Influence of music genre and composition on entertainment noise limits

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ABSTRACT

Liquor licensing authorities across Australia typically require an entertainment noise test to be conducted before a venue can host amplified entertainment. The purpose of this test is to simulate live entertainment in order to determine the maximum permissible noise source limits allowed for the venue. In this paper, several disadvantages of the current method used for entertainment noise testing are identified and discussed. It was found that the choice of music can affect the resulting source noise level limits. An alternative approach has been suggested which involves playing band-limited pink noise across the 63 to 2kHz octave bands. A correction is then applied to determine the source noise level limits associated with different genres of music. The advantages of this method are that it reduces the time required to conduct the test, the nuisance caused to neighbouring premises is reduced and the variance in source noise level limits caused by different choice of test music is eliminated.

INTRODUCTION

Throughout Australia, licensed venues such as hotels and clubs regularly provide entertainment ranging from stand-up comedy to rock bands. The noise emissions from such venues are closely regulated by liquor licensing authorities in each state. It is a common practice for authorities to specify a noise source limit which can be monitored inside the venue and if adhered to, achieves an acceptable level of noise emissions outside the venue at any noise-sensitive receptor such as a residence.

Noise source limits are specific to an individual entertainment venue and depend on factors such as the noise reduction performance of the building envelope and the ambient noise environment outside the venue. Most authorities require the noise source limits to be determined experimentally. This is done by creating simulated entertainment using recorded music and a high-powered PA system. The source noise level inside the venue is deliberately set to a high volume, which facilitates measurements with good signal-to-noise ratio at receptor premises – the so-called Intrusive Noise Test. The noise limit is then determined by calculation.

The amount by which the intrusive noise emission exceeds the acceptable noise limit at the receptor premises is deducted from the test level inside the venue to establish the source noise limit. The manager of the venue is then charged to ensure compliance through the regular measurement of the source noise level using an inexpensive sound level meter.

For the Intrusive Noise Test, acoustic consultants are required to use source music which is considered to be representative of the actual (or proposed) music to be played at the premises. The consultant usually selects an arbitrary piece of music which is considered to represent the worst-case scenario of the type of music to be played.

Because of the temporal variability of music, to obtain a statistically relevant result it is necessary to repeat the same music track several times. This would typically result in a test duration of 10 to 15 minutes at a single receptor location, increasing to over an hour for multiple receptor locations. This exposes the nearby noise-sensitive premises to repetitions of the same song for long periods of time.

To minimise the costs incurred on the client, background noise measurements are often taken at the noise sensitive receivers at 10pm before the intruding noise component of the test is conducted. Background measurements are also taken after the conclusion of the test at a time appropriate for the venue in order to define the noise criteria after 10pm. For a nightclub or venue open until early morning, this time is usually between 2 and 3am.

The current method of conducting an entertainment noise test has several disadvantages. These are:

1. It is possible to derive different entertainment noise limits for the same premises due to the arbitrary song selection.
2. The tests cause annoyance for the surrounding premises due to the necessity of exceeding the unreasonable noise limits.
3. A test can become quite protracted if multiple noise-sensitive receivers exist. This is due to the necessity of measuring the noise intrusion at each receiver for the duration of the song.

This paper examines the influence of music genre on entertainment noise limits. An alternative method to conducting an entertainment noise test is proposed which results in consistent noise level limits and a shorter test time with less inconvenience to all of the stakeholders.

NOISE EMISSION CRITERIA

In Queensland, the Liquor Licensing Division sets specific limits for the noise of entertainment emanating from licensed premises (LLD 2005). These limits apply at commercial premises and noise-sensitive receptors, which includes private residences, caravan parks, marinas, schools and hospitals.

Between the hours of 6am and 10pm, the required method of measurement is the overall, A-weighted noise level (dB(A)). The intrusive noise at the receptor is measured as the ten-percentile statistical level (L_{A10}) and adjusted for tonal and

impulsive components ($L_{A10\ adj}$). The background level is measured as the ninety-percentile level in the absence of entertainment (L_{A90}). The noise limit for this time period is such that the adjusted intrusive level must not exceed the background by more than 10dB(A):

$$L_{A10\ adj} \leq L_{A90} + 10dB(A) \quad (1)$$

Between 10pm and 6am, the measurement must be conducted in octave bands (L_{oct}). The intrusive noise is again measured as the ten-percentile level; this time in octave bands without any penalty adjustment ($L_{oct\ 10}$). The background level in the absence of entertainment is measured as the ninety-percentile level ($L_{oct\ 90}$). The limit is such that the intrusive noise must not exceed the background by more than 8dB in any octave band from 63Hz to 2kHz inclusive.

$$L_{oct\ 10} \leq L_{oct\ 90} + 8dB \quad (2)$$

MUSIC GENRES

In order to determine the influence of music genre and composition on entertainment noise limits, it is necessary to be able to categorise a piece of music into an easily recognisable genre. Music is known as a dynamic art, and as such, new musical genres are being created all of the time. There are thousands of music genres in existence. For example, Amazon.com has over 700 different music genres, while AllMusicGuide has over 500 genres (Pachet and Cazaly 2000). Of these two sites, approximately 200 genres are common to both.

Pachet and Cazaly state that a piece of music can be assigned a genre a number of ways, including:

- *Genealogical* – based upon musical evolution.
- *Geographical* – based upon geographical location.
- *Aggregation* – the combination of two existing genres. For example, "Rhythm" and "Blues".
- *Repetition* – this means that a given term (e.g. "Reggae") is polysemic, and denotes both a meta-genre and an actual genre.
- *Historical period* – based upon the time period the music was composed. For example, the term "Classical" can be used to denote the musical period from 1770 to 1830.
- *Specific dimensions of the sub-genre* – for instance, music can be divided according to the main instruments: "Brass", "Organ", etc.

With so many different ways of classifying music and the large number of genres, it could be argued that it is impossible to maintain consistency when classifying music into its appropriate genre.

However, in this instance, the task is simplified as entertainment noise tests are usually concerned with amplified western music. As such, a list of 14 of the main genres of music, termed "meta-genres", has been determined as presented in Table 2. These "meta genres" were based upon numerious classifications given to music by Internet based search engines. Examples of the sub-genres associated with each meta-genre are presented in this table. Genres such as "Acoustic", "Novelty", "Comedy/Spoken Word", "Seasonal", "Experimental", "Show Tunes", "Contemporary Christian", "New Age", "World", "Children's" and "Classical" have been omitted, as this study focuses on the common types of music played in entertainment venues.

INFLUENCE OF MUSIC GENRE ON ENTERTAINMENT NOISE LIMITS

To demonstrate the influence of music type on entertainment noise limits, an experiment was conducted at The University of Queensland. A classroom in the Mechanical Engineering building was used to represent an entertainment venue. A compact disc player was connected to an amplifier, which in turn was connected to two loudspeakers.

Entertainment noise tests were simulated using several different songs representing different music genres. The room set-up, sound system set-up and measurement locations were identical for each test. The source noise levels were measured at a distance of 3m from the speakers, along the centreline between the speakers. In each instance, the overall source noise level was set to be 102dB. The background and intruding noise levels were measured at a location 23m from the façade of the building. The intruding noise was clearly audible at this location.

Table 1: Meta-genres and example sub-genres of the music analysed during this investigation

Meta Genres	Example Sub-Genres
Modern Rock	Alternative Rock, Experimental Rock, Indie Rock, Jam Rock, New Wave, Post Punk, Power Pop
Rock	Classic Rock (British Invasion, Glam Rock, Folk Rock), Hard Rock, Prog Rock, Southern Rock
Metal	Funk Metal, Industrial Metal, Thrash
Punk	'77 Style Punk, Hardcore Punk, Pop Punk, Ska Punk, Riot Grrrl, Psychobilly
Folk	60s Revival, Anti-Folk, Contemporary Folk, Singer-Songwriter, Traditional Folk
Electronica	Acid Jazz, Ambient, Downbeat, Intelligent Dance Music, Techno, Industrial, Drum 'n' Bass
Jazz	Be Bop, Big Band, Crossover Jazz, Lounge, Vocal Jazz, Cool Jazz, Soul Jazz
Blues	Chicago Blues, Electric Blues, Country Blues, Female Vocal Blues
Country	Alt Country, Bluegrass, Contemporary Country, Country Rock, Traditional Country
Oldies	Doo Wop, Early Rock & Roll, Rockabilly, Surf
Pop	Dance Pop, Easy Listening, Euro Pop, Soft Rock, Teen Pop, Vocalists
Hip Hop	Abstract Hip Hop, Bass, Gangsta Rap, Pop Rap
R&B	Funk, Disco, Gospel, Soul
Reggae	Roots Reggae, Ska

The noise levels were measured using a Rion NA27 sound level meter. The noise levels were measured in 1/1 octave bands using a linear weighting. The artists, titles and genres of the songs used in the tests are presented in Table 2.

Table 2: Artists, titles and genre of the songs used in the simulated entertainment noise tests

Artist	Song Title	Music Genre
Rose Tattoo	Bad Boy for Love	Rock
Van Morrison	Moondance	Jazz
Oasis	Hello	Modern Rock
Kylie Minogue	I Should be so Lucky	Pop
Coolio	Gangsters Paradise	Hip Hop

The source noise level limits were calculated for each piece of music, based upon the noise emission criteria presented in

equations 1 and 2. Where required, the A-weighted sound levels were calculated by converting the measured linear-weighted sound levels. These limits are presented in Table 3. It can be seen in this table that there is a range of 8dB and 10dB respectively in the source noise limits before and after 10pm.

Table 3: Source noise level limits

Artist	Source Limit Before 10pm (dB)	Source Limit After 10pm (dB)
Rose Tattoo	95	90
Van Morrison	94	88
Oasis	97	95
Kylie Minogue	102	98
Coolio	96	89

The reults presented in Table 3 show that pop, represented by the song *I Should be so Lucky*, resulted in the highest source noise level limits both before and after 10pm. The Van Morrison song *Moondance*, representing Jazz, resulted in the lowest source noise level limits. The source noise limits of Rose Tattoo, Van Morrison, Oasis and Coolio are all significantly lower than that of Kylie Minogue.

These results demonstrate that through song selection, it is possible to manipulate an entertainment noise test to produce higher source noise limits than might otherwise be obtained.

SPECTRAL AMPLITUDE DISTRIBUTION OF MUSIC GENRES

In order to show why differences in the source noise limits were found between the various genres of music, the spectral amplitude distributions of music across all of the meta-genres presented in Table 1 were measured.

Measurement of the spectral amplitude distribution of music is not new. Sivian, Dunn and White (1931) conducted a study of musical spectra using live musicians. They were able to obtain a series of graphs that showed for each instrument or ensemble the spectral amplitude distribution of the performed musical passage.

More recently, Bauer (1970) and Greiner and Eggers (1989) examined the spectral amplitude distribution of records and compact discs respectively. The purposes of these investigations were to give some insight into recording practices and to aid in the search for better ways to reproduce music.

DATA GATHERING AND PROCESSING

The set-up of the system used to measure the spectral distribution of the music is shown in Figure 1. The lineout signal from a compact disc player was fed through a summing amplifier to combine the stereo channels into a mono channel. The output from the amplifier was AC-coupled before it was connected via a B&K 2614 dummy microphone to a Larson-Davis 824 sound level meter (SLM). The SLM was used to record the L_{10} noise levels across the 1/3 octave bands using a linear weighting.

The results of the measurements were recorded in an Excel spreadsheet that was then used to conduct further processing. The 1/3 octave bands were converted into their equivalent 1/1 octave bands. The data were then normalised so that the overall sound pressure level for each measurement was 120dB. This value was chosen as it represents the typical source noise level in a contemporary nightclub.

The source music discs were obtained from a variety of sources. To obtain a statistically relevant sample a minimum of 200 songs were measured for each meta-genre. Compact discs were chosen that represented a single genre only. Each compact disc was played and measured for its duration. This was done as it was considered to represent the continuity of the songs that would be encountered in a venue hosting live entertainment. The average of all of the compact discs measured for each meta-genre was calculated using weighting corrections to account for the varying lengths of the discs.

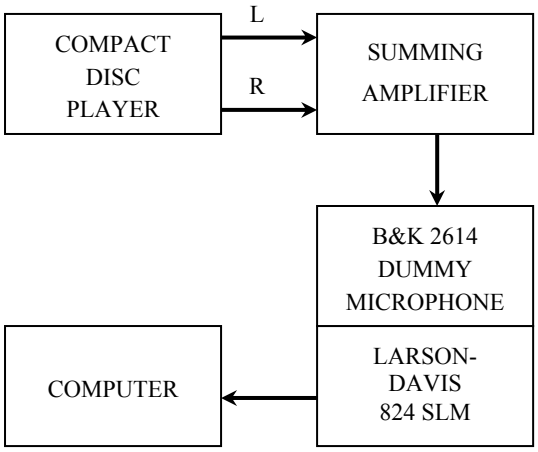

Figure 1: Diagram of system used for obtaining the spectral amplitude distributions of the music

Examples of the artists measured for each meta-genre are presented in Table 4. Even though it is conceivable that an artist may belong to multiple meta-genres, each artist was assigned to a single genre that was considered to best represent the artist as a whole.

Table 4: Examples of the artists measured for each music meta-genre

Meta Genres	Examples of Artists Measured
Modern Rock	Oasis, Red Hot Chilli Peppers, Grinspoon
Rock	Dire Straits, Electric Light Orchestra, Spinal Tap, Bon Jovi
Metal	Linkin Park, Yngwie Malmsteen, Dream Theater
Punk	Greenday, Sex Pistols, Nirvana
Folk	Joni Mitchell, Bob Dylan, Donovan
Electronica	The Crystal Method, The Herbaliser, The Avalanches, Hexstatic, Chemical Brothers, Groove Armada, Fatboy Slim
Jazz	Norah Jones, Ella Fitzgerald, Tony Bennett, Miles Davis, Charlie Parker
Blues	Stevie Ray Vaughan, Vaughan Brothers, Gary Moore, Jeff Beck, John Mayall, Eric Clapton
Country	Lee Kernaghan, Josh Arnold, Slim Dusty, Dolly Parton, Willie Nelson
Oldies	Chuck Berry, Beach Boys, Herman's Hermits, Buddy Holly
Pop	Village People, ABBA, Roxette, Madonna, Robbie Williams, Natalie Imbruglia
Hip Hop	Hilltop Hoods, Koolism, Beastie Boys, Cypress Hill
R&B	Barry White, KC & the Sunshine Band, Hot Chocolate
Reggae	Salmonella Dub, Peter Tosh, Bob Marley

MEASUREMENT RESULTS

Figures 2 to 15 show the spectral amplitude distributions for the different meta-genres of music. Comparing between the figures, the variations in sound levels associated with each meta-genre can be seen.

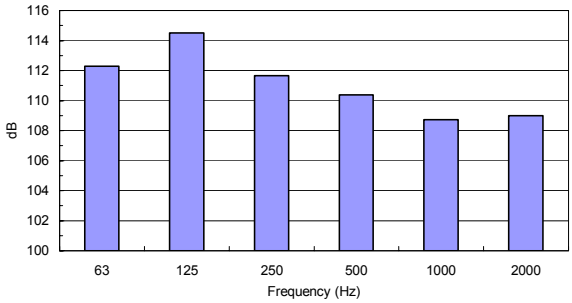

Figure 2: Spectral amplitude distribution for Modern Rock

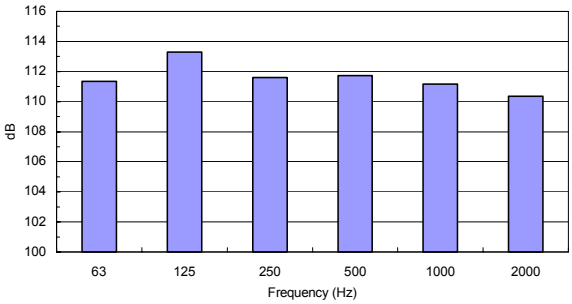

Figure 3: Spectral amplitude distribution for Rock

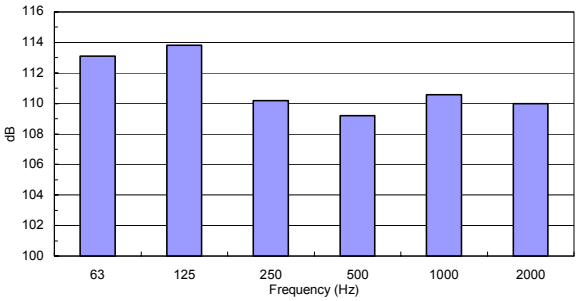

Figure 4: Spectral amplitude distribution for Metal

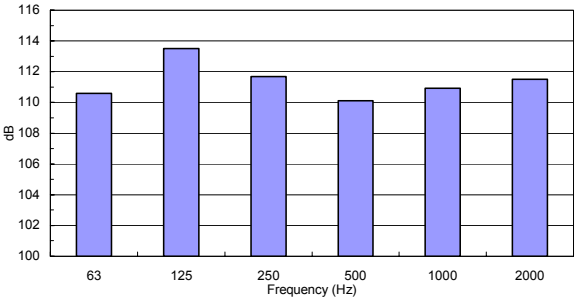

Figure 5: Spectral amplitude distribution for Punk

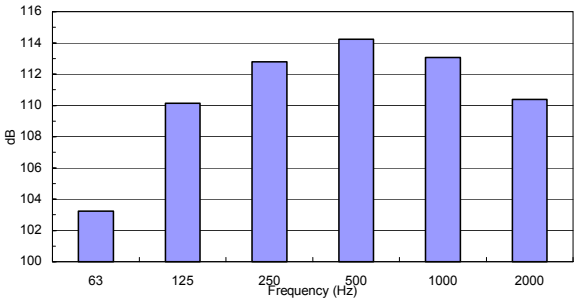

Figure 6: Spectral amplitude distribution for Folk

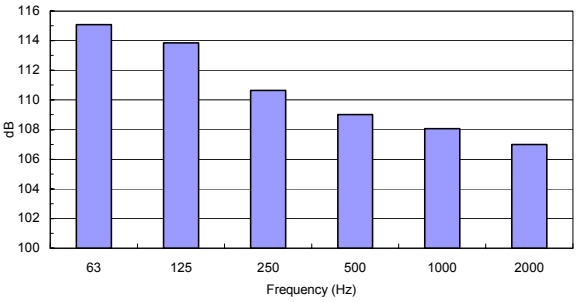

Figure 7: Spectral amplitude distribution for Electronica

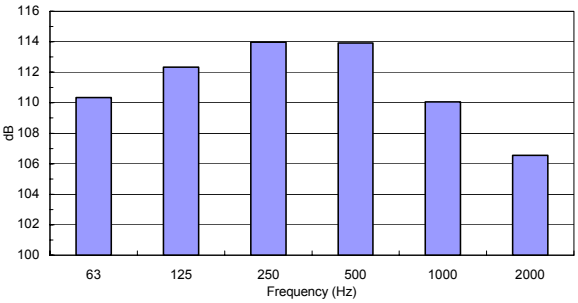

Figure 8: Spectral amplitude distribution for Jazz

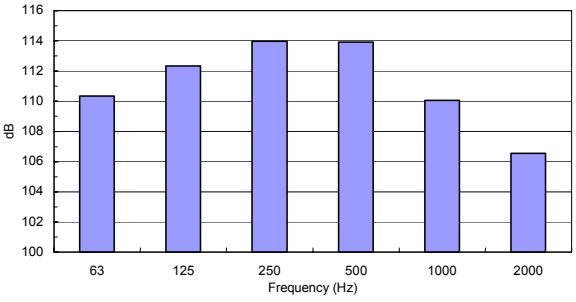

Figure 9: Spectral amplitude distribution for Blues

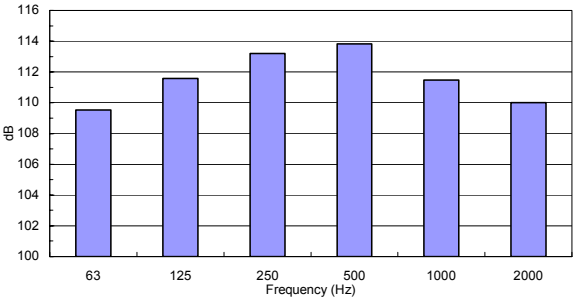

Figure 10: Spectral amplitude distribution for Country

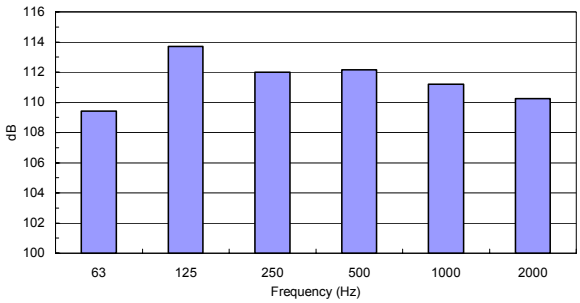

Figure 11: Spectral amplitude distribution for Oldies

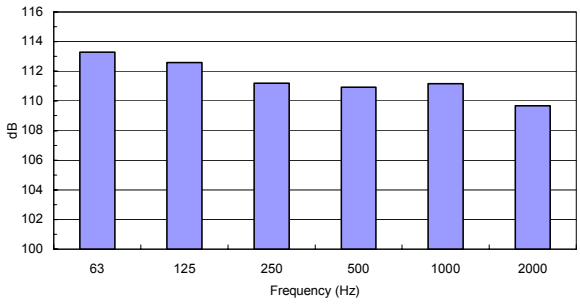

Figure 12: Spectral amplitude distribution for Pop

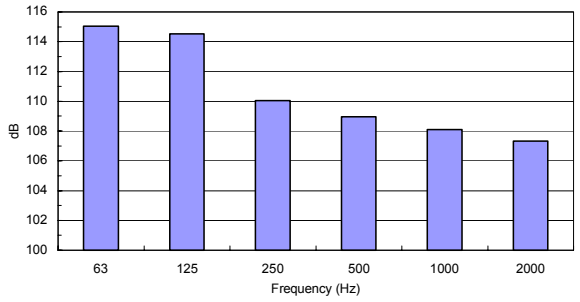

Figure 13: Spectral amplitude distribution for Hip Hop

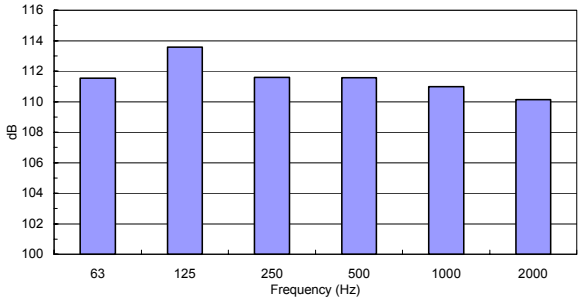

Figure 14: Spectral amplitude distribution for R&B

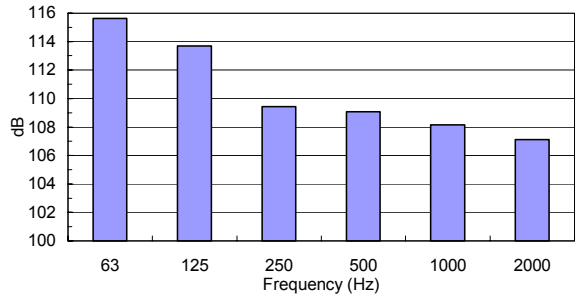

Figure 15: Spectral amplitude distribution for Reggae

DISCUSSION OF RESULTS

It can be seen in Figures 2 to 15 that the spectral amplitude distributions of the music fall into three broad categories:

Category 1 where the magnitude of the spectral amplitude distribution is the highest in the 63Hz or 125Hz octave bands and decreases as the frequency is increased. The shape of spectral amplitude distribution is reminiscent of a ski ramp.

Category 2 where the shape of the spectral amplitude distribution is relatively flat across all of the octave bands.

Category 3 where the spectral amplitude distribution is the highest in the 250 or 500Hz octave bands. As the frequency increases or decreases, the magnitude of the amplitude distribution decreases. The shape of the spectral amplitude distribution is reminiscent of a hill.

The category each meta-genre belongs to is presented in Table 5. Category 1 is representative of the type of music usually played in nightclubs. This music is commonly termed "doof-doof" music and represents the hardest type of music to contain within a building envelope. Category 2 music is slightly easier to contain than Category 1 music, while Category 3 music is the easiest to contain.

Table 5: Categories describing the overall shape of the spectral amplitude distributions

Category	Meta-Genres
1	Electronica, Hip Hop, Reggae
2	Modern Rock, Rock, Metal, Punk, Oldies, Pop, R&B
3	Folk, Jazz, Blues, Country,

The ability of a venue to contain music is usually determined by the noise levels in the 63Hz or 125Hz octave bands. This is due to the lower transmission loss of building façade and roof materials usually found in these octave bands. The different shapes of the spectral amplitude distributions indicate that a venue tested using Category 2 music would result in higher source noise levels than if Category 1 music was used. Similarly, a venue tested using Category 3 music would be expected to have higher noise source level limits that those tested using Category 1 or 2 music.

While it is possible to only test venues using Category 1 music, this may unfairly penalise venues where only Category 2 or 3 music will be played. An alternative method for conducting entertainment noise tests is presented below which does not unfairly penalise a venue due to the type of music it plays.

AN ALTERNATIVE METHOD FOR CONDUCTING ENTERTAINMENT NOISE TESTS

An improved method for conducting an entertainment noise test would be to use band-limited pink noise at the 63, 125, 250 500, 1K and 2K octaves for the source. The intruding noise levels would then be measured to find the attenuation provided by the building envelope. The corrections presented in Table 6 would then be applied to give the intruding noise levels expected for the type(s) of music to be played at the venue. The criteria for entertainment noise could then be applied as usual to give the source noise level limits for each type of music.

Table 6: Corrections to be applied at each octave band for each music meta-genre

Meta Genres	dB Correction @ Frequency (Hz)					
	63	125	250	500	1k	2k
Modern rock	0	2	-1	-2	-3	-3
Rock	-1	1	-1	0	-1	-2
Metal	1	2	-2	-3	-2	-2
Punk	-2	1	-1	-2	-1	-1
Folk	-9	-2	1	2	1	-2
Electronica	3	2	-2	-3	-4	-5
Jazz	-2	0	2	2	-2	-6
Blues	-1	0	0	0	-1	-1
Country	-3	-1	1	2	-1	-2
Oldies	-3	1	0	0	-1	-2
Pop	1	0	-1	-1	-1	-3
Hip hop	3	2	-2	-3	-4	-5
R&B	-1	1	-1	-1	-1	-2
Reggae	3	1	-3	-3	-4	-5

The advantages of this new method are:

1. All noise consultants would use a consistent approach for entertainment noise tests. This would result in consistent results for a particular venue.
2. The time required for the tests would be reduced, as the duration the intruding noise would need to be measured is less.
3. The annoyance experienced by neighbouring premises due to the entertainment noise test would be reduced as the source volume needed to achieve audibility for each octave band at the receiver would be reduced. This is due to the use of band-limited pink noise.

A disadvantage of this method is the added complexity due to the number of different music genres. Dividing the genres into the Categories presented in Table 5 reduces this complexity. The corrections associated with each category are presented in Table 7.

Table 7: Corrections to be applied at each octave band for each category

Category	dB Correction @ Frequency (Hz)					
	63	125	250	500	1k	2k
1	3	2	-2	-3	-4	-5
2	-1	1	-1	-1	-1	-2
3	-4	-1	1	2	-1	-3

ACCURACY OF THE METHOD

The accuracy of the method can be estimated by calculating the 95% confidence intervals of the spectral amplitude distributions. Assuming normal population means, the average 95% confidence interval for each octave band is approximately ±0.6dB. This results in a 95% confidence interval of approximately ±1.5dB for the overall source noise level. This error is acceptable when it is considered that the inexpensive sound level meters used by venue managers to check the compliance limits have a typical error of ±3.5dB.

AN EXAMPLE APPLICATION OF THE ALTERNATIVE METHOD

Applying the improved method to the simulated tests conducted at The University of Queensland, the veracity of the approach method can be shown. Assuming that the source and background noise levels are the same and the building envelope provides the same attenuation as determined from the tests, the intruding noise levels can be calculated. In this instance, Rose Tattoo, Oasis and Kylie Minogue belong to Category 2, while Van Morrison and Coolio belong to Categories 3 and 1 respectively.

The intruding noise levels calculated using the proposed method are compared to the experimentally measured values in Table 8. It can be seen that the largest error is 3dB for Kylie Minogue, followed by 2dB for Oasis.

Table 8: Comparison between the measured and calculated intruding noise levels

Artist	Calculated (dB)	Measured (dB)	Difference (dB)
Rose Tattoo	73	74	-1
Van Morrison	80	79	1
Oasis	75	73	2
Kylie Minogue	74	71	3
Coolio	75	75	0

The calculated and experimental source noise level limits are presented in Table 9. The agreement between the experiment and calculations is good, demonstrating the efficacy of the method.

Table 9: Comparison between the calculated and experimental noise source level limits

Artist	Source Noise Level Limits			
	Calculated		Experiment	
	Before 10pm (dB)	After 10pm (dB)	Before 10pm (dB)	After 10pm (dB)
Rose Tattoo	96	90	95	90
Van Morrison	93	87	94	88
Oasis	95	94	97	95
Kylie Minogue	99	95	102	98
Coolio	96	86	96	89

CONCLUSIONS

This paper has examined the influence of music genre and composition on entertainment noise limits. The results of simulated entertainment noise tests showed that it is possible to achieve a large variation in the source noise level limits for a venue through the choice of different genres of music.

The influence of music genre and composition on entertainment noise limits was further examined by measuring the spectral amplitude distributions of various types of music.

An alternative approach to entertainment noise testing was presented. When compared to experimentally obtained data, agreement was achieved which demonstrated the efficacy of the method. With this new method, several disadvantages associated with the current testing method are also eliminated; the duration of the testing; the nuisance caused to neighbouring premises due to the testing and the variance in source noise level limits caused by different choice of test music.

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