainment venues would have confidence that noise compliance can be achieved in the new buildings over the long term.
- Over the long term as more and more new residential apartments replace old apartment complexes, potential new venues whose noise emissions would affect only new residential buildings would have a noise target that allows them considerable flexibility in their entertainment offering with the confidence that noise compliance can be achieved in the new buildings.

Providing this certainty creates the need for an amenity criterion for venues, as the desired noise level inside apartments is related to the sound level outside the apartments by the sound transmission loss of the apartment façade.

D. Health and Natural Ventilation

We understand the following considerations and requirements have been articulated by the City's internal health, building and planning experts.

- Noise is now recognised as having a major effect on health of the community.
- The City must assess DAs for residential development against the amenity requirements in the Apartment Design Guide (ADG), which accords equal importance to the provision of suitable noise amenity and natural ventilation. Interestingly, the ADG allows flexibility in other amenity requirements, such as solar access, in order to maintain high standards of noise and ventilation amenity.
- The requirement to jointly provide suitable noise amenity and natural ventilation in apartment buildings near entertainment venues will require the acoustic design of new apartments to be substantially more sophisticated, which will also require early consideration of noise ingress to inform the siting and layout of buildings.
- Residential buildings can readily have a life of one hundred years, whereas the life of a venue may be less than twenty years. Accordingly, the noise criteria that are assigned to new apartment buildings will determine the

noise amenity of residents in the far future.

Unlike social problems such as carbon emissions that are addressed by progressive targets over a given time frame, reduction of venue emissions cannot have a time frame. Once the venue and the receiver buildings are constructed, they cannot readily be modified over time, and therefore the relationship between sound levels inside venues and residential receivers becomes fixed for a given type of music and its sound level. In addition, the conditions that apply at the time of DA are locked in for the life of the building. Consideration was given to standards that could be progressively increased over time; however, this is not appropriate as the impacts are fixed and immediate rather than cumulative over time.

The upshot of this fixed situation is that the DCP must set suitable amenity requirements now which are appropriate for many years to come.

E. Implications of Natural Ventilation

a) Natural ventilation can be provided by open windows; however, we consider that it would be too onerous for entertainment venues to limit their noise breakout to a level that is satisfactory for residential amenity when windows are open. Although the ambient noise level inside a residence would increase when the windows are open, this increase in noise is usually not sufficient to mask the music noise.

b) With receiver windows open, the only mitigation option is to reduce the level of music inside the venue, and this would unavoidably alter the enjoyment of patrons, and the venue would be likely to close. We detail in Section 4.5 the relationship between windows open or closed and the background noise levels rising and falling.

c) Under the recent NSW vibrancy reforms, L&GNSW will expect that residents who move to an area close to an existing venue will take reasonable measures, such as closing their windows, before L&GNSW will consider complaints about entertainment noise complaints. Given that natural ventilation is to be provided in new apartments while windows and doors are closed, the only recourse available to reduce entertainment noise is passive acoustic attenuation included in the paths in which fresh-air enters apartments.

d) The standard approach used by acoustic consultants for DA reports is to require apartments to be mechanically ventilated so that suitable internal noise amenity can be provided. This approach is no longer possible due to the ADG requirement for natural ventilation and cross-ventilation requirements, and therefore a more innovative acoustic and architectural approach will be required that considers the siting and orientation of new apartment buildings and passive acoustic attenuation methods. This approach will require early consideration of noise from entertainment sources to inform concept design, similar to overshadowing, deep soil and other fundamental design considerations

In essence, the current acoustic-design approach of "bolting-on" noise attenuation measures after the building is conceptually designed must change to an approach of consideration of acoustics as a major driver in the conceptual design of the building.

F. Regulation

Post 1 July 2024, L&GNSW became the lead regulator for entertainment noise complaints from liquor-licensed premises in NSW. They are supported in this by Local Government and other agencies. Relevant entertainment sound controls, criteria and conditions are still necessary because:

- Whilst venues may not have their conditions of a DA enforced by local government, the venues are approved on basis of noise not adversely affecting the surrounding amenity, and a venue must still comply with its DA approval. These conditions can be used by the City and Liquor & Gaming to check a venue's compliance with its consent, with L&GNSW leading this.
- Conditions of consent could be used by L&G and or NSW Police in 'Improvement Notices'.
- If a venue is deemed to not comply with its liquor licence or the Liquor Act, it may be subject to regulation under the Protection of the Environment Operations Act (POEO) by local government. In effect, the controls incorporated in the City's DCP, and its noise conditions may be used in an instrument under this Act.
- L&GNSW were not made the lead regulator for conditions of consent that require building upgrades to manage noise mitigations. The extent of building upgrades required for a venue must be informed by an assessment against noise criteria. This ensures that the burden (and cost) of noise mitigation is balanced and fair, not over or under done.
- Un-licensed premises are still required to comply with the controls, as are licensed premises that trade beyond the hours of their liquor licence without serving liquor.
- The Minister for Planning has issued a planning requirement that local government must continue to evaluate

and condition licensed premises as previously done and in accordance with good practice.

2.2. Requirements of the DCP document

a) The DCP provisions need to be set out as performance outcomes, in order to allow flexibility in achieving the desired amenity outcome. However, it can also include more detailed and prescriptive guidance which can be voluntarily followed to achieve the performance outcomes.

b) To encourage venue operators and proponents to recognise the balance between their responsibility in noise mitigation as well as providing vibrancy.

The DCP should encourage venue operators and proponents to consider the various techniques that can be used to reduce noise emissions, so that they are equipped to submit a DA that demonstrates detailed noise controls that will show compliance with the criteria.

c) The DCP should provide guidance for the acoustic engineers working for venue proponents about information that should be included in acoustic reports to create a standardised assessment method and framework to assist the City's assessment process.

d) In this context, we recommend that the document contains standardised approaches to estimating internal background noise levels, and for identifying typical sound transfer pathways to sensitive receivers.

e) In addition, the DCP requirements and associated guidance should not impose an unreasonable requirement on proponents and their acoustic consultants to have a high level of expertise and background knowledge in order to understand the DCP.

f) The DCP should assist acoustic consultants to prepare a concise application and provide guidance about information that is required.

g) The DCP must be strongly supported by evidence and robust against unfounded criticism.

2.3. Education

An extensive campaign will be required to re-educate the acoustic consulting and architecture professions and potential venue operators about the requirements of the DCP and how to go about addressing them. The required process will be a major departure from current practice for developers, consultants and architects. A series of public workshops would assist with raising awareness. In addition, the co-operation of the Association of Australasian Consultants should be sought to disseminate the new DCP.

3. GENERAL TECHNICAL PARAMETERS

The information in this section has provided the foundation of our work to develop criteria for the DCP.

3.1. Human Hearing and Masking

A. The Octave Band Concept

Both the City and the L&GNSW assess entertainment noise in octave-wide frequency bands as tabled below:

Table 1. Octave Band Centre Frequences (Hz)

31.5	63	125	250	500	1000	2000	4000	8000

This simple but effective method assesses the degree of audibility of music noise and relies on the human hearing's ability to focus on the loudest sound. In technical terms, the vibrations of the hair cells in the inner ear are dominated by the loudest sound, leading to the term masking.

Masking of music noise is most effective when the ambient noise is in a same frequency range as the music. For convenience, the frequency range of music is divided into nine frequency bands that are one-octave wide. Accordingly, the ambient noise is also divided into the same frequency bands.

B. Thresholds of Audibility

The threshold of audibility in human hearing can be thought about as another masking mechanism in our ear. Although masking isn't actually a noise that is generated inside our ears, it can be regarded as such. When the level of entertainment noise is below that threshold in each frequency band, the entertainment noise is no longer heard. This is an important aspect is determining sound criteria with a focus on improving receiver amenity.

The threshold of hearing varies considerably with frequency and also shows considerable variation both with age and within an age group. An increase in the hearing threshold at each frequency is an integral part of the human ageing process.

At low frequencies below 250 Hz, the hearing threshold varies greatly with frequency, as shown in **Table 2**. Given that contemporary music has a frequency range that sometimes extends below 31.5 Hz, these thresholds must form an important part of the consideration of audibility within the DCP.

If a noise sound was presented to a listener so that every frequency was just at the threshold of hearing, then the total sound level would be approximately 27 dBA and 65 dBC. Of course, if the noise at some frequencies is not present, then the total sound levels would be lower than these values, which always occurs.

Table 2. ISO 226 - Nominal thresholds of hearing (audibility) in young people.

Metric	Third Octave Band Centre Frequency (Hz) dBZ										
	25	31.5	40	50	63	80	100	125	160	200	250
SPL	68.5	59.5	51.2	43.8	37.4	31.5	26.5	22.0	18.0	14.4	11.4

C. Perception of Audibility at Low Frequencies

It is pertinent to consider the differences in the audibility of low frequency sounds over the general population. The introduction in the UK's DEFRA publication[1] provides the following concise illustration of these differences:

How is it that one person could describe a sound as loud while another cannot even hear the same sound?

One possible explanation is based on the way the human hearing system operates at low frequency. The perceived loudness of low frequency sounds increases very rapidly with increasing sound level. Therefore, low frequency sounds only just above the threshold of hearing can be perceived as loud, even uncomfortably loud. Added to this is the fact that individual hearing thresholds vary, so that people with more sensitive hearing can hear sounds inaudible to others.

Putting these two facts together we may find a situation where a low frequency sound is sufficiently above one person's threshold to sound relatively loud, whereas another person with less sensitive hearing cannot hear it. This situation

[1] Proposed criteria for the assessment of low-frequency noise disturbance. Prepared for DEFRA by Moorhouse et al. Revision 1, December 2011, Contract no NANR45.

does not arise with most other non-low-frequency sounds, because their perceived loudness increases much more slowly with increased sound level. In other words, "normal" sounds need to have very much more sound level above the hearing threshold before they become uncomfortably loud. The experience of low frequency sound can therefore be "counterintuitive", i.e. it may contradict our more usual experience of sound.

D. Use of the dBA Metric

The A-weighting of sound level measurements was originally intended only for the measurement of low-level sounds. The attenuations that are applied to each frequency by a filter in a sound level meter approximate the level at each frequency relative to 1 kHz of the 60 phon level in human hearing.

Reybrouck et al[2] discuss the difficulty in predicting the loudness and annoyance of such low-frequency sound, particularly if measured with dBA. The authors state that "Although the A-weighting filter provides a useful approximation for annoyingness in mid- to high-frequency stationary noise, it underestimates annoyance and perceived loudness for the low-frequency components. Noise that contains high levels of low-frequency noise is perceived as more annoying than higher frequency noise, even at low levels. Comparison between broadband noises centred at 80, 250, 500, and 1,000 Hz showed that the 80-Hz frequency band was more annoying than the other noise bands at equal A-weighted levels (Persson and Björkman, 1988)".

Although L&GNSW specify that measured noise levels are A weighted so that the measured levels supposedly reflect the subjective impact of the noise, we do not endorse the use of f within the DCP as we consider that it has led to more problems that it is intended to solve.

Problems that we see with the use of A weighting are:

- Internal sound levels in venues are often A-weighted, which bears no relationship to the actual perceived sound level.
- When used with music inside and outside venues, it allows levels to be understated, which in turn can lead to design errors.
- As noted above, even at low levels, the A weighted levels do not properly indicate the perceived sound levels.

E. Use of the dBC Metric

Although the use of an internal amenity criterion measured as an overall dBC level might appear attractive due to its simplicity, this fact that inaudible low-frequency noise could readily dominate the measured L_{Ceq} level makes it too risky for use. The only reliable alternative is to use octave or one-third octave band levels.

We have elected to adopt the octave bands starting from 31.5Hz (which previously matches the City's and L&GNSW's criteria) to 4,000Hz (which excludes the highest typical octave band of 8,000Hz due its ineffectiveness in assessment and compliance based on our experience as consultants)

3.2. Venue Internal Levels and Spectra

A. Measured Levels and Spectra

During the 2023 Entertainment Noise Study, we measured the sound levels inside a number of dance venues in and around the City's entertainment areas. The overall A and C weighted levels inside these venues are shown in **Figure 1** and the associated frequency spectra are shown in **Figure 2** and **Figure 3** below.

[2] *Music and Noise: Same or Different? What Our Body Tells Us.* Reybrouck et al. Frontiers in Psychology, 25 June 2019

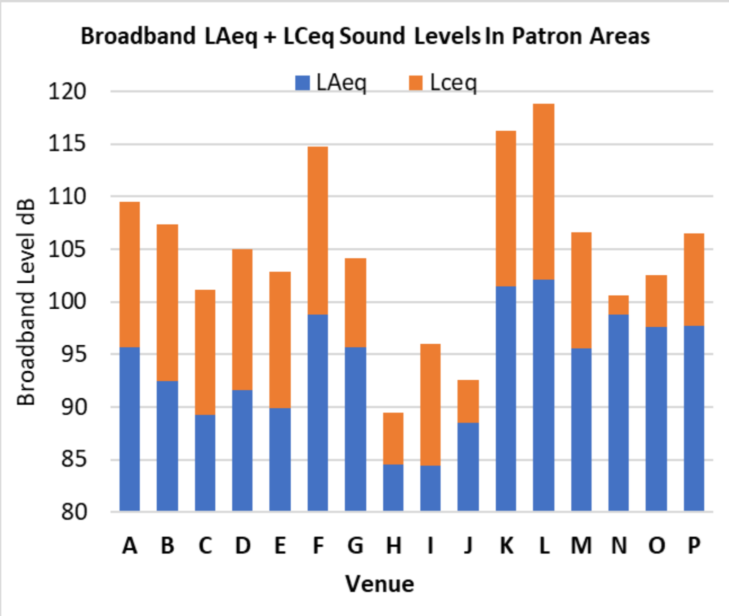


Figure 1. Overall A and C weighted levels inside dance venue

Label	Venue
A	CBD Nightclub A Level 1
B	CBD Nightclub A Level 2 top of stair
C	CBD Nightclub A Level 2 Stage right
D	CBD Nightclub B alfresco pre-midnight
E	CBD Nightclub B alfresco post-midnight
F	CBD Nightclub C Basement
G	Taylor Square - Venue A Level 1
H	Taylor Square – Rooftop Party
I	Taylor Square – Venue B Inside
J	Taylor Square - Venue C Level 1
K	Taylor Square - Nightclub D sample 1
L	Taylor Square -Nightclub D -sample 2
M	Taylor Square - Nightclub E Level 1
N	Taylor Square - Nightclub E Ground Fl
O	Taylor Square - Nightclub E Level 2
P	Taylor Square - Nightclub F Basement

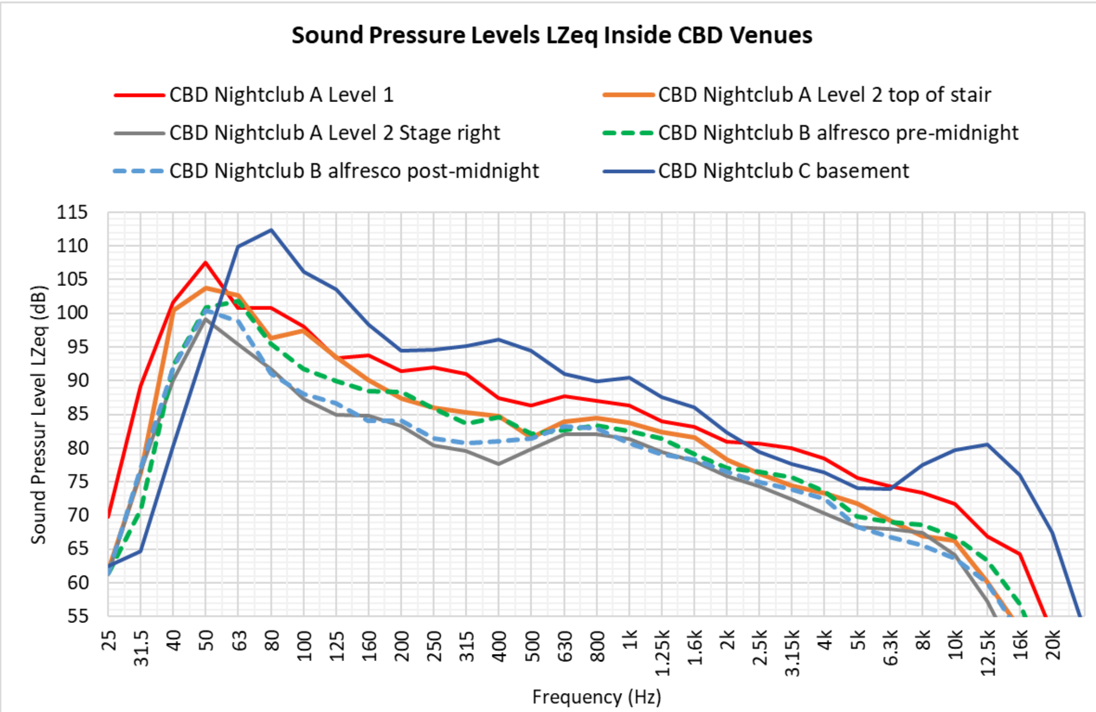


Figure 2. Spectra of sound levels inside CBD venues.

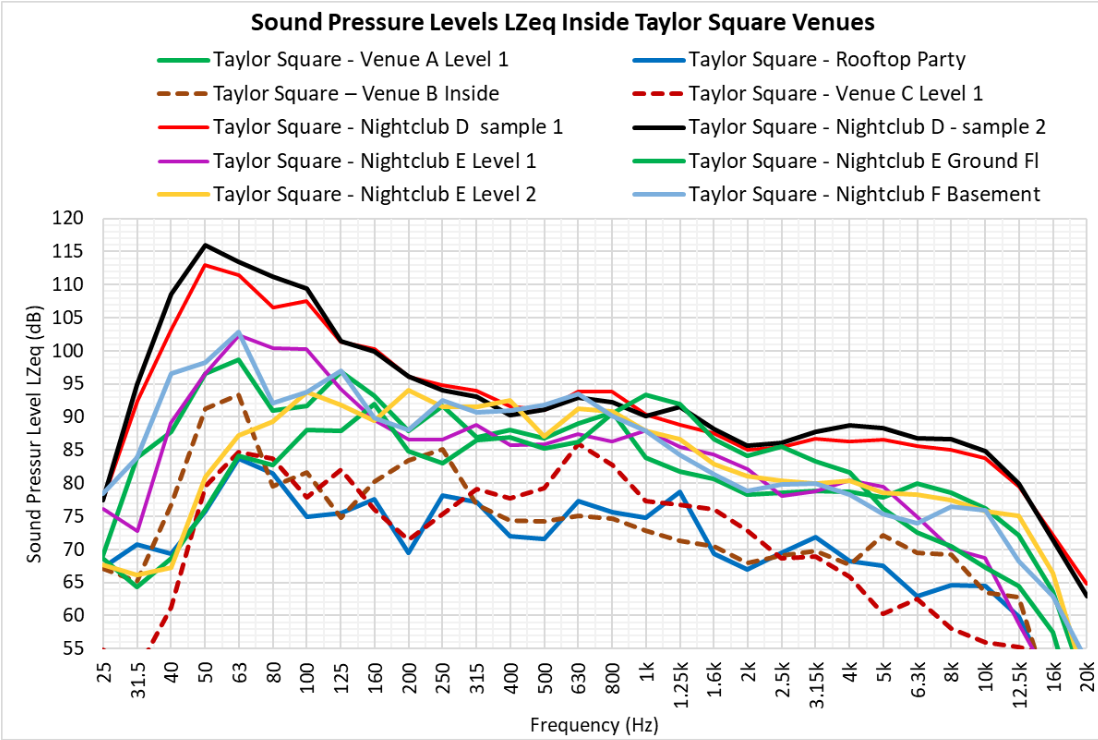


Figure 3. Spectra of sound levels inside Taylor Square venues.

B. The Increasing Demands of Contemporary Music

The combination of the trends in contemporary music and advances in loudspeaker transducer design is increasing creating more sound energy at frequencies below 42 Hz. In turn, this creates increasing demands on the attenuation requirements for internal amenity inside receivers. Three examples illustrating this trend are:

- The five-string bass guitar is increasingly being used in contemporary music. The lowest note of this type of bass guitar is 31 Hz, compared to the lowest note of the four-string bass guitar and double bass of 41 Hz.
- Increasing use of synthesisers for low-frequency effects.
- Subwoofer loudspeakers and amplifiers are much more able to reproduce frequencies 25 Hz to 50 Hz with high sound pressure levels than previously.

3.3. Temporal Structure of Music

The current entertainment noise conditions refer to the L_1 metric for measuring the maximum level inside habitable rooms of residential situations.

Supporting the discussion in Section 4.3.4, there is another way to include the concept of L_1 levels inside receivers, which is to use metrics that are more readily measured and apply an adjustment that those metrics to replicate the L_1/L_{max} metrics.

We have analysed the temporal data from a number of loud dance and live band venues to assess the relationships between the L_1, L_{10} and L_{eq} parameters. The data for loud dance music is shown in **Table 3**, while the data for live venues is shown in **Table 4**.

Table 3. Filtered averages over three loud dance venues in Sydney (Venues A, P, and K)

Description	Metric Comparison	Octave Band Centre Frequency (Hz) dBZ								
		31.5	63	125	250	500	1000	2000	4000	8000
Continuous (long sample)	L_1 to L_{eq}	7.0	8.0	8.0	7.5	8.0	8.5	7.0	7.0	7.5
Continuous (long sample)	L_{10} to L_{eq}	4.5	4.5	4.0	3.5	3.0	3.0	3.0	3.5	3.5
Low Frequency dominant (short sample)	L_1 to L_{eq}	5.0	6.0	6.5	6.5	7.0	7.5	7.0	6.0	6.0
Low Frequency dominant (short sample)	L_{10} to L_{eq}	3.5	3.5	3.5	3.0	2.5	2.5	2.5	3.0	3.0

Table 4. Filtered averages over three bands in outdoor Sydney festivals and two other live venues

Description	Metric Comparison	Octave Band Centre Frequency (Hz) dBZ								
		31.5	63	125	250	500	1000	2000	4000	8000
Continuous (short sample)	L_1 to L_{eq}	8.0	5.0	5.0	6.0	7.0	7.0	6.0	5.0	6.0
Continuous (short sample)	L_{10} to L_{eq}	2.5	2.5	3.0	2.5	2.5	3.0	3.0	2.5	2.5

Given the dynamic nature of music and different genres and songs, the averaged data in **Table 3** and **Table 4** are remarkably close, and given the range of factors that affect the level of entertainment noise within a noise receiver, the differences can be regarded as trivial.

Based on the data in the tables, we conclude that the L_1 is typically 7 dB above the L_{eq} and the L_{10} is typically 3 dB above the L_{eq} across the relevant octave bands.

If we elect to adopt the use of L_{eq} metric for music, based on its simplicity in measurement and the ease of subtracting the ambient noise from combined measurements of music and noise, then suitable adjustments to recognise the L_1 and L_{10} metrics would be:

- $L_{eq} = L_1 - 7$ dB
- $L_{eq} = L_{10} - 3$ dB

However, the L_1 of the music over a shorter period than fifteen minutes is likely to be closer to the Leq level. For example, analysis of the recording of the dance track 'On My Knees' by Rufus du Sol showed that over a one-minute period, the L_1 levels in the 31 Hz to 250 Hz bands were between only 1 and 2 dB higher than the L_{eq} levels in those bands. (Note that the 'Fast' time constant of 125 ms was used to that analysis to simulate a sound level meter's response.)

3.4. Key Questions to Address

In relation to setting criteria for entertainment noise, our research and conclusions have been derived partly from the 2023 Entertainment Noise Study. However, there are other questions that are pertinent.

Key questions that must be answered before suitable entertainment noise criteria can be developed are listed below:

i) What is the degree to which noise from music with a strong regular bass-beat modulation would need to be below the ambient noise to be inaudible compared a music without a strong bass-beat. This reduction would reflect the increased annoyance that that is associated with music noise that has a bass-beat modulation.

   This is a complex issue, and we are unaware of any academic research that has investigated the subjective annoyance of noise with a bass beat.

ii) How much noise amenity can be removed from a residential environment to allow venues to produce higher noise emissions?

iii) What are the usual internal ambient noise levels inside residences with windows closed at various times of the night (free of entertainment noise)?

iv) Setting an amenity criterion for internal areas requires knowledge of the internal ambient noise inside the receiver. In turn, this relies on knowledge of the means by which HVAC is achieved.

v) If the windows in an apartment are opened, how will this affect residential noise amenity.

vi) How will the need for passive ventilation in new apartment buildings affect the internal noise level within residents?

Although we have used our expert judgement and experience to develop these criteria, we note that an in-depth research project into bass-beat audibility could refine our recommendations.

3.5. Statutory Controls in Other Cities

The report titled "*Literature Review and Study: Entertainment Noise Planning Management And Criteria*" that Acoustic Directions prepared for the City in 2015 investigated Australian and international criteria for entertainment noise and considered a wide range of issues. Although that report was written nine years ago, we reviewed it closely to ascertain if noise criteria used in other locations could assist this current study.

We conclude that the criteria used in 2015 across the world and in Australia are generous for music venues, and likely to produce a significant loss of amenity for residents living near venues. Given the goal of this DCP is to find a suitable balance between venue constraints and residential amenity, we were unable to adopt any of those criteria for this study.

3.6. Listening Tests to Establish the Suitability of Intrusiveness Criteria

To gain an insight into the bass-beat issue, we have undertaken an extensive series of listening tests to investigate the audibility of contemporary music with a strong low-frequency beats. The listening tests were intended to replicate the situation of post-midnight internal music noise, with windows and doors closed. For these tests, the music was presented at various L_{eq} levels in each octave band relative to the L_{90} of traffic noise in the same bands.

3.6.1 Testing Method

We used the method described below investigate the audibility of music within traffic noise.

a) Contemporary soundtracks selected were:
   - Dance: On My Knees by Rufus du Sol
   - Rock: Hold Choke by Bad Pony.

b) Using filters implemented in audio-editing software, a one-minute section of each music track was isolated into the four octave bands (31.5 Hz, 63 Hz, 125 Hz and 250 Hz) and the L_{eq} level of each band computed.

c) The upper limit of 250 Hz was selected for this listening exercise based on our experience of windows closed having significantly greater sound insulation in higher frequencies than the lower frequencies, effectively creating a 'low pass filter' effect to the traffic noise ingress.

d) The statistical exceedance levels of a three-minute-long section of recorded traffic noise were calculated to provide the L_{90} levels in the octave frequency bands spanning the range 31.5 Hz to 250 Hz.

e) The L_{eq} level of each isolated octave band of the music was then adjusted to be a defined level below the level of the traffic noise in that band. The defined levels were steps of 5 dB (+ 5 dB, 0 dB, -5 dB, -10 dB, and -15 dB) below the L_{90} of the traffic noise in each band.

f) The octave bands for each track were then recombined to produce a shaped music track in which the L_{eq} level was exactly the defined amount below the L_{90} of the traffic noise in that band. Five such tracks resulted, corresponding to the five defined levels relative to the L_{90} of the traffic noise.

g) The recombined and shaped music track was then mixed with the traffic sound to form the internal residential listening situation.

h) The five mixes of music and traffic were then listened to on headphones and monitor loudspeakers to assess the degree of audibility and subjective annoyance that each defined L_{eq} level of the music below the L_{90} level of the traffic noise.

3.6.2 Listening Results

A. Perceptual Results

Table 5 presents our team's perceptions of music noise level intrusion assuming the listener is located within an apartment with the windows closed.

Table 5. Listener perception of music noise

Track	Description	L_{eq} level of music tracks in octave bands in relation to L90 of traffic noise (dB)				
		L90 + 5 dB	L90 + 0 dB	L90 - 5 dB	L90 - 10 dB	L90 - 15 dB
Listener 1						
Dance (Rufus)	Audibility	Clear	Noticeable	Audible	Just Perceptible	Barely Perceptible
	Pre Midnight	Tolerable	Reasonable	Quiet	Very Quiet	Very quiet
	Post Midnight	Annoying	Intrusive	Tolerable	Reasonable	Quiet
Rock (Bad Pony)	Audibility	Noticeable	Audible	Audible	Barely Perceptible	Barely Perceptible
	Pre Midnight	Reasonable	Quiet	Quiet	Very quiet	Very quiet
	Post Midnight	Intrusive	Tolerable	Tolerable	Quiet	Very quiet
Listener 2						
Dance (Rufus)	Audibility	Clear	Noticeable	Audible	Just Perceptible	Barely Perceptible
	Pre Midnight	Intrusive	Tolerable	Reasonable	Quiet	Very quiet
	Post Midnight	Annoying	Annoying	Intrusive	Quiet	Very quiet
Rock (Bad Pony)	Audibility	Clear	Noticeable	Just Perceptible	Barely Perceptible	Barely Perceptible
	Pre Midnight	Intrusive	Tolerable	Reasonable	Very quiet	Very quiet
	Post Midnight	Annoying	Intrusive	Tolerable	Quiet	Very quiet

Listener 3						
Dance (Rufus)	Audibility	Clear	Noticeable	Just Perceptible	Barely Perceptible	Barely Perceptible
	Pre Midnight	Annoying	Intrusive	Quiet	Very quiet	Very quiet
	Post Midnight	Annoying	Intrusive	Quiet	Very quiet	Very quiet
Rock (Bad Pony)	Audibility	Clear	Audible	Barely Perceptible	Barely Perceptible	Barely Perceptible
	Pre Midnight	Intrusive	Tolerable	Quiet	Very quiet	Very quiet
	Post Midnight	Annoying	Tolerable	Quiet	Very quiet	Very quiet
Listener 4						
Dance (Rufus)	Audibility	Clear	Clear	Audible	Just Perceptible	Barely Perceptible
	Pre Midnight	Intrusive	Tolerable	Quiet	Very quiet	Very quiet
	Post Midnight	Annoying	Annoying	Quiet	Quiet	Very quiet
Rock (Bad Pony)	Audibility	Clear	Noticeable	Audible	Just Perceptible	Barely Perceptible
	Pre Midnight	Intrusive	Tolerable	Quiet	Very quiet	Very quiet
	Post Midnight	Annoying	Intrusive	Tolerable	Very quiet	Very quiet

B. Conclusions

a) On the basis of the results, we have elected to nominate a level of L_{90} -12 dB as a substitute for the inaudibility criterion for post-midnight entertainment noise assessment.

b) Based on our temporal investigation outcomes in Section 3.3, the L_{10} to L_{eq} conversion of -3 dB results in an approximation of the $L_{10} \leq L_{90}$ -10 dB which acoustic consultants commonly use in assessing L&GNSW post-midnight inaudibility.

c) We note that true inaudibility lies somewhere between $L_{eq} \leq L_{90}$ -15 to -20 dB, however we believe the -12 dB is a suitable compromise that promotes nightlife while balancing residential amenity.

d) Noting that the L_1 level could range from 1 dB to 7 dB above the L_{eq} level depending on the nature of the music and the measurement period, the relationships shown in Table 6 result:

Table 6. Relationships of L_1 levels of music to L_{eq} (music) and L_{90} (background)

Range of L_1 to L_{eq}	Range of L_1 to L_{90}
L_{eq} + 1 dB	L_{90} -11 dB
L_{eq} + 7 dB	L_{90} -5 dB

3.7. Ambient Noise Levels in the City

3.7.1 Measured Levels

The scope of our 2023 Entertainment Noise Study allowed us to capture ambient and background noise levels in the city, specifically the residential areas within the Taylor Square area. The measurement locations were within 150 m of each other, and within 75 m of the Oxford Street entertainment area.

Table 7 presents the late-night (post 2 am) steady-state noise levels where venues were less dominant or not operating.

Table 7. Ambient and background noise levels in Taylor Square of the City, predictions to internal apartments

Description	Metric	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ								
				31.5	63	125	250	500	1000	2000	4000	8000
Campbell St (Rooftop)	L_{90}	**52**	**63**	58	60	56	53	49	47	43	35	24
Bourke St (Street level)	L_{90}	**52**	**62**	57	59	57	48	50	49	43	35	25
Little Oxford Ln (Street level)	L_{90}	**52**	**63**	55	60	57	55	50	45	42	37	28
Campbell St (Rooftop)	L_{eq}	**53**	**65**	60	63	57	54	50	48	44	36	25
Bourke St (Street level)	L_{eq}	**55**	**66**	63	62	60	53	52	51	46	38	30
Little Oxford Ln (Street level)	L_{eq}	**53**	**67**	59	66	59	56	51	46	42	37	29
Averaged difference (Δ)	$L_1 - L_{eq}$	**3.5**	**5.0**	6.5	5.5	3.5	3.5	3.0	3.5	3.5	5.0	5.0
	$L_{10} - L_{eq}$	**1.5**	**2.0**	2.5	2.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0
	$L_{eq} - L_{90}$	**1.5**	**3.0**	4.0	3.5	2.0	2.0	1.5	1.5	1.5	1.5	1.5
Averaged external ambient noise levels	L_{eq}	**53**	**64**	59	62	58	53	50	48	43	36	27
Typical existing 3mm glazing transmission loss				-12	-14	-16	-20	-25	-25	-22	-22	-22
Predicted internal ambient noise level assuming 3mm glazing and no room corrections.	L_{eq}	**31**	**50**	47	48	42	33	25	23	21	14	5
Open bedroom windows reduction assuming 5% of floor area. Based on AD-PKA CoS Passive Guide predictions				-8.0	-8.1	-8.6	-8.3	-8.5	-9.0	-9.4	-10.2	-11.1
Predicted internal ambient noise level assuming open windows of existing residential.	L_{eq}	**44**	**56**	51	54	49	45	42	39	34	26	16

Comments:

a) The data in **Table 7** shows that the 'urban hum' in Taylor Square is evident in the consistency of the measured noise levels.

b) A spectrum such as shown in **Table 7** could be used in determining an internal background noise for existing residential in late-night trading areas. An adjustment would be applied based on the assumed loss through open windows.

c) Not all residential areas around the city will experience these 'urban hum' noise levels. The concern for new residential developments outside high-activity trading areas is that the background noise will not be sufficiently high to mask existing entertainment noise. Our proposed internal noise-masking solution described in Section 4.5.2E will help balance the quiet and loud city areas to within our recommend internal noise level.

d) It is noteworthy that the external ambient noise levels in the city are already much higher than the EPA's amenity criterion of 50 dBA and 45 dBA for the evening and night periods respectively.

3.7.2 Difficulties with Determining the Background Noise Levels

In high-activity, late-night trading areas with venues that are emitting entertainment or mechanical noise, the measurement of background noise free of the contribution of noise from the venue is very difficult, especially before midnight. In our 2023 Entertainment Noise Study, the only period that we could find that was mostly free of entertainment noise was after 2 am when the venues in the Taylor Square region were effectively not operating or not dominating the sound scape. This late-night background noise was applied throughout the evening / night.

An alternative approach to determine the background noise level is to find an area where the venue(s) are inaudible such as a rear lane, or further away from the venues. However, there is a strong risk that the measured background noise would not be representative of the residential situation under assessment, such as shop-top or multi-story residences facing a busy street which are also exposed to entertainment noise.

It is essentially impossible to measure the true background noise in the city on a Saturday night. The only way is to close all entertainment venues, but this action will also reduce the background noise from traffic and urban activity that is also associated with those venues.

Therefore, specifying a predefined background noise for urban living would minimise the risk of measuring or assuming background noise levels that are not representative of the residential experience.

3.8. Discussion of Amenity and Intrusiveness Criteria

Th EPA's NSW Noise Policy for Industry (NPfI) uses intrusive and amenity criteria, as described below.

The scientific literature indicates that both the increase in noise level above background levels (that is, intrusiveness of a source), as well as the absolute level of noise are important factors in how a community will respond to noise from industrial sources.

Intrusiveness criteria aim to protect against significant changes in noise levels, whilst the amenity criteria seek to protect against cumulative noise impacts from industry and maintain amenity for particular land uses.

For a given situation, the EPA applying the more stringent of these two types of criteria to ensure that intrusive noise is limited, and amenity is protected and that no single industry can unacceptably change the noise level of an area.

3.8.1 Intrusiveness

A. Is an Internal Intrusive Noise Criterion Useful?

We conclude that a type of internal intrusive noise criterion or its equivalent should be included in the DCP to protect amenity inside residences. The benefits of such a criterion are:

- If the "agent-of-change" is the entertainment venue, an intrusive noise criterion allows noise situations that are distressing for residents to be assessed, whereas an amenity criterion may not be able to capture all the subtleties that affect the perception of low frequency music noise.
- There may be local sources of other commercial or industrial noise that could mask the noticeable entertainment noise in specific residential situations.
- Factors such as room modes, and adverse building resonances (such as the mass-air-mass frequency inherent in double glazed windows) in the receiver room can be accounted for. This will be especially important when all windows and doors are closed.
- Unless an intrusive criterion is very low in relation to the background noise, it cannot readily account for the subjective annoyance of a rhythmical bass-beat.
- Intrusive criteria are expressed as intrusive noise relative to the background noise, which introduces difficulties in determining what the actual background level is inside a residence. If the intrusive criterion for post-midnight noise is stringent, there is the added difficulty of measuring the actual level of the music as it is less than the background noise.

B. Noise Creep

a) For a situation with a single venue in an area, an intrusiveness criterion for a venue is simple and sufficient. As the intrusiveness criterion is structured in relation to the background noise levels it allows the ambient noise level to progressively increase (or creep) over time when multiple venues progressively open in a small area open. Creep occurs when the noise from one venue forms the background noise for another proposed venue and so on. This also creates a situation in which venues may blame other venues and not take responsibility for their noise emissions. This outcome subsequently degrades residential amenity.

For example, if the noise emitted from each three closely-spaced venues meets the nominated background noise level, then the new combined background noise level would be 4.7 dB higher than the nominated background noise level.

Accordingly, with multiple venues in a small geographic area, some type of amenity criterion is needed to limit the compounding increase of venue noise impact.

C. Nominating a Defined External Background Noise Level

a) Nominating a defined background noise level that every venue must work with (i.e. an amenity criterion) solves the problem of noise creep, particularly if the nominated background noise level is allowed to rise by up to 5 dB as more venues open. However, setting a defined background noise level could adversely affect areas with quieter noise levels than the defined noise level.

b) A practical problem arises in the short term; there is insufficient ambient noise data captured and analysed across the City to accurately create a sound map displaying colour coded background and ambient noise levels as is the case with areas of London such as the Camden Borough. We have suggested to The City that a future scope could be commissioned where we cooperate with other acoustic consulting firms to implement a citywide collection of ambient noise data.

c) As background noise levels are typically lower after midnight, to differentiate between venues that close at midnight or trade after midnight, separate deemed background noise levels are recommended for these two periods, so that it is not overly restrictive for venues closing early.

3.8.2 Amenity

a) The NPfI document prescribes a different amenity level for urban, suburban and rural communities, and simply requires the noise from industrial sources to not exceed this level in situations where the ambient noise level is higher than the amenity criterion for the applicable community. However, as the NPfI specifically excludes "amplified music/patron noise from premises" it cannot provide guidance for the formulation of an entertainment DCP.

b) Given the recent NSW Government's publication in relation to the 24 Hour Economy, the new DCP cannot propose an amenity criterion that will hinder this strategy. Very low amenity criteria as typified by the NPfI, are not appropriate for regulating entertainment noise in the City of Sydney, as the City is a dense, mixed-use environment with an established history and widespread acceptance of some degree of entertainment noise.

c) To prevent intractable assessment and compliance problems from occurring, an amenity criterion must be formulated in the context of the existing ambient noise levels.

d) An important problem that can occur with amenity criteria is that the one loud venue could possibly 'use up' the available amenity level in an area. The result would be that newer venues would need to greatly restrict their noise emissions so that the amenity level is not exceeded.

Ideally, if an area close to residents were to ultimately contain multiple venues, then each venue would contribute a level that is lower than the prescribed amenity limit.

e) Complicating both the amenity and intrusiveness criteria is the fact that the combination of internal amenity and building construction (generally glazing) sets the external entertainment noise level. This is a major problem which is discussed at length in Section 4.5. Ultimately, any external receiver noise criteria should directly serve internal receiver amenity.

3.9. Receiver Internal Levels

A. Overview

a) The internal level of L_{Aeq} 30 dB post-midnight nominated in the current draft DCP might be satisfactory with windows open, but not if windows are closed, as this would likely make the low-frequency sound very audible, particularly with music that has a strong beat.

The ingress of low-frequency music noise into sleeping and living areas with the windows closed is much more problematic than if they are open, due to the following factors:

- low frequency modulations of the music beat become more noticeable as higher frequencies are more readily attenuated.
- the substantial amplification that can be produced at low frequencies in a residential bedroom by room modes (aka standing waves) due to the room's geometry.
- the potentially low internal ambient noise (due to the closed window) allows the entertainment noise to be more audible, whereas open windows can provide a higher ambient noise level and therefore mask some entertainment noise
- reduced noise ingress from other noise sources may worsen intertenancy privacy between apartments and hotel rooms, especially with high performance facades such as double glazing.

b) We have measured the background noise level as low as 17 dBA at 10 pm inside a receiver in an urban environment immediately adjacent to a brewery that was presenting pre-recorded music. The intrusive noise was due to internal-to-internal transmission.

c) A simple internal criterion such as 30 dBA post-midnight doesn't necessarily take account of the masking that noise from an HVAC system or other source can provide. In addition, a single-number criterion cannot be tailored to address the more problematic low frequencies from entertainment noise ingress.

d) The looming question is 'what receiver internal maximum noise level should be allowed' that could mask entertainment sound without introducing amenity issues for the residents?'

B. Example of Audibility

The audibility of entertainment noise for receivers can be illustrated by the situation we measured inside an elevated hotel accommodation suite near a Sydney nightclub. This suite has a fixed double-glazed unit on its façade and is exposed to entertainment noise from the open-air nightclub over 100 m away. Salient details that arose from i) analysis of our data that we measured inside that suite and ii) listening to the audio that was recorded with the sound level measurements are:

- In the short periods after midnight without music, the ambient noise level in the hotel room was 30 dBA and 48 dBC.
- The spectrum of the ambient noise in the room, shown as the dark-red trace in **Figure 4**, was such that at frequencies below 80 Hz, the ambient noise was lower than the threshold of audibility.
- During its softer sections, the music was only audible at frequencies below 315 Hz. The dotted blue trace in **Figure 4**, shows the calculated component of the music, after the ambient noise level was subtracted from the measured combination of the venue and ambient noise levels (solid blue trace in **Figure 4**).
- However, in louder sections of the music with greater bass content, the low frequency music content in the 50 Hz and 63 Hz bands was very audible, even though the levels were close to the ISO threshold of audibility. This is likely due to a combination of the rhythmic modulations (i.e. the 'beat') in the music and the absolute level being 10 dB above the measured ambient noise. This is illustrated in **Figure 5** in which the dotted green trace is the music component of the measured ambient plus music noise (green trace).

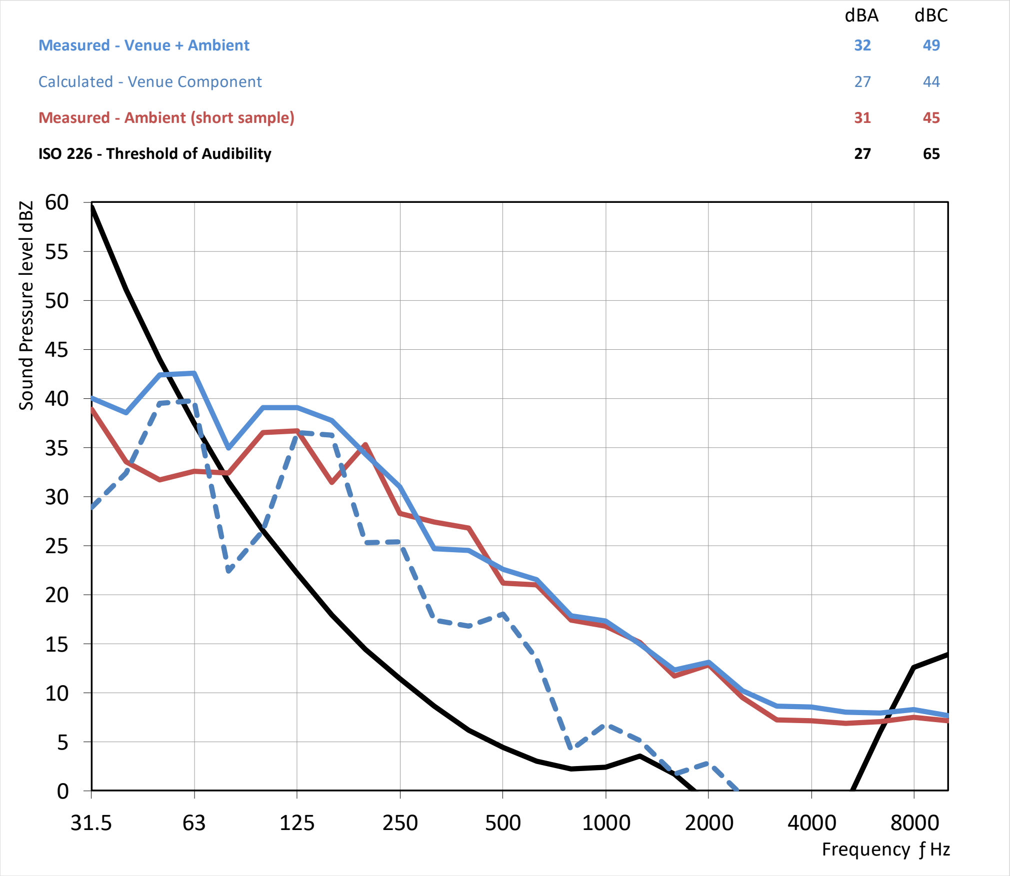


Figure 4. Spectra of ambient noise and music components during a quieter section of the music in a hotel suite.

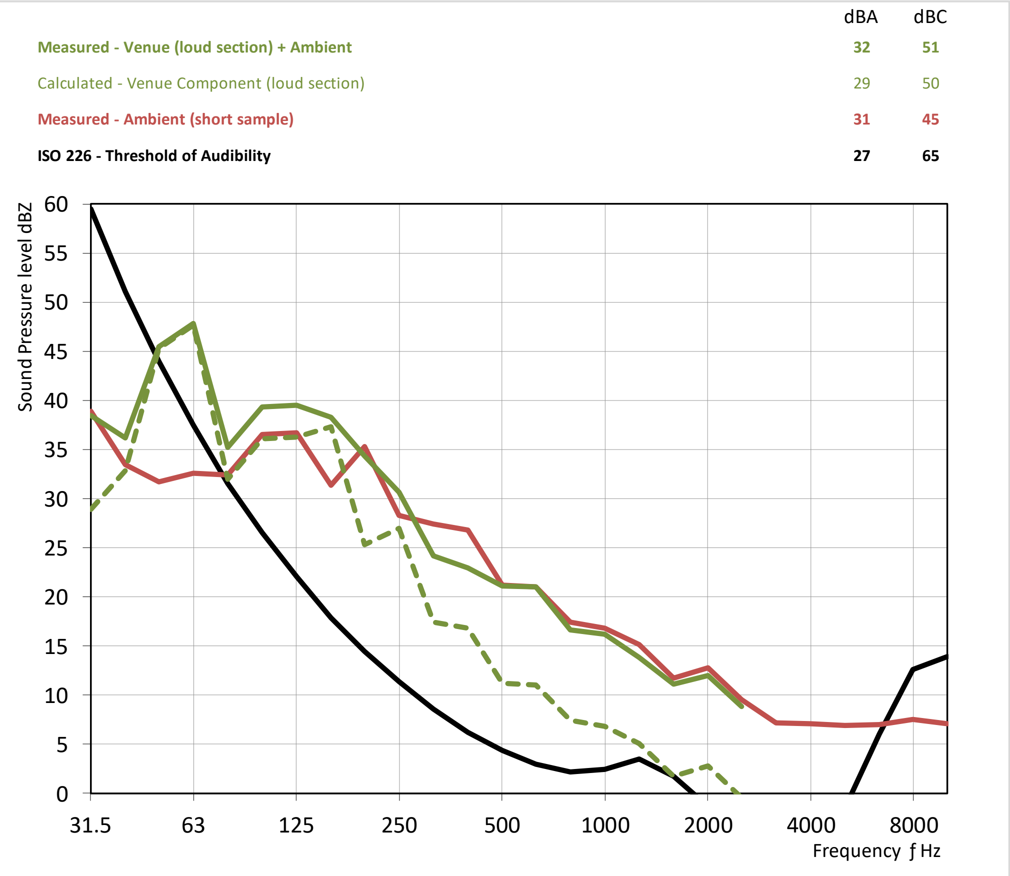


Figure 5. Spectra of ambient noise and music components during a louder section of the music in a hotel suite.

C. Example of Entertainment Noise Ingress

To highlight the limitations in relying on existing receiver buildings to adequately reduce entertainment noise, **Table 8** and **Table 9** below show the in-situ "insertion losses" of the existing glazing in an apartment near an entertainment venue. Insertion loss is the degree to which the sound level inside a room is reduced when an open window is closed, receiver.

The measurements were conducted in the 2023 Entertainment Noise Study during nighttime venue trading periods. Attended measurements were made in the same location with windows open and closed:

i) All operable windows that were accessible were open for at least 15 minutes. Note that the window area was typically 1-2 m^2.

ii) Windows were closed for at least 15 minutes.

Table 8. Hotel accommodation - Entertainment noise ingress from CBD nightclub.

Description	Metric	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ								
				31.5	63	125	250	500	1000	2000	4000	8000
Inside Windows Open	L_{eq}	50	60	56	58	52	50	45	43	40	35	28
Inside Windows Closed	L_{eq}	32	56	49	56	44	33	25	20	18	15	14
Insertion Loss of Windows - double glazed, separate hinged frame with deep reveal (leaky perimeter)	L_{eq}	18	4	7	2	8	17	20	23	22	20	14

Table 9. Residential apartment - Entertainment noise ingress from Taylor Square venue.

Description	Stat	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ								
				31.5	63	125	250	500	1000	2000	4000	8000
Inside Windows Open	L_{eq}	53	63	61	58	58	53	50	48	43	40	32
Inside Windows Closed	L_{eq}	44	59	57	53	54	47	38	37	33	28	21
Insertion Loss of Windows - single glazed, double hung frame (leaky perimeter)	L_{eq}	9	4	4	5	5	5	11	11	10	12	11

Comments:

a) In the hotel accommodation, the low frequency performance below 125 Hz of the glazing was poor. This is a well understood problem with double glazing, which is compounded by this poor performance being in the same frequency region of high entertainment noise energy. In contrast, the sound isolation at mid and high frequencies of double glazing is superior which can further imbalance the entertainment noise spectrum and make low frequencies appear louder.

b) The insertion loss of 2 dB at 63 Hz in the hotel room is poor and probably results from the likely construction of the double-glazed window system. The windows appear to have 2 x 4 mm glass panes separated by a gap of approximately 110 mm, and this results in an adverse mass-air-mass resonance of 72 Hz, which falls within the 63 Hz octave band. The amplification of noise due to standing waves in the room could also account for some of the poor performance.

c) The Taylor Square residence has old double-hung (single glazed) windows and shows a more consistent insertion-loss spectrum, due to the absence of a mass-air-mass resonance in the windows. However, due to the leaky window frame system, the insertion loss performance is capped at 12 dB, which highlights the problem of existing residential receivers with leaky building façades.

4. DISCUSSION OF THE CURRENT ENTERTAINMENT CONDITION

4.1. Current Conditions

For convenience, the City's current entertainment noise conditions (enacted prior to our 2024 Entertainment DCP) are reproduced below.

a) The $L_{Aeq,\ 15\ minute}$ noise level from the use must not exceed the background noise level ($L_{A90,\ 15minute}$) in any octave band (reference frequency 31.5 Hz to 8 kHz inclusive) by more than 5dB between 7.00am and 12.00 midnight when assessed at the boundary of any residential accommodation or tourist and visitor accommodation.

b) The $L_{Aeq,\ 15\ minute}$ noise level from the use must not exceed the background noise level ($L_{A90,\ 15\ minute}$) in any octave band (reference frequency 31.5 Hz to 8 kHz inclusive) between 12.00 midnight and 7.00am when assessed at the boundary of any residential accommodation or tourist and visitor accommodation.

c) Notwithstanding (a) above, the $L_{Aeq,\ 15\ minute}$ noise level from the use must not exceed the greater of the following levels between 7 am and 12 midnight inside any habitable room of a residential accommodation or tourist and visitor accommodation, or at any time in an affected commercial premises:

   i. The existing internal $L_{A90,\ 15\ minute}$ noise level (from external sources excluding the use) in any octave band (reference frequency 31.5 Hz to 8 kHz inclusive).

   or,

   ii. If the $L_{Z90,\ 15\ minute}$ background level is below the hearing threshold curve (Tf - Table 1 of ISO 226 : 2003) in an above octave band, the lowest audible sound level (Lp) of the Tf curve in that octave band shall become that octave's $L_{Zeq\ 15\ minute}$ noise criteria level.

d) Notwithstanding (b) above, the $L_{A1\ 15\ minute}$ noise level from the use must not exceed the greater of the following sound pressure levels inside any habitable room between 12 midnight and 7am inside any habitable room of an affected residential accommodation or tourist and visitor accommodation:

   i. The existing internal $L_{A90,\ 15\ minute}$ (from external sources excluding the use) minus 10 dB in any octave band (reference frequency 31.5 Hz to 8 kHz inclusive) inside a habitable room of an affected residential accommodation or tourist and visitor accommodation.

   or,

   ii. If the $L_{Z90,\ 15\ minute}$ minus 10 dB level is below the hearing threshold curve (Tf - Table 1 of ISO 226 : 2003) in an above octave band, the lowest audible sound level (Lp) of the Tf curve in that octave band shall become that octave's $L_{Z1\ 15\ minute}$ noise criteria level.

Note: L_{eq}, $L_{1,}$ and $L_{90,}$ metrics and 'A' (weightings) are as per the definitions in the standard AS1055-20148. 'Z' means unweighted noise. An internal L_{A90} level must be determined in the absence of noise emitted by the use and be sufficiently representative of the receiver in a low noise level quiet state. External L_{A90} levels for planning must be established as per the long-term methodology in Fact Sheet B of the NPfI unless otherwise agreed by the City's Area Planning Manager.

4.2. Comparison of Current Criteria Issued by L&GNSW and the City

A comparison of the criteria for entertainment noise issued by L&GNSW and the City is provided in **Table 10**.

Table 10. Comparison of entertainment-noise criteria issued by the L&GNSW and the City of Sydney.

Item	Liquor & Gaming NSW	City of Sydney	Comment
Location of measurements	Boundary only	Boundary and inside residences and visitor accommodation.	City's locations are much more comprehensive and include noise transmission within the venue's building.
Time periods	Both use the periods of 7:00 am to midnight and midnight to 7 am.		
Octave band comparison	Both use octave bands to compare entertainment noise with background noise. (See Section 3.1A).		
Background noise	Not explicitly stated but assumed to be L_{90}.	The background noise level must be established in accordance with the NPfI.	The City's requirement might be more rigorous but could also be overly restrictive if there is always a large difference between the background levels between different days of the week, e.g. Tuesday and Saturday.
Metric for entertainment noise at the boundary	Uses the L_{A10} metric.	Uses the L_{Aeq} metric.	City's is likely to be slightly more lenient, by up to 3 dB.
Internal noise level before midnight	Not assessed.	Before midnight, the internal L_{Aeq} noise level should not exceed the background noise or the threshold of audibility, whichever is the greater.	City's criterion is more comprehensive.
Internal noise level after midnight	Noise from a venue should not be audible within a habitable room.	After midnight, the L_1 noise level should not exceed the background noise level minus 10 dB or the threshold of audibility, whichever is the greater.	Inaudibility is difficult to measure and could be overly restrictive to venues. The City attempts to overcome this by the use of L_1 minus 10 dB and is intended to permit brief periods of faintly perceptible sound.
Noise transmission within a building	Not addressed as it mentions 'boundary' only.	Provides a criterion for this.	

4.3. Weaknesses of the City's Current Entertainment Condition.

4.3.1 Background Noise Levels

The NPfI specifies a process to determine the long-term background noise level in three time periods; day, evening and night determined over a seven-day interval. While this process has merit for continuous noise sources such as mining and manufacturing industry, it can be overly restrictive for the entertainment industry. Entertainment does not necessarily occur for seven days per week or during the entire nighttime period. Given that the background noise changes according to the day of the week and time, this "one-size-fits-all" approach is not necessarily appropriate for entertainment. For example, Using an RBL that is based on midweek days at 4 am for the night-time period is likely to not be a suitable criterion for an entertainment venue operating on Friday night at 11 pm.

Noting that the City specifies the RBL to be determined in accordance with the NPfI, which states that the nighttime period ends at 7 am, we consider that the night-time RBL for a venue should be limited to the actual trading hours of the venue, and not the entire period of midnight to 7 am.

4.3.2 A-Weighting of Octave Band Levels.

We consider that the use of A weighting of octave bands in the current entertainment condition can lead to unnecessary problems and uncertainty for venue operators for the following reasons:

i) The use of A-weighted octave bands automatically reduces the actual numerical sound levels inside the venue and inherently encourages acoustic consultants to not consider the implications of high sound levels at low frequencies.

ii) As the threshold of hearing is specified as an unweighted level, the A-weighted octave-band could readily be used instead of the unweighted level when being compared with the threshold of hearing,

iii) A-weighting of sound levels is not an accurate measure of the sound levels perceived by patrons in music venues.

iv) The A-weighting method is an attempt to measure sound levels in a manner that matches the perceived sound at low sound levels and is based on the 60 phon contour of perceived sound levels. When an A-weighting is applied as single number to an entire octave band, such as -39.4 dB to the 31 Hz octave band allows frequencies above the band centre frequency such as near 40 Hz to be measured at a lower level than would be heard, which should have a weighting of -34.5 dB. Although this problem potentially occurs also with the 63 Hz and 125 Hz octave bands, it can be argued that the extra deration of the level at frequencies below the band centre compensates for the elevation of the levels above the band centre frequency. But in the case of the 31 Hz band, the music content is much more likely to have 40 Hz than 25 Hz.

4.3.3 Threshold of Audibility

When windows and doors of residential receiver premises are closed, the majority of noise ingress into those premises occurs at low frequencies, often below 125 Hz. Although it is unusual, there are situations such in tall residential buildings in which the background noise can be very low. In these situations, the determining noise criterion becomes the threshold of audibility as stated in Table 1 of the standard ISO 226: 2003. The 2023 version of ISO 226 only states the thresholds in one-third octave wide frequency bands.

Noting that the criteria are based on octave bands, if the threshold at 31.5 Hz of 60 dB is used for the octave band centred at 31.5 Hz, then a bass sound at 41.2 Hz (the lowest note on a four-string bass guitar) at a level of 60 dB would be some 10 dB above the threshold of audibility at that frequency. As such, the use of octave-wide bands to specify the threshold of audibility can allow some bass sounds to be significantly above each band's threshold.

We recommend that numbers be specified for such thresholds to address the inaccuracies introduced by the use of (relatively wide) octave bands and the rapidly changing thresholds at low frequencies.

4.3.4 Use of L_1 as a Metric for Entertainment Noise

A. General Use of L_1 Metric

We note that the current draft DCP does not specify inaudibility as the use of 'inaudibility' has proven difficult to implement in practice. As such, the City's current conditions of consent replaces the requirement for inaudibility with the requirement for the L_{A1} to not exceed L_{A90} minus 10dB in each octave band or the threshold of audibility.

We have considered the use of L_1 and L_{max} metrics to quantify the music levels internally in relation to possible inaudibility, as the idea that underpins such use has strong merit. However, we have concluded that the following potential difficulties and dangers associated with using or measuring these two metrics preclude their inclusion in the DCP:

i) The L_1 is not a typical metric to assess music sound.

ii) Acoustic consultants preparing DA reports may not have access to data for the L_1 spectrum of venue music and would therefore use an adjustment factor that could easily be incorrect.

iii) The L_1 music contribution has proven difficult to ascertain accurately during compliance testing of entertainment noise at receivers. This difficulty arises from other noise sources such as loud vehicles, car horns, wind gusts, and pedestrian's talking loudly. To measure L_1 music levels in the field would necessitate very careful exclusion of extraneous noise events by the operator, along with careful listening.

There is however another way to use the concept of the L_1 metric and inaudibility that will be substantially less prone to error, which is discussed later in this report.

B. Specific Use of the L_1 Metric

The current entertainment noise condition requires the $L_{1,\ 15\ minute}$ internal level of entertainment noise after midnight to be 10 dB below the background noise inside the residence.

To assess the ability of this condition to satisfactorily replace the requirement for inaudibility used by L&GNSW and previously used by the City, we undertook the listening tests described in in Section 3.6.

4.3.5 The phrase 'Use of the Premises'

We consider that the phrase 'use of the premises' in the City's DA consent conditions can easily allow mechanical noise to be conflated with entertainment noise.

We recommend that a less confusing name be given to all forms of noise emissions from a venue other than entertainment noise.

4.4. Problems with Existing Draft DCP

The problems with the draft DCP were extensively discussed in Section 3.3 of our report 2023 Entertainment Noise Study and are not discussed further.

4.5. The Primary Difficulty with Simultaneous External and Internal Criteria

4.5.1 Overview

a) When an external sound consisting of entertainment and ambient noise enters a residential receiver room either via windows and doors or via natural ventilation apertures, the resulting sound in the room will always be an attenuated version of the external sound. Although the attenuation of the façade will be different at each frequency, the decibel relationships between the entertainment noise and the ambient noise at each frequency will be preserved.

b) The result of this preservation of decibel relationships between inside and outside is that the entertainment noise cannot be assessed against different external and internal criterion that are based on the background noise. In other words, different internal and external criteria based on the background noise level are mutually exclusive; and cannot simultaneously coexist.

c) An outcome of this mutual exclusivity is that a required internal level of 'background + 0 dB' (pre-midnight) and 'inaudibility' (post-midnight simultaneously imposes two different external venue noise limits directly outside the receiver building. Given that venue noise outside a receiver building is ultimately directly related to the sound level inside the venues, this situation creates strong difficulties for the operation of venues if their building envelopes have low attenuation, particularly at low frequencies.

d) This mutual exclusivity between internal and external noise levels has existed since the advent of the dual requirements of "background + 0 dB externally" and "internal inaudibility" were brought into effect by L&GNSW and the City.

e) This problem should be resolved in this DCP, which in turn will set a precedent for future noise criteria.

4.5.2 Ways to Resolve the Mutual Exclusivity

A. Non-Simultaneous Criteria

One way to prevent this mutual exclusivity before midnight is to not specify simultaneous internal and external levels or audibility, but to specify an internal level only when measurement at the residential boundary is not possible, such as situations with:

i) multistorey residential buildings such as hotels where access to external measurements is not possible; and

ii) receivers that are in the same building as the venue, and airborne or structure-borne sound is directly transmitted through the building from venue to receiver.

However, this method does not remove the nexus between the external and internal background noise levels when the internal ambient noise level inside residential rooms is very low.

B. Attenuate the Noise to Inaudibility

The façades of residential buildings (including natural ventilation apertures) could be designed to provide sufficient attenuation to reduce the music and external ambient noise to levels that are below the auditory threshold or allow other internal noise to mask the music noise. However, this method will be problematic as it will result in a general internal ambient noise level that is permanently low, which in turn will result in a loss of acoustic privacy between adjacent apartments.

Although this loss of privacy would be addressed by substantially uprating the intertenancy walls, floors and ceilings, this will consume considerable internal real estate, and developers will be highly unwilling to accommodate the additional cost of such constructions.

C. Addition of Masking Noise to the Receiver Room

a) The key to breaking the nexus between the external and internal background noise levels lies in the control of internal ambient noise levels. Adding small amounts of ambient noise from internal sources can have a major masking effect on the audibility of entertainment noise.

b) Masking simultaneously eases the venue's acoustic constructions and provides practical inaudibility inside residences. Without it, the music noise entering the residence would be 23 dBA which could well be audible Alternative, onerous residential constructions such as heavy double-glazing with deep air gaps and long lined ducts etc could be used, with the hope that the noise break-in at low frequencies is below the threshold of hearing. This will result in a very low internal ambient noise level (for example 17 dBA)l, which could then invoke a loss of privacy from other units in the same building.

c) Ambient noise produced by sources inside the residential apartment can be used to supplement the external ambient noise entering each room, thereby providing additional masking of the entertainment noise. Such sources could include:

    i. air conditioning noise (HVAC)
    ii. room heaters
    iii. dehumidifiers
    iv. refrigerators (although these operate periodically)
    v. computer fans
    vi. traffic noise entering through another façade that is not affected by entertainment noise.

d) The greater the attenuation of external noise that is provided by the building façade, the greater the potential exists for internally-produced noise to mask the entertainment noise.

e) If HVAC is used as to elevate the internal ambient noise so that the music is masked, then the HVAC would need to be implemented in new residential buildings similar to a hotel that uses continuously-ducted air to set the background noise. In addition, the building would still need to provide the required natural ventilation, using techniques such a façade ducts / louvres, and wintergardens.

f) Although the use of noise from HVAC systems to mask music noise would appear attractive, this can be fraught with difficulties for the following reasons:

    - Unless the system is specifically tailored to the required masking noise spectrum, it is likely that music noise in one or more octave bands will not be sufficiently masked to ensure inaudibility.
    - Designing a residential HVAC system in the form of a hotel system to have the required masking noise spectrum in each entertainment-noise-affected room will require significant acoustic expertise, which may not be available given the poor experience and low fees in the acoustic consulting industry.
    - The arrangement of mechanical devices that are able to shape the frequency spectrum of the noise will be complex.

D. External Noise Masking Systems

The City could install externally mounted sound masking systems in specific locations near sensitive residential receivers to increase the background noise level at low frequencies entering those premises. Other options such as courtyard fountains and other urban renewal options could be explored to improve nightlife vibrancy near residential developments.

E. Internal Noise Masking Systems

a) The use of an electronic noise generating system to add noise to the internal receiver environment is an elegant solution to the need to breaking the link between internal and external ambient noise for at least eight reasons:

i. The level of external ambient noise entering each room via windows, doors and natural ventilation apertures can be specifically supplemented in each octave frequency band to produce the desired masking level in each octave band for music.

ii. The ambient noise can be tailored to specific phon level in each space, which can be set and certified during building commissioning, and eventually by residents using a control in each room.

iii. The level in each band can be manually adjusted to produce additional masking if required to overcome the frequency-selective amplification of music noise by standing waves in the room.

iv. There will be no need to increase the acoustic constructions of walls, floors and ceilings to maintain acoustic privacy.

v. The more attenuation that the façade can provide, the more that the noise masking system can take advantage of the non-linear equal loudness properties of the human ear; i.e. as the sound level of low frequency sound is reduced, it is perceived as having greater reduction than the actual numerical change in sound level.

vi. Sound masking can be tailored to each space, is more reliable than mechanical system, and can be adjusted during commissioning, and even by residents after occupation.

vii. Noise masking provides a robust buffer against the following situations.

- Sections of the background L_{90} noise entering the room might fall below the threshold of audibility, allowing the music to be become much more audible. Due to the shape of the equal loudness contours, small differences between the peaks of the music and the threshold of audibility will become much more audible.
- As many residents don't use air-conditioning at night, noise masking can provide the required ambient noise to mask the music noise.

viii. With defined internal ambient noise levels in octave band in new residential situations, venue proponents can have more confidence that if their noise emissions after midnight are appropriately controlled, they will not be problematic for residents in the long term.

b) The overall level of the noise masking system should be set to 30 to 35 dBA in bedrooms and 35 to 40 dBA in living rooms, with the spectral shape of the masking noise set to account for the combination of the following four factors:

- the threshold of audibility at low frequencies,
- the composite sound transmission loss of the façade (glazing and natural ventilation system)
- the spectrum of the external ambient noise
- the spectrum of the entertainment noise.

c) One idea pertaining to natural ventilation that will require future research is to use a lined duct for broadband noise attenuation, and then use one or more small openings to allow mid and high frequencies to enter the room and provide masking at midrange frequencies, thereby delocalising the sound of the noise masking system at these frequencies. However, to prevent external entertainment noise at mid and high frequencies from entering the room, these openings would need to be on a façade that is shielded from the entertainment noise.

F. Summary

a) The mutual exclusivity between the external and internal criteria can be somewhat mitigated by the typical internal noise sources and the use of non-simultaneous criteria; however, we don't believe that this problem can be properly resolved without either internal artificial noise masking or external city-wide noise masking.

b) If the above options cannot be implemented, then the criteria must change to remove the mutual exclusivity.

c) If developers want certainty in venue or residential design without the use of noise-masking systems, then an internal criterion of L_{90} - 12dB in octave bands effectively becomes the external criterion, because it eliminates the mutual-exclusivity problem.

5. RATIONALE BEHIND PROPOSED RESIDENTIAL AND VENUE CONTROLS

The rationale behind our proposed venue controls is described below.

A. Relativity to Background Noise

We recommend retention of the concept of background noise level plus 5 dB externally before midnight as it is used by L&GNSW and has its historic root in the EPA's noise policies.

B. Shoulder Period

Using the process specified by the NPfI for the defined night-time period of 10 pm to 7 am / 8 am to establish the rating background noise level could be overly restrictive for venues that close before midnight. We recommend the use of a quasi-shoulder period from 10 pm to midnight to assess the background noise level during this period, rather than including this period in the overall night-time period. This process will allow the higher background noise level during the 10 pm to midnight period to be appropriately applied to venues that close before midnight.

C. Defined External Background Noise Level

a) Ideally, we would like to specify a defined external background level to limit noise creep and protect residents that have acoustically-poor glazing from being badly affected by noise from multiple venues.

b) However, we consider that there is not sufficient data for ambient noise levels in the city to make such a definition. Accordingly, the potential problem of noise creep remains.

D. Octave Bands

a) We recommend retention of octave-wide frequency bands for simplicity.

b) The 8 kHz octave band should be removed from Entertainment Noise DCP assessment criteria due to unnecessary complexity. In our experience the high frequencies in the 8 kHz octave band are not problematic for residents, as well as sound data for building materials is rarely reported.

c) The 4 kHz octave band becomes the highest assessment frequency, which is important as the coincidence dip in glazing results in adverse acoustic performance in this frequency band.

E. Concept of the L_1 metric

a) Retain the concept of the L_1 value of the internal level the current condition for existing residential accommodation with the following changes:

- Substitute the Leq level with an offset to reflect the difference between the L_{eq} and L_1, so that assessment and measurement are simplified.
- Use the highest $L_{eq, 1 min}$ level occurring in any fifteen-minute period, as the loud sections of songs are often approximately 1 minute long, and this is more likely to correspond to residential annoyance.

b) Our conclusions from the listening tests suggest that in the pre-midnight period, the internal sound level should be L_{eq} – 2 dB in octave bands to prevent excessive annoyance for residents. However, given that the current consent condition is L_{eq}+0 dB, we have elected to retain this condition.

c) Although this level of L_{eq} + 0 dB is suitable as design target, it does present a potential difficulty with measurements of a venue's noise emissions if a complaint was being investigated. However, measurement of this level would not a problem during compliance testing, as the venue can simply reduce its level by a specific number of dB after a valid measurement of its emissions has been made at a level of approximately 5 dB above the ambient noise level.

d) The listening tests also lead us suggest that after midnight for inaudibility, the L_{eq} level of music noise in each octave band in any one-minute long period should be at least 12 dB below the L_{90} level of the ambient noise in the receiver room.

F. Threshold of Audibility

The City's Conditions of Consent provides clarifying comments about how to interpret the ISO 226 *Threshold of Audibility* curve as a third-octave band when utilised in an octave band criterion. In our opinion this text will cause unnecessary confusion with acoustic consultants and City assessors.

Instead, we propose the adoption of a tabled spectrum that provides the exact requirement of the City's intentions. The workings are presented in **Table 11** below:

We note that, although ISO 226 shows a constant curve of threshold with frequency, the values are actually quantised to third-octave band frequencies.

Table 11. Threshold of audibility interpretation (example 25 Hz to 250 Hz).

Description	Third Octave Band Centre Frequency (Hz) dBZ											
	25	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**
ISO 226 – Threshold of Audibility	68.7	59.5	51.1	44.0	37.5	31.5	26.5	22.1	17.9	14.4	11.4	8.6
City's current consent conditions: "lowest audible sound level of the curve in that octave band"	51.1			31.5			17.9			8.6		
AD/PKA Proposed Threshold of Audibility (rounded for simplicity)	51			32			18			9		

For reference, the threshold of audibility values for the octave band range up to 500 Hz is provided below **Table 12**:

Table 12. Proposed threshold of audibility table for DCP adoption.

Description	Metric	Octave Band Centre Frequency (Hz) dBZ				
		31.5	**63**	**125**	**250**	**500**
AD/PKA Proposed threshold of audibility inside receivers	L_{eq}	51	32	18	9	3

6. RECEIVER CONTROLS

6.1. Inaudibility

A discussed earlier in this report, inaudibility is only achieved if entertainment noise is either i) significantly lower than background noise or ii) the entertainment noise is below the threshold of hearing. As noise receivers cannot selectively filter entertainment sound, receivers cannot easily make entertainment sound inaudible on their own. This leaves three options to achieve inaudibility inside residential premises:

i) Maintaining responsibility for the venue to provide low levels of entertainment sound in relation to external ambient levels

ii) Insulating receivers down to total inaudibility, which would be onerous, expensive and potentially reliable, or

iii) For receivers to provide their own internal ambient noise independent of external sources (in combination with some insulation).

6.2. Salient Items

a) Noise-sensitive receivers included in the scope of the DCP are new residential accommodation and tourist and visitor accommodation in mapped sites that are designated as late-night trading areas and sites within close proximity to existing venues.

b) Receiver controls are items about the way that receiver noise is managed and controlled. For example; distance, and internal noise levels from internal noise sources.

c) If the residential building is the agent of change, then an amenity criterion applies for internal sound levels. That means that the developer has to identify the existing noise from entertainment venues for the residential development to enable the design of the glazing and the natural ventilation.

However:

- The entertainment noisescape that is reported during the DA stage must be representative of the area, so consultants must identify the venues in a radius of 200 m and measure their noise, and if necessary, by listening to the audio recording captured with the logged environmental noise data.

- If the venue is quiet because of seasonal things or rain etc, the consultant must make an estimate of the entertainment noisescape.
- The EHO officer evaluating the DA must be satisfied that the consultant has captured the prevailing condition.

d) If the residential building is not the agent of change, but it being constructed in a designated late-night area, then, then an external entertainment noise level must be assumed so that venues have potential to open without incurring future noise complaints from nearby residents.

e) In new residential buildings, the glazing and ventilation apertures can be controlled to provide the required internal noise levels.

f) The DCP only relates to new residential developments and therefore existing residential buildings are excluded from the controls. We understand from The City that many older style buildings have a high degree of natural ventilation due to their floor plate layout and the narrow building plan. However, these buildings often have poor glazing in acoustic terms.

g) We have assumed that windows and doors in residential and visitor accommodation are closed, as we understand that this accords with L&GNSW policy for assessments. We note that ventilation is still required to comply with the ADG.

6.3. Additional Rationale

a) We prefer to use the term 'Entertainment Design Criterion', rather than 'Amenity Criterion' to avoid confusion with the amenity type of criterion used in the NPfI.

b) In summary, we wish to mitigate the following risks:

- Unsatisfactory acoustic assessments that may not identify the existing entertainment noise impacting a proposed new residential development.
- Under-design of new residential acoustic façades where existing venue(s) may have currently low noise emissions but may increase their noise emissions under existing consents without becoming the Agent(s) of Change.

c) The DCP controls should provide protection for future entertainment noise in a designated late-night trading area. It is effectively a 'pre-emptive' Agent of Change principle.

d) New venues would still need to assess their noise impact on existing residential buildings with the intrusiveness criterion.

e) The benefit of this approach is that the Agent of Change is not necessarily a burden on new venues, if the surrounding residential has been designed to the new DCP. However, the Agent of Change principle would apply to a venue (new or existing) if the change results in noise impacts at residential façades that exceed the proposed Defined External Entertainment Noise Spectrum. This term is defined in in the next section

6.4. Proposed 'Entertainment Design Criterion' for Residential Developments

We propose the following two-pronged Entertainment Design criterion:

New residential external façades within mapped areas should be designed to accommodate the greater of the following octave band spectra as measured outside the façade as an equivalent free-field measurement.

- the Defined External Entertainment Noise Spectrum (DEENS)

  or

- the measured existing L_{Zeq} spectral levels of entertainment noise near the proposed residential building'.

The above concept is illustrated with three examples below in which an acoustic survey is conducted at a proposed new residential site within a mapped area:

i) **Example 1**: The survey is carried out in winter or during a period in which the identified venue might have a quiet weekend. That survey reveals that the measured noise level is lower than the DEENS level in each octave band and therefore the acoustic assessment would need to adopt the DEENS of entertainment noise that could impinge on the external residential façade. The façade would then be designed to achieve the pre-midnight and post-midnight internal noise criteria within habitable rooms with this DEENS.

ii) **Example 2**: The survey is carried out in summer with high activity trade from one or more identified venues. The survey shows that the measured noise exceeds the specified DEENS in each octave band and therefore the design of the façade would need to account for the measured (i.e. louder) entertainment noise impact to achieve the required internal residential noise criteria within habitable rooms.

iii) **Example 3**: The survey is carried out in spring and shows that the measured ambient noise level is lower than the DEENS level in the 31 Hz and 63 Hz octave bands, but higher than the DEENS levels in the other octave bands. In this situation, the basis for the façade design would be the combination of i) the level in the 31 Hz and 63 Hz of the DEENS and ii) the measured entertainment noise in the octave bands 125 Hz to 4 kHz.

6.5. Recommended Internal Ambient L_{eq} Levels

A. Basis for Our Recommendations

a) There is a difficult compromise to make between the desire to have a higher external DEENS to assist vibrancy and a lower internal ambient noise for residential amenity,

b) The only potential acoustic differentiators between bed and living rooms are differences in the areas of the glazing and the room and the reverberation times. However, as these factors could readily be similar between bed and living rooms, we have assumed that the same internal level is required in both types. There are situations where the orientation of bedrooms could result in a lower exposure to entertainment noise, but this has not been considered in this study.

c) It is well understood that internal noise levels should be between 30 to 40 dBA in bedrooms for urban areas, entertainment areas or near major roads. SEPP 2021 Infrastructure states a maximum level of 35 dBA at any time.

We consider it important that the internal level lies under the maximum 35 dBA $_{1\ hr}$ in bedrooms and 40 dBA in living rooms, similar to other acoustic criteria such as the SEPP (Infrastructure) and Australian Standard AS2107 for areas near entertainment districts.

d) British Standard BS 8233: 2014 suggests that for steady external noise sources, during the day, an internal noise level of 35 dB $L_{Aeq,T}$ is appropriate for resting conditions within living rooms and bedrooms and a level of 40 dB $L_{Aeq,T}$ is applicable to dining rooms. During the night, an internal noise level of 30 dB $L_{Aeq,T}$ is recommended within bedrooms.

e) In relation to internal noise levels in visitor accommodation rooms, we do not consider that a higher internal noise level should be adopted for the sake of expediency. We opine that visitors are entitled to the same amenity as provided to residents.

f) To develop a satisfactory internal noise level that is pleasant to listen to, but still provides useful masking of low frequency music noise, we have carefully considered the gamut of noise rating and phon loudness curves. The noise rating curves we have considered are:

- Noise Rating (NR)
- Noise Criteria (NC)
- Balanced Noise Criteria (NCB)
- Room Criteria (RC)
- Preferred Noise Criteria (PNC)

The recommended levels are a combination of various curves.

g) **Table 13** lists the recommended internal ambient noise levels and the noise rating curve that was used to select the particular level in each octave band.

It is important to note that recommended levels are not the actual noise-masking levels; they are the combined noise levels from traffic ingress, in-room mechanical noise, and the noise masking system.

Table 13. Recommended internal ambient noise levels in octave bands and the basis for their selection (from masking and other sources).

Description	dBA	Octave Band Centre Frequency (Hz) dBZ							
		31.5	63	125	250	500	1000	2000	4000
Internal Ambient L_{eq}	35	65	55	44	35	30	25	20	18
Basis for octave band selection		Best fit: NC25 NCB25 PNC25	NR25	NR25	NCB25	NCB25	PNC25	PNC25	PNC25

B. Target Internal Entertainment Noise Spectrum Levels (TIENS)

a) For inaudibility after midnight, we concluded that the L_{Zeq} level of entertainment noise in each octave band should be 12 dB below the recommended internal ambient noise levels. On this basis, the upper limit of entertainment noise inside residences can be computed.

b) Pre-midnight, audibility is allowed inside residences and therefore the total noise level in residences should not exceed 35 dBA. If the entertainment noise intrusion is at 30 dBA, the total level of noise in the bedroom would increase by 1 dB.

c) For the total noise level in living rooms to be not greater than 40 dBA, the TIENS could be equivalent to 35 dBA before midnight and 28 dBA after midnight. (NB TIENS must be specified in octave frequency bands.)

d) The results of our listening tests described in Section 3.6.2 indicate that after midnight, the entertainment noise levels should be 12 dB below the background noise levels.

e) **Table 14** states the Target Internal Entertainment Noise Spectrum (TIENS) levels for pre and post-midnight periods. It must be noted that although these levels cannot be measured, they are the targets that must be adopted in the acoustic design of the building façade. Note that compared to the recommended internal ambient levels in **Table 13**, the recommended TIENS levels are 5 dB lower before midnight and 12 dB lower after midnight.

Table 14 Target Internal Entertainment Noise Spectrum (TIENS) levels pre and post-midnight.

Description	dBA	Octave Band Centre Frequency (Hz) dBZ							
		31.5	63	125	250	500	1000	2000	4000
Pre-Midnight TIENS	30	60	50	39	30	25	20	15	13
Post-Midnight TIENS	23	53	43	32	23	18	13	8	6

6.6. Establishing the Defined External Entertainment Noise Spectrum

a) To establish the Defined External Entertainment Noise Spectrum (DEENS) levels in octave bands, we could reverse engineer the situation by applying the combined attenuation resulting from the room gain and façade loss through windows and natural ventilation systems to the adopted internal criterion. However, the mutual exclusivity problem of specifying internal and external noise levels relative to the ambient noise levels still remains.

b) To establish the internal criteria, two items that come to mind are:

- Limit the noise to the threshold of hearing: This produces the most conservative façade design but is a potentially troublesome target due to the loss of acoustic privacy between apartments, as described in Section 4.5.2B.
- Provide noise masking: Broadband noise would be selectively introduced externally or internally to elevate the background noise above the threshold of audibility as described in Section 4.5.2E.

c) We consider that the best and most robust way forward is to provide an electronic noise masking system in each residential situation so that the internal criterion can be robustly set.

6.6.2 The Defined External Entertainment Noise Spectrum

a) For a new residential development, the DEENS levels represent the minimum external level for which the residential façade must be designed.

b) From the perspective of a new entertainment venue (when no other venues are in the area), the DEENS levels are the maximum allowed noise levels which will be incident as a free field on the residential façade. During modelling or measurement, the levels would be adjusted to yield façade-corrected (i.e. free field) levels.

c) We have undertaken calculations to confirm the ability of buildings to accommodate the external DEENS so that consistency can be provided for assessors and consultants.

d) The DEENS has been developed using the following assumed acoustic parameters:

- 14 m^2 bedroom (4 m x 3.5 m x 2.7 m) with reverberation time of 0.5 secs
- The worst-case but typical scenario with a large, glazed sliding door of area 5 m^2 with R_w 33 sound reduction index on the façade.
- An opening in a solid façade for natural ventilation.
- Conversion from incoming sound power to reverberant pressure in the room of -6 dB, which is constant with frequency. (NB, this is a conservative estimate.)

Table 15 lists the levels in each octave band of the DEENS, along with the overall dBA and dBC levels for reference.

Table 15. Defined External Entertainment Noise Spectrum (DEENS)

Description	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ							
			31.5	63	125	250	500	1000	2000	4000
Defined External Entertainment Noise Spectrum (DEENS)	51	68	69	63	53	49	47	44	42	45

6.6.3 Example of Derivation of DEENS

Our process to derive the Defined External Entertainment Noise Spectrum (DEENS) is shown in the reverse-engineered examples in **Table 16** and **Table 17** below along with the following comments: **Table 18** shows how the DEENS levels were determined.

- The dBA and dBC values are provided as a guide only. The DEENS is stipulated to be an octave band only criterion.
- The Internal ambient L_{eq} noise level is effectively the Internal background L_{90} noise level due to the constant internal noise masking proposed in Section 4.5.2E.

Table 16. Example 1: Bedroom with a sliding-door façade.

Description	Metric	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ							
				31.5	63	125	250	500	1000	2000	4000
Desired internal ambient as per Section 6.5.	L_{eq}	35	63	65	55	44	35	30	25	20	18
Proposed DCP Post-Midnight intrusive criteria as per Section 7. $L_{eq\text{-entertainment}} \leq L_{eq\text{-ambient}}$	$L_{eq} \leq$			-12	-12	-12	-12	-12	-12	-12	-12
Effective entertainment noise limit inside receiver	L_{eq}	23	51	53	43	32	23	18	13	8	6
Room adjustment for internal sound pressure to internal sound power for bedroom 14 m^2				6	6	6	6	6	6	6	6
Transmission loss of new residential bedroom façade assuming R_w 33 sliding door 5 m^2				17	21	25	28	30	32	35	40
Adjustment for radiating area of façade element 5 m^2				-7	-7	-7	-7	-7	-7	-7	-7
Example 1: Bedroom sliding door DEENS at façade of new residential	L_{eq}	51	68	69	63	56	50	47	44	42	45

Table 17. Example 2: Bedroom with lined duct in the façade for natural ventilation.

Description	Metric	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ							
				31.5	63	125	250	500	1000	2000	4000
Desired internal ambient as per Section 6.5	L_{eq}	35	63	65	55	44	35	30	25	20	18
Proposed DCP Post-Midnight Intrusive Criteria as per Section 7	$L_{eq} \leq$			-12	-12	-12	-12	-12	-12	-12	-12
Effective entertainment noise limit inside receiver	L_{eq}	23	51	53	43	32	23	18	13	8	6
Room adjustment for internal sound pressure to internal sound power for bedroom 14 m^2				6	6	6	6	6	6	6	6
Attenuation of lined duct (1000 mm (L) x 300 mm x 200 mm) below balcony balustrade with soffit absorption as per AD/PKA Passive Guide Section 10.2.					17	15	21	45	57	43	37
AD/PKA Conservative attenuation for natural ventilation lined duct				10	15	15	20	40	40	40	35
Example 2: Bedroom Lined Duct DEENS at façade of new residential	L_{eq}	64	70	69	64	53	49	64	59	54	47

Table 18. Deriving a best fit DEENS from the data in **Table 16** and **Table 17**.

Description	Metric	dBA	dBC	Octave Band Centre Frequency (Hz) dBZ							
				31.5	63	125	250	500	1000	2000	4000
Example 1: Bedroom sliding door DEENS	L_{eq}	51	68	69	63	56	50	47	44	42	45
Example 2: Bedroom lined duct DEENS	L_{eq}	64	70	69	64	53	49	64	59	54	47
Defined External Entertainment Noise Spectrum (DEENS) Minimum of the above examples	L_{eq}	51	68	69	63	53	49	47	44	42	45

6.7. Simplified Scenarios of Receiver Amenity and Venue Operating Levels

This section demonstrates the benefits of the proposed use of internal noise-masking to solve the mutual exclusivity problem between internal and external noise levels that will otherwise occur. Five scenarios with different receiver and venue parameters as shown in **Table 19** were investigated using simplified calculations based on total sound levels measured as dBA and dBC for ease of comparison. The outcome of each calculated scenario is the type of activity and sound level inside a music venue. The calculations are shown in **Table 21** and **Table 22**.

Table 19. Scenarios with different receiver and venue parameters.

	Scenario 1*	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Receiver Amenity Goal	High Priority ($L_{eq} \leq L_{90}$ -12 dB)	High Priority ($L_{eq} \leq L_{90}$ -12 dB)	Low Priority ($L_{eq} \leq L_{90}$ -0 dB)	High Priority ($L_{eq} \leq L_{90}$ -12 dB)	High Priority ($L_{eq} \leq L_{90}$ -12 dB)
Venue Construction	Typical	Typical	Typical	High Isolation Upgrade	Typical
Receiver Construction	Typical with internal masking	Typical, no masking	Typical, no masking	Typical, no masking	High Isolation, no masking

* Recommended by AD/PKA.

Table 20: Conclusions arising from Scenarios in **Table 19**.

Conclusions	
Scenario 1*	Receiver internal masking promotes city vibrancy by optimising receiver internal amenity and venue sound along with patron experience, with no further construction upgrades for venue or receiver.
Scenario 2	The lack of receiver masking restricts city vibrancy if residential amenity is prioritised. Significant construction upgrades to both venues and receivers are necessary for vibrancy
Scenario 3	No noise masking at receiver and poor residential amenity limits city vibrancy due to low frequency limit, unless construction upgrades to either receiver or venues are undertaken.
Scenario 4	Substantial acoustic isolation of venues is needed to provide city vibrancy when receiver amenity is prioritised without receiver masking.
Scenario 5	Substantial acoustic isolation of receivers is needed such as deep double glazing and deep acoustical louvres for natural ventilation to provide city vibrancy when receiver amenity is prioritised. Venue levels still insufficient with risk of complaints.

Table 21. Calculations supporting Scenarios 1 and 2.

	Scenario 1: AD-PKA Recommended	**Scenario 2**
Receiver Amenity Goal	High priority ($L_{eq} \le L_{90}$ -12 dB)	High Priority ($L_{eq} \le L_{90}$ -12 dB)
Venue Construction	Typical	Typical
Receiver Construction	Typical with internal masking	Typical, no masking

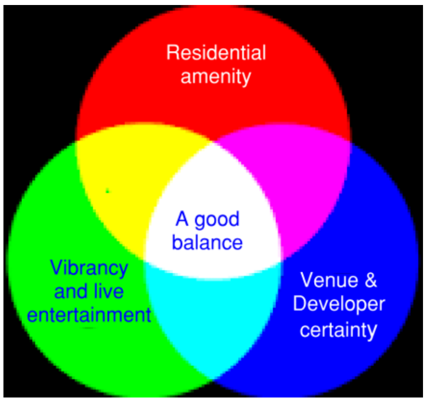
Description	Report Ref	**dBA**	**dBC**	**dBA**	**dBC**
Receiver internal maximum ambient noise level	Section 6.4	35	63	22	42
Noise masking system?		Yes		No	
Receiver Post-Midnight Internal Entertainment Noise Criteria relative to ambient noise in receiver room for inaudibility.	Section 7.1	- 12	- 12	- 12	- 12
Receiver post-midnight internal entertainment noise limit	Section 6.5.3	23	51	10	30
Receiver façade attenuation and room acoustics etc.	Section 6.5.3	+ 28	+ 17	+ 28	+ 17
AD/PKA comment: Receiver construction		Typical glazing + acoustic ventilation		Typical glazing + acoustic ventilation	
Receiver external entertainment noise limit	Section 6.5.3	51	68	38	47
Distance loss from venue to receiver estimated 40 m: [15*log(distance)]		+ 24	+ 24	+ 24	+ 24
Venue façade attenuation (estimated)		+ 30	+ 20	+ 30	+ 20
AD/PKA comment: Venue construction		Typical façade with fire-doors		Typical façade with fire-doors	
Venue operating maximum sound level (estimated)		**105**	**112**	**92**	**91**
AD/PKA comment: Allowable venue activity		Live band, typical DJ		Acoustic duo, background music	
AD/PKA comment: Receiver experience and city vibrancy		Receiver internal masking promotes city vibrancy by optimising receiver internal amenity and venue sound along with patron experience, with no further construction upgrades for venue or receiver.		The lack of receiver masking restricts city vibrancy if residential amenity is prioritised. Significant construction upgrades to both venues and receivers are necessary for vibrancy.	

Table 22. Calculations supporting Scenarios 3, 4 and 5.

	Scenario 3		Scenario 4		Scenario 5	
Receiver Amenity Goal	Low Priority ($L_{eq} \le L_{90}$ + 0 dB)		High Priority ($L_{eq} \le L_{90}$ -12 dB)		High Priority ($L_{eq} \le L_{90}$ -12 dB)	
Venue Construction	Typical		High Isolation Upgrade		Typical	
Receiver Construction	Typical, no Masking		Typical, no Masking		High Isolation, no Masking	
Description	dBA	dBC	dBA	dBC	dBA	dBC
Receiver internal maximum ambient noise level	22	42	22	42	17*	37*
Noise masking system?	No		No		No	
Receiver post-midnight internal entertainment noise	0	0	- 12	- 12	- 12	- 12
Receiver post-midnight internal entertainment noise limit	22	42	10	30	5	25
Receiver façade attenuation and room acoustics.	+ 28	+ 17	+ 28	+ 17	+ 45	+ 35
AD/PKA comment: Receiver construction	Typical glazing + acoustic ventilation		Typical glazing + acoustic ventilation		Deep double glazing with acoustic treatment	
Receiver external entertainment noise limit	50	59	38	47	50	60
Distance loss from venue to receiver estimated 40 m: [15*log(distance)]	+ 24	+ 24	+ 24	+ 24	+ 24	+ 24
Venue façade attenuation (estimated)	+ 30	+ 20	+ 50	+ 40	+ 30	+ 20
AD-PKA comment: Venue construction	Typical façade with fire-doors		Treated building with sound-locks		Typical façade with fire-doors	
Venue operating maximum sound level (estimated)	104	103	112	111	104	104
AD-PKA comment: Allowable venue activity	Limited band, Limited DJ		Live band, Typical DJ		Limited band, Limited DJ	
AD/PKA comment: Receiver experience and city vibrancy	No noise masking at receiver and poor residential amenity limits city vibrancy due to low frequency limit, unless construction upgrades to either receiver or venues are undertaken.		Substantial acoustic isolation of venues is needed to provide city vibrancy when receiver amenity is prioritised without receiver masking.		Substantial acoustic isolation of receivers is needed such as deep double glazing and deep acoustical louvres for natural ventilation to provide city vibrancy when receiver amenity is prioritised. Venue levels still insufficient with risk of complaints.	

* Internal ambient noise level is reduced due to the reduction in traffic-noise ingress from increased receiver façade construction.

Our goal for this work can be illustrated with the Venn diagram shown on the right. The central white area represents Scenario 1, with receiver noise masking providing the key. Without balance, one domain suffers, which is what is currently occurring.



6.8. Entertainment Sound Management Maps

The City has prepared Entertainment Sound Management Maps (ESM) which identifies the following information:

i) Late night management areas
ii) Existing live music and performance venues
iii) Map a 50 m buffer around the above of *"land that may be affected by entertainment sound or high activity areas"*

Figure 6 shows an example of a map.

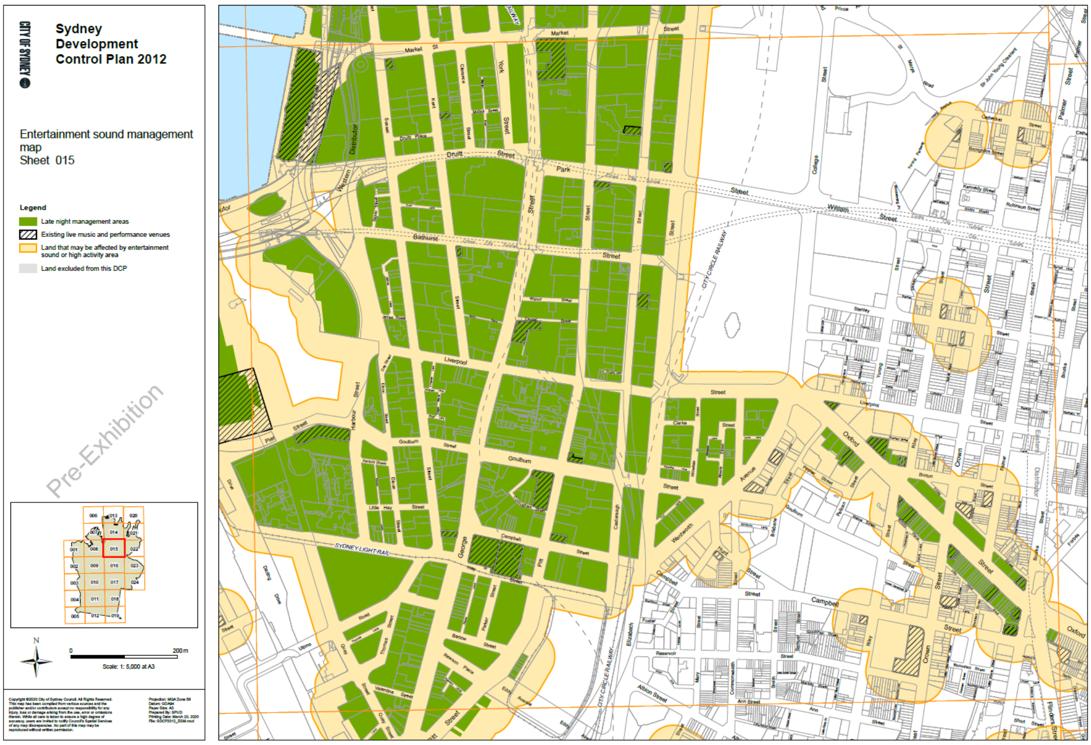


Figure 6: Example ESM prepared for Pre-Exhibition

In our 2023 Sound Study we identified that the 50 m buffer zone will not sufficiently capture the potentially affected land that triggers new residential developments to address entertainment noise intrusion. The example provided was that 75 m distance is only a 3.5 dB further reduction than 50 m distance which is not sufficient to substantially change the audibility of entertainment noise intrusion.

In preparing our 2024 Entertainment DCP we have collaborated with the City and have proposed a 2-tier approach to the ESM as follows:

- 1st Tier: 50 m buffer of existing venues as originally exhibited
- 2nd Tier: 150 m buffer of existing venues that trade post-midnight, or near mapped late night trading areas

The intent of the 2nd Tier being a wider buffer but limited to post-midnight entertainment noise intrusion, is to prioritise residential amenity during sensitive hours, without casting the net too wide over the whole City and unduly burdening new residential developments.

The 1st Tier would apply to all new residential developments within the 50 m buffer, triggering an acoustic assessment to meet the entertainment noise criteria.

The 2nd Tier would be used by the proponent's urban designer/architect team to identify likely entertainment noise affected façades of new residential developments within the 150 m buffer zone, triggering an acoustic assessment. In the second tier, the proponent would undertake basic urban design analysis to determine if there is likely to be a noise impact to certain parts of the development.

As the City does not possess a sound map of the entire Council area, showing existing and future entertainment noise affected façades, we have developed guidance in this report to help urban designers apply the 2nd Tier buffer.

In a free field environment without any buildings, the noise level at 75 m from a venue will only be 3.5 dB below the level at 50 m, which is not a sufficient reduction to substantially change the audibility of noise; i.e., the loss of amenity for residents at 75 m from a venue will be only slightly lower than that for residents at 50 m.

7. VENUE CONTROLS

7.1.1 General Controls

We have divided our proposed intrusiveness entertainment criteria into two types.

- Type 1, shown in **Table 23**, is for new venues impacting residential developments that have been built in accordance with the new DCP.
- Type 2, shown in **Table 24**, pertain to new venues impacting existing residential buildings built prior to the new DCP.

For reference, the intrusiveness entertainment criteria currently used by the City are shown in **Table 30** . Comments on both sets of criteria are provided.

In our experience, internal-to-internal noise transmission has a greater disturbance on residences as for residents are unable to escape the noise. Often in mixed-use developments, the entire floor plate of the residential apartment is the noise-radiating element. To account for this additional disturbance, we have reduced the allowed pre-midnight level by 3 dB.

Table 23. **Type 1** octave-band criteria for venues impacting residential developments built according to the new DCP-

Assessment Period	Entertainment Sound Path	Assessment Location	Octave Band Assessment Criteria	Comments and applicability
Pre-midnight	External airborne	External	Greater of either: $L_{eq} \le L_{90}$ + 5 dB OR $L_{eq} \le$ DEENS + 7 dB*	Entertainment noise will still be audible
	Internal-to-internal#	Internal	Pre-Midnight TIENS	Entertainment noise will still be audible
Post-Midnight	External airborne	External	$L_{eq} \le$ DEENS	Electronic noise masking provides the required residential amenity.
	Internal to internal#	Internal	Post-Midnight TIENS	

* Entertainment noise will increase overall noise level in the room by 1 dB.
# Airborne or structure-borne transmission within the same building.

Table 24. **Type 2** octave-band criteria for venues impacting existing residential buildings built prior to new DCP.

Assessment Period	Entertainment Sound Path	Assessment Location	Octave Band Assessment Criteria	Comments and applicability
Pre-midnight	External airborne	External	$L_{eq} \le L_{90}$ + 5 dB	No change from current DCP condition
		Internal	$L_{eq} \le L_{90}$ + 0 dB	Internal measurements only required when external measurement at property boundary is not possible (e.g. inside high-rise hotel or residential buildings). The stricter of the internal or external becomes the assessment criteria.
	internal-to-internal	Internal	$L_{eq} \le L_{90}$ -3 dB	Provides additional amenity as noted above. Assumes the ambient noise in the residence is sufficiently high to provide this relationship. Assessing the ambient noise level in residences is likely to be difficult.
Post-Midnight	External airborne	External	$L_{eq} \le L_{90}$ + 0 dB	No change from current DCP condition
		Internal	Greater of either: $L_{eq} \le L_{90}$ -12 dB Or the Audibility Threshold Table.	The external and internal discrepancy is a mutual exclusive situation which has no simple resolution. To ensure residential amenity after midnight, the ambient noise level in the residence must be much higher than the

Assessment Period	Entertainment Sound Path	Assessment Location	Octave Band Assessment Criteria	Comments and applicability
Post-Midnight (cont.)				transmitted external L_{90} level. As per pre-midnight regarding measurement locations and adoption of more stringent assessment criteria. Accordingly, assessing the ambient noise level in residences is likely to be difficult.
	Internal airborne / structure-borne			Assumes the ambient noise in the residence is sufficiently high to provide this relationship. Assessing the ambient noise level in residences is likely to be difficult.

7.1.2 Applicability of Proposed Venue Controls

a) If residents in existing building are forced to close windows to reduce their internal entertainment noise, they will have no source of ventilation. Accordingly, we must assume that windows will be open for existing residential buildings.

b) If there are no existing venues in close proximity to these existing dwellings, this need for open windows creates substantial difficulties for potential new venues to achieve compliance. In turn, new venues might elect to move into existing late-night high-activity areas or areas where new residences have been constructed in accordance with the new DCP.

c) To circumvent this problem, we recommend that the proposed venue controls (**Table 23** and **Table 24**) are applied according to the usage matrix in **Table 25**.

Table 25. Usage matrix of the proposed venue controls

	Existing Residences	New Residences
Existing venues	DCP does not cover; compliance reverts to previous consent conditions and L&GNSW.	Proposed DCP covers these situations with the TIENS and DEENS criteria as described in **Table 14** and **Table 15**.
New Venues	New venues rarely get access to existing residences to measure the internal background level. Have to assume a level, and the assumptions can vary widely. Given that need for open windows to provide ventilation, with noise amenity, this is problematic. Only way to solve is to impose a stringent external criterion for post-midnight trade, or the internal criteria listed in Table 23.	

7.1.3 Examples of Type 1 Controls in Situ

Three background-noise noise scenarios are used to illustrate the applicability of the Type 1 venue criteria **Pre-Midnight** with the DEENS concept at the external residential façade.

A proposed new entertainment venue conducts an acoustic survey near new residential area that has been constructed according to the new DCP. Three scenarios with different existing background noise levels that were measured in a free field are shown in **Table 26**.

Table 26: Background noise scenarios.

Example	Existing Pre-Midnight Background Noise	dBA	dBC
Scenario 1	Quiet	40	50
Scenario 2	Moderate (similar to DEENS external criteria)	50	60
Scenario 3	Loud 'urban hum'	60	70

For simplicity, in the following scenarios, the dBA and dBC metrics are utilised for illustration purposes only. The actual assessments would be conducted in octave bands. The levels in **Table 27**, **Table 28**, and **Table 29** are the free-field levels at the building façade for the three background noise scenarios.

Table 27. Scenario 1

Description	dBA	dBC
Scenario 1: Quiet background noise pre-midnight	40	50
Pre Midnight $L_{eq} \leq L_{90}$ + 5 dB	45	55
Pre Midnight: DEENS (51 dBA and 68 dBC) + 7 dB	58	75
Proposed DCP: Greater of the above	58	75
Comment: DEENS + pre-midnight adjustment is generous for venues. Note that new residential internal spaces would still need to meet 35 dBA pre-midnight.		

Table 28. Scenario 2

Description	dBA	dBC
Scenario 2: Moderate background noise pre-midnight	50	60
Pre Midnight $L_{eq} \leq L_{90}$ + 5 dB	55	65
Pre Midnight: DEENS + 7 dB	58	75
Proposed DCP: Greater of the above	58	75
Comment: As above, DEENS + pre-midnight adjustment is still generous for venues.		

Table 29. Scenario 3

Description	dBA	dBC
Scenario 3: Loud background noise pre-midnight	60	70
Pre Midnight $L_{eq} \leq L_{90}$ + 5 dB	65	75
Pre Midnight: DEENS + 7 dB	58	75
Proposed DCP: Greater of the above	65	75
Comment: Background noise + 5 dB in high-activity urban environments would control the entire spectrum.		

7.1.4 Existing Controls

The table below summarises the current DCP entertainment noise conditions for ease of reference.

Table 30. Current CoS Entertainment Condition in octave bands with levels measured in fifteen-minute periods.

Assessment Period	Entertainment Sound Path	External Assessment	Internal Assessment	Comments and applicability
Pre-midnight	External airborne	$L_{eq} \leq L_{90}$ + 5 dB	$L_{eq} \leq L_{90}$ + 0 dB	5 dB discrepancy showing internal and external conditions are mutually exclusive. Therefore, the stricter control would be applied, however assumptions must be made regarding the internal background noise levels.
	Internal airborne / structure-borne		$L_{eq} \leq L_{90}$ + 0 dB	Applicable but defining the internal noise level may be difficult.
Post-Midnight	External airborne	$L_{eq} \leq L_{90}$ + 0 dB	Greater of: CoS: $L_1 \leq L_{90}$ - 10dB (equivalent to: $L_{eq} \leq L_{90}$ - 17dB) Or threshold of audibility	≥ 10 dB discrepancy showing internal and external conditions are mutually exclusive.
	Internal airborne / structure-borne	N/A		No discrepancy but defining the ambient noise may be difficult. Given that the L_{eq} levels are approximately 7 dB below the L_1 levels, this is a highly stringent criterion.

8. INFORMATION IN THE DCP TO ASSIST THE CITY WITH ASSESSING DEVELOPMENTS

This section is still to be fully developed, and we recommend that the City provides input. Depending on the extent of information the City considers would be helpful, another project may be required

8.1. General

a) The goal of this information is to provide guidance about information that should be included in acoustic reports to create a standardised assessment method and framework for the following two user groups.

i. Acoustic engineers who are engaged by proponents of venues and residential developments.

ii. City EHO staff who review acoustic DA reports for venues and residential developments so that the assessment process can be consistent between developments and easy to assimilate.

b) To maximise the ease of assessment, the information should be presented in tabular form, so that EHOs can rapidly assess the acoustic design in a proposed development.

We consider that City EHO staff should be able to enter a tick into a check box if the information pertaining to each component of the acoustic design is satisfactory or a cross if the information is unsatisfactory.

8.2. Acoustic Information for Venues to be Provided in Acoustic Reports

A. Source Information

a) Nominate predetermined likely genres to be presented in the venue. Examples of genres to be identified are:

- high-end EDM club
- live rock band venue
- jazz venue
- comedy
- pub with nightclub room
- pub with live band
- outdoor terrace/beer garden

b) Nominate the anticipated sound levels in the audience area in the octave bands 31 Hz to 4 kHz (not A weighted).

For indoor bars and outdoor terraces, the Lombard effect on vocal levels must be considered. Note that it no sufficient to simply refer to a raised voice. Note the AAAC[3] Guideline for Licensed Premises provides guidance on how to predict vocal levels in speech for groups of people.

c) Location of the sound sources:

- internal
- external
- distributed
- centralised

d) Where possible, thought should be given to the location(s) of the stage and loudspeakers in relation to vulnerable breakout surfaces.

e) As audience sound levels in a venue are not a direct indicator of the sound levels striking surfaces that are vulnerable for noise breakout, the levels incident on each of these surfaces should be stated.

f) All spectra should be stated in L_{Zeq} levels and not A or C weighted. However, total A and C weighted levels should be stated.

g) Identify if the directionality of loudspeakers is to be used to reduce the sound levels impinging on a vulnerable surface, such as air locks, roofs and windows. Note that it is not sufficient to state that directional speakers will be aimed in a particular direction to reduced noise emissions, and specific off-axis reductions should be quoted in octave frequency bands. The use of directional subwoofer systems can substantially reduce the sound power levels at low frequencies incident on various building elements.

[3] The Association of Australasian Acoustical Consultants (www.aaac.org,au)

h) Venues should be assumed to have either direct-field or semi-reverberant field incidence on the vulnerable surfaces, and not reverberant incidence.

i) Alternatively, an adjustment term k should be used which is added to the spatial-average sound pressure level in the audience area to provide simplistic estimate of sound power impinging on the leaky surface due to proximity of speakers to the wall or lack of directionality. We recommend a value of +6 dB for k.

For example, if the spatial average SPL in a new venue in the 63 Hz is 100 dB, then the consultant should assume that a level of 106 dB impinges on all vulnerable breakout surfaces.

If acoustic consultants wish to deviate from the above process, then they should provide technical details to support their proposal.

B. Noise Egress Elements in Venue

a) The sound transmission loss (STL) in octave frequency bands for the roof and walls should be identified.

b) The sound power radiated by each wall and roof should be determined from the STL and the area of the element.

c) Acoustically leaky elements and penetrations should be identified, such as:

- mechanical ducts, doors, voids, windows
- smoking terrace – rear door , fire escapes

d) Assess noise emissions with doors in closed state? But do you assess it in an open state. Is entry door permanently open? Is there a sound lock How long is the door open for over a 15 minute period.

e) As the mass-air-mass resonance in construction elements with air gaps are often a problem at low frequencies, the mass-air-mass resonant frequency should be identified for each single or dual cavity construction. Examples of this type of construction are double-glazed windows, ceiling and roof systems, double brick/block constructions, and brick/block walls faced with plasterboard mounted on furring channels.

f) Identify acoustic shielding provided by structures that may be applicable to each major noise egress element.

g) As contemporary music is now using frequencies as low as 25 Hz, and STL data does not extend to this frequency, prediction the STL at frequencies below 50 Hz can be difficult.

C. Information for Receivers of Venue Noise Emissions

a) Identify receivers.

b) Identify operational days and hours.

c) The entertainment noise environment reported in the DA acoustic report must be representative of the area, so consultants for music venues must identify all venues in a radius of 300 m and measure their noise and listen to the audio file captured with the logged environmental noise data to confirm that the measured data accords with their listening.

d) If the venue(s) are quiet because of seasonal reasons or inclement weather, the consultant should make an estimate of the background noise environment into which the venue will be emitting noise.

D. Example Information to be Provided for Venues

We recommend that consultants be asked to identify key details in a table for airborne and internal to internal sound transmission. **Table 31**, **Table 32**, and **Table 33** show examples of the recommended reporting. Note that this data should be provided in octave bands.

Table 31. Airborne sound elements. (NB, octave band information to be provided)

Element	Radiated Sound power	Distance loss	shielding	Nature of path to receiver	reflections
roof	85 dB	-40 dB (100 m)	0 dB	Free field	3 dB
glazing	65 dB	-37 dB (75 m)	-3 dB	Free field	0 dB
Wall 1	60 dB	-37 dB (75 m)			
Entry doors	55 dB	-37 dB (75 m)			

Table 32. internal to internal sound elements.

Element	Sound power radiated	Distance loss		Nature of path to receiver	Room gain in receiver
walls				Free field f	

Table 33. Identification of mass-air-mass resonances in venues that degrade STL.

Element	Construction	Frequency of mass-air-mass resonance	Effect of mass-air-mass resonance on TL
Ceiling and roof	Plasterboard x 4 layers + metal deck	25 Hz	Reduces TL at 31 Hz
Double glazing	4 mm 120 mm gap 4 mm	71 Hz	Reduces TL at 63 Hz

8.3. Acoustic Information for New Receivers to be Provided in Acoustic Reports

A. Source Information

a) Nominate entertainment genres being presented in nearby venues. Examples of genres to be identified are:

- high-end EDM club
- live rock band venue
- jazz venue
- comedy
- pub with nightclub room
- pub with live band
- outdoor terrace/beer garden

b) The operating hours of the venue(s) should be identified.

c) The ambient venue and background noise levels incident on various storeys on the affected building façade(s) should be identified. Note that measurements at street level are not necessarily representative of the noise levels at various heights.

B. Receiver Information

a) The siting and orientation of the receiver buildings should be considered in relation to opportunities to take advantage of acoustic shielding of noise-sensitive facades.

b) The STL of each façade element should be identified in octave bands and not as simple R_w ratings.

c) Calculations shall be done in octave frequency bands.

d) As the mass-air-mass resonance in construction elements with air gaps are often a problem at low frequencies, the mass-air-mass resonant frequency should be identified for each single or dual cavity construction. Examples of this type of construction are double-glazed windows, double brick/block constructions, and brick/block walls faced with plasterboard mounted on furring channels.

e) The attenuation through an open window into a room is not necessarily 10 dB at all frequencies and should be calculated or estimated on a case by case basis.

f) The noise ingress through natural ventilation openings should be determined on an octave band basis.

9. ACOUSTIC TECHNIQUES FOR VENUES AND TO REDUCE NOISE EMISSIONS

If the doors and windows are closed, then the majority of the sound leakage from venues will be at low frequencies. In particular, with venues in which the roof is above the music area, the leakage at low frequencies is likely to be through the roof and doors, rather than the walls. However, with residents immediately adjacent to venues, leakage heavy brick walls can be the limiting factor.

Techniques include

- sound locks that ensure at least one door is almost always closed.
- nominate the patron area and the locations of the loudspeakers and use directional subwoofers to direct as much sound as possible to the audience/patrons and while reducing the amount of sound striking vulnerable elements.

9.1. Venue Calibration

There will be some situations in which it will not be possible to measure the required Leq levels in the presence of ambient noise. In these situations, the following work-around may assist.

If substantial sound level is available from the venue's sound system, then during calibration, the engineer can increase the volume, measure the Leq levels at this increased level and compare them with the criteria. The levels can then be reduced by a known number of decibels so that they will meet the criterion.

10. APPENDIX A - GLOSSARY OF ACOUSTIC TERMS

10.1. Index to Terms

The glossary is arranged alphabetically to assist readers to find the required information by clicking on the link.

Assessment Background Level (ABL)

A-Weighted Sound Level dBA

Clarity Ratio

C-Weighted Sound Level dBC

Decibel (dB)

$D_{nT,w}$

Equivalent Continuous Sound Level (L_{eq})

Equivalent Acoustic Distance

Frequency Response

$L_{A1,}$(T)

$L_{A10,}$(T)

$L_{A90,}$(T)

Lmax,T - Maximum Sound Level

Rating Background Level (RBL)

Reverberation Time

Rw

Sound

Sound Absorption

Sound_Absorption_Coefficient

Sound Insulation

Sound Level Indices

Sound Power

Sound Pressure Level

Sound Reduction Index

STI

Vibration

Z- Weighted Sound Level dBZ

10.2. Glossary

SOUND

Sound is an instantaneous fluctuation in air pressure over the static ambient pressure and is transmitted as a wave through air or solid structures.

SOUND PRESSURE LEVEL

Commonly known as "sound level", the sound pressure level in air is the sound pressure relative to a standard reference pressure of 20µPa (20x10-6 Pascals) when converted to a decibel scale.

DECIBEL (dB)

A scale for comparing the ratios of two quantities, including sound pressure and sound power.

The ratio of sound pressures which we can hear is a ratio of 106:1 (one million to one). To measure this huge range in pressure, a logarithmic measurement scale is used with the associated unit being the decibel (dB).

An increase or decrease of approximately 10 dB corresponds to an approximate subjective doubling or halving of the loudness of a sound. A change of 2 to 3 dB is subjectively a small change and may sometimes be difficult to perceive.

As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply to dB values.

The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.

SOUND POWER

The sound power level (Lw) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (Lp) varies as a function of distance from a source or other factors such as shielding. However, the sound power level is an intrinsic characteristic of a source.

FREQUENCY

Frequency is the rate of repetition of a sound wave. The subjective equivalent of frequency in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to the number of cycles per second. A thousand hertz is often denoted kiloHertz (kHz), e.g., 2 kHz = 2000 Hz.

Human hearing ranges from approximately 20 Hz to 20 kHz.

OCTAVE BAND

The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the octave band below it. In subjective terms, it corresponds to a doubling of pitch.

For design purposes, the octave bands ranging from 31.5 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

A-WEIGHTED SOUND LEVEL dBA

The unit of sound level, weighted according to the A scale, which takes into account the increased sensitivity of the human ear at some frequencies. The unit is generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dBA.

A weighting is based on the frequency response of the human ear at moderate and low sound levels and has been found to correlate well with human subjective reactions to various sounds.

Sound level meters usually have an A-weighting filter network to allow direct measurement of A-weighted levels.

C-WEIGHTED SOUND LEVEL dBC

As the sound level increases, the ear is better able to hear low frequency sounds, The C-weighting filter allow low frequencies to contribute to the measurement much more than the A weighting filter.

Z-WEIGHTING dBZ

The Zero-weighting is equivalent of non-frequency shaping or weighting the measured sound level, and as no filter is applied to the sound before measurement, it is sometimes referred to as “linear” weighting.

SOUND LEVEL INDICES

Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so several different noise indices have been defined, according to how the averaging or statistics are carried out.

Examples of sound level indices are L_{eq},T Lmax, L_{90}, L_{10} and L_1, which are described below. The reference time period (T) is normally included, e.g., $dBL_{A10,\ 5min}$ or $dBLA_{90,8hr}$.

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{eq})

Another index for assessment for overall noise level is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. This allows fluctuating sound levels to be described as a single figure level, which assists description, design and analysis.

The L_{eq} is often A-weighted to remove the contribution of low frequencies, which may be less audible and is written as L_{Aeq}. It can also have no weighting as L_{Zeq} or C-weighting as L_{Ceq}.

L_{max},T - MAXIMUM SOUND LEVEL

A noise level index defined as the maximum noise level during the measurement period duration T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.

L_{90}(T)

A noise level index. The L_{A90} is the sound pressure level measured in dBA that is exceeded for 90% of the time over the measurement period T. In other words, the measured noise levels during the period were greater than this value for 90% of the measurement period.

L_{90} can be considered to be the "average minimum" noise level and in its A-weighted form is often used to describe the background noise a L_{A90}.

L_{A10}(T)

A noise level index. The L_{A10} is the sound pressure level measured in dBA that is exceeded for 10% of the time interval (T). In other words, the measured noise levels during the period were only greater than this value for 10% of the measurement period.

This is often referred to as the average maximum noise level.

L_{A1}(T)

Refers to the sound pressure level measured in dBA, exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement but is not the same as L_{Amax}.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night-time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e., the measured background noise is above the ABL 90% of the time.

Reverberation Time

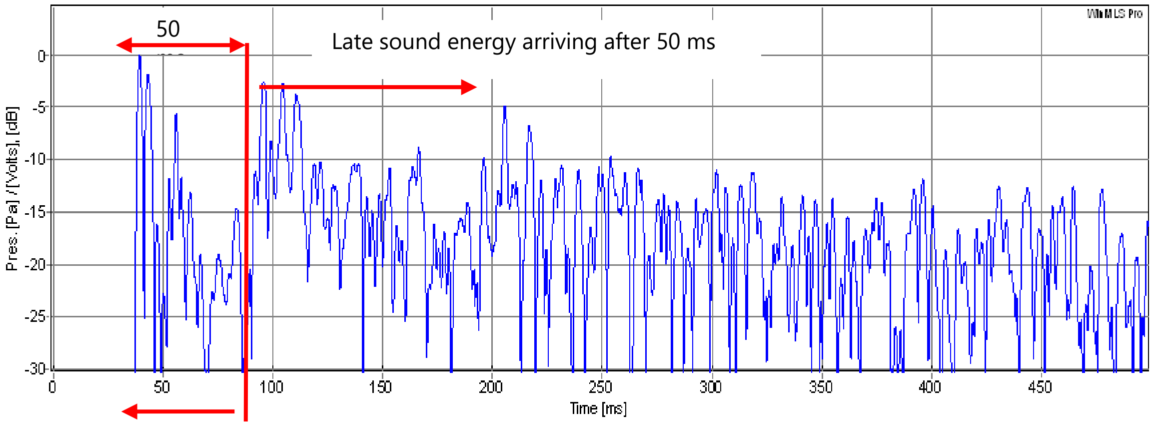
The time in seconds required for the sound at a given frequency to decay away (or reduce to) to one-thousandth of its initial steady-state value after the sound source has been stopped. This degree of reduction is equivalent to 60 decibels.

CLARITY RATIO

The clarity ratio is a metric that is used to assess the degradation in speech intelligibility due to the temporal effects of reverberation and echo. It is defined as the ratio of the sound energy of early-arriving sound that is useful for intelligibility to the energy of late-arriving sound which is not useful. Early-arriving sound consists of the direct sound and some reflections, while late arriving sound consists of reverberation and echoes.

Early-arriving sound consists of sound that arrives between the start of an extremely short pulse (an impulse) up to 50 ms after the start of the pulse, while late arriving sound is the total sound energy arriving later than 50 ms after the start of the pulse.

The following figure shows a typical impulse response and illustrates the dividing period of 50 ms between early and late arriving sound, which is used to compute the C_{50} clarity ratio.



Early sound energy arriving before 50 ms

Typical impulse response illustrating how the clarity ratio C_{50} is computed.

As the ear and therefore subjective intelligibility is sensitive to the amount of reverberation and echo at different frequencies, the C_{50} ratios must be as high as possible at all frequencies to maximise intelligibility.

STI - SPEECH TRANSMISSION INDEX

The Speech Transmission Index (STI) is one of the better available metrics to assess the capability of a transmission system to transmit intelligible speech. STI is a single number that ranges between 0 and 1. It attempts to assess the degradation in intelligibility caused by reverberation/echoes and background noise by measuring the reduction in modulation of the speech-like waveform. Phonemes in speech are produced by modulating vocal sounds in a specific pattern, and when perfect transmission of the modulation pattern is present at a listening location, the clarity is perfect. When modulations are corrupted by reverberation or noise, the time pattern of the phonemes is changed, and the clarity is degraded.

However, STI has three fundamental weaknesses:

iv) It is almost blind to the effects of tonal balance on intelligibility.

v) It is partially blind to the effects of echo on intelligibility.

vi) It reduces many complex factors (frequency/level/time) into to a single number, thereby concealing important and audible components that contribute to the degradation of speech intelligibility.

To accommodate these weaknesses in STI, Acoustic Directions uses two other metrics (clarity ratios and frequency response) in conjunction with STI to assess speech intelligibility produced by a sound system.

The STI value is computed from weighted MTI values, which represent the loss of modulation in each octave-wide frequency range. When assessing STI performance, it is instructive to assess the loss of modulation in each frequency range by inspecting the associated MTI values.

Given that the majority of speech sounds occur in the 250 Hz and 500 Hz frequency ranges, the MTI values in these frequency ranges are a direct indicator of the smearing or degradation in vowel sounds. In turn, this indicates the extent to which long vowel sounds will subjectively mask sounds with higher frequency content such as consonants.

FREQUENCY RESPONSE

Subjective tonal balance is measured as a system's frequency response at each location. As the ear is very sensitive to the direct sound field (the first-arriving part of the sound before reflections arrive), the response of the direct field with speech must be as consistent as possible over the listening area in the frequency range of 100 Hz to 12 kHz.

EQUIVALENT ACOUSTIC DISTANCE

By amplifying a talker’s speech, a sound system reduces the apparent acoustic distance between a talker and distant listener. The equivalent acoustic distance defines the resulting acoustic distance between the talker and listener and is a direct measure of the amount of voice amplification that the system can provide before the onset of acoustic feedback. Feedback is often heard as a strong colouration to the voice or howling sound.

We are accustomed to holding conversations in relatively close proximity, and to produce similar conditions in a courtroom and allow soft talkers to be heard, the EAD should be less than 2.2 m and typically 1.8 m without any trace of feedback or tonal ringing in the sound.

EAD is associated with speech intelligibility as it directly relates to the amount of speech amplification that the system can provide in order to deliver a satisfactory level of speech signal above the noise to each listener.

Factors affecting the EAD include:

- The number of microphones switched on at any time.
- The relationships between the directional response characteristics of the microphone and loudspeaker.
- The sound level reaching the audience at the critical mid and mid-high frequencies.
- Room acoustic behaviour.

VIBRATION

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structure-borne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value e.g., 1mms-1 or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, LV (dB) = 20 log (V/Vref),

(where the preferred reference level, Vref, for vibration velocity = 10-9 m/s).

The decibel approach has advantages for manipulation and comparison of data.

SOUND ABSORPTION

This is the removal of sound energy from a room or area by conversion into heat.

SOUND ABSORPTION CO-EFFICIENT

Sound absorption co-efficient indicate the extent to which a material absorbs sound power at a specific frequency and is expressed on a scale of 0 to 1, with a value of 1 representing the maximum possible absorption.

SOUND INSULATION

The sound insulation is the capacity of a structure such as a wall or floor to prevent sound from reaching a receiving location.

SOUND REDUCTION INDEX

This parameter is used to describe the sound insulation properties of a partition and is the decibel ratio of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. It is usually measured in specific frequency bands, such as octave or one-third octave.

$D_{nT,w}$

The single number quantity that characterises sound insulation between rooms over a range of frequencies with airborne sound.

R_w

Single number quantity that characterises the sound-insulating properties of a material or construction element over a range of frequencies with airborne sound.