NOISE FROM PUBS AND CLUBS – RESEARCH TO DEVELOP A NEW NIGHT NOISE OFFENCE

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1 INTRODUCTION

Changes to the licensing laws in 2005 mean that licensed premises can be open later and for longer. The Environmental Audit Committee made a recommendation to extend the provisions of the Noise Act 1996 from dwellings to other premises and the bringing of licensed premises within the scope of the Noise Act is intended to complement existing powers.

The noise Act 1996 uses a noise measurement protocol to assess whether a permitted level is being exceeded. It is an offence to cause a night noise above the permitted level in a specified period once a warning has been issued. The current noise protocol was developed for domestic night noise. Noise from licensed premises may be of a different nature, so a different noise protocol might be more appropriate.

This Defra funded research project, undertaken jointly by Capita Symonds and BRE[1], was designed to investigate different methods of noise assessment and to provide a recommendation for the assessment methodology to be used for licensed premises under the extended noise act.

Phase 1 of this project was completed in 2005 by Hepworth Acoustics and the University of Salford[2]. This entailed a detailed literature review of research into noise from pubs and clubs and current custom and practice in assessing such noise across England and Wales. An outcome from phase 1 of the project was a table of candidate methodologies and criteria for assessment of noise from pubs and clubs for further testing and comparative assessment (reproduced below).

Table 1. Candidate assessment methodologies identified in phase 1

Name	Parameter	Type
IOA working group annex	L_{Aeq} vs. L_{A90} plus L_{10} vs. L_{90} in 40-160 Hz 1/3 octave bands	Relative
BS 4142/Noise Act 1996	L_{Aeq} vs. background (L_{A90}, L_{A99}, etc.)	Relative
Noise Rating curve	1/3 octave (L_{eq}, L_{10} or L_{max}) vs. NR curve	Absolute
Absolute L_{Aeq}	L_{Aeq}	Absolute
DIN 45680/Moorhouse	10-160 Hz 1/3 octave L_{eq} vs. reference curve	Absolute
Inaudibility	Subjective	Relative

2 LABORATORY TESTS

The main emphasis of the comparison undertaken by this project was a series of laboratory-based tests, undertaken at BRE in January 2006. This was further supplemented by field trials at a number of pubs and clubs across the country.

2.1 Test facility

The decision was made to use houses rather than listening rooms. This was partly because it enabled testing of noise sources from within the building and from outside the building and also because it created a more realistic environment for subjects. Two identical houses were used, each of which has three upstairs bedrooms. One test subject was in each bedroom.

Each test bedroom contained a table and a chair, at which the subjects were instructed to sit, and a bed. In addition, a noise analyser (Norsonic 121) was used to monitor noise levels in each room for the duration of each test. The noise analysers continuously recorded a large range of noise indicators, including L_{Aeq}, L_{Ceq} and 1/3-octave L_{eq} spectra each 125 ms. These short time interval measurements then allowed various noise indicators, including statistical indicators, to be calculated for each noise condition.

The microphone for each noise analyser was positioned in the central area of the room away from the window and at least 1 m from all reflecting surfaces. Noise measurements were taken in each room, both with and without the entertainment noise.

The sound system used was chosen to be representative of a typical high performance system that would be installed in a club. The system comprised of full range JBL cabinets supplied by Harman Pro UK, who have extensive experience at supplying these types of systems in numerous clubs.

Four different noise types were used for the laboratory testing, namely:

- Noise Type A, Guitar Orientated Rock
- Noise Type B, Modern Dance Music
- Noise Type C, Non-music entertainment noise
- Noise Type D, Karaoke

Each noise type was presented to the test subjects at five different levels. These were subjectively described as:

1. inaudible to an average listener,
2. just audible to an average listener,
3. a noise level which is plainly audible i.e. the content of the noise is communicated to the test subject so they can recognise its type (music or speech etc) but the content is not intelligible;
4. a noise level which is clearly audible i.e. the noise is communicated so that the content is intelligible to an average person and subjects can make out words and recognise songs/tracks etc;
5. a noise level that an average listener might describe as loud.

2.2 Test subjects

Five of the tests (total of 30 subjects) had the source of the noise in the ground floor of the test houses, to simulate structure-borne transmission from a noise source within the same building. In another five tests (30 more subjects), the noise sources were outside the test houses, to simulate airborne transmission from a noise source outside of the building.

Subjects were selected according to a number of criteria, in order to cover a broad mixture of the population. The pre-selection questionnaire was designed to obtain information on the age and sex of volunteers, any level of hearing impairment, and a confirmation of their ability to hear and understand instructions, and to read and complete questionnaires. For each test, then, a balanced group of subjects were selected.

Subjects received a standard information sheet about the tests (this did not include a technical description of the testing being carried out) before the test, and a more detailed briefing once they arrived at the BRE site.

2.3 Questionnaires

Two questionnaires were used during the testing. The first was a single-page questionnaire that was used at the end of each noise segment, i.e. 20 times during the testing (4 types of entertainment and at 5 noise levels). It included a series of questions on various aspects of environmental comfort, including noise. These were necessary so that any confounding effects of other comfort factors could be controlled for in the analysis. The remaining questions referred to the entertainment noise – have they heard any in the last few minutes, whether what they heard would affect their activities at home, and an overall acceptability rating for the noise. This last question was the primary target variable for the analysis.

The second questionnaire was presented after the noise segments were finished, and asked for some background information about the subjects, including their general attitudes to noise and entertainment noise, and some information about their normal exposure to entertainment noise.

2.4 Experimental protocol

One test per day was carried out on the dates 16-20 January and 23-27 January. The tests in the first week used internal noise sources i.e. the sound systems in the ground floor of each test house with transmission of entertainment noise through the floor/ceiling to the test bedrooms above. The tests in the second week used external noise sources i.e. the sound systems were placed externally and transmission of entertainment noise was through the façade with closed thermally insulated glazing.

Testing took place in the late evening. This was to make the tests as psychologically and physiologically realistic as possible. Previous work has shown differences in responses between daytime and evening testing, and as the main research questions in this project relate to the impact of entertainment noise at home during the evening and night, moving the testing into the evening seemed an obvious and necessary decision.

All subjects experienced all noise types at all levels, which equated to a total of 20 segments (4 noise types x 5 noise levels). Each subject only experienced one transmission scenario (either internal source or external), as incorporating both scenarios would make testing very onerous for subjects and likely to prejudice the quality of the responses. The order of presentation for the noise types and levels was balanced as far as possible. During each test, the segments for each noise type were grouped together, so subjects would hear all five levels of each noise type before moving to a different one. The order of levels within each noise type were randomised and balanced throughout the five internal-source tests, and the five external-source tests.

2.5 Results

During each laboratory test noise levels were recorded continuously in each test room. This enabled checking for any anomalies in noise levels.

Two further test runs were carried out (one for airborne and one for structure-borne transmission) with no subjects in the test rooms. Data from these tests were used to calculate a number of different noise indicators. Each noise indicator was calculated separately for each room and each noise condition (combination of airborne/structure-borne transmission, noise type and level). This gave a total of 40 noise conditions for each of the six rooms.

The initial list of 6 noise assessment methods was expanded into a total of 19 indicators, as described below:

- Institute of Acoustics Draft Good Practice Guide on the Control of Noise from Pubs and Clubs – Annex 1: Criteria and Measurement Guides[3]
    - A-Weighted – difference between L_{Aeq} of entertainment noise and L_{A90} without entertainment noise
    - 1/3rd Octave – difference between L_{A10} of entertainment noise and L_{A90} without entertainment noise in 1/3rd-octave bands between 40 Hz and 160 Hz. The maximum value in any of these bands was then used for the analysis
    - Maximum value of each of the above
- Noise Act / BS4142
    - Noise Act methodology: $L_{Aeq} – L_{A99.8}$ with entertainment noise present for both. It should be noted that this was based on a total 5 minute measurement from which both the L_{Aeq} and $L_{A99.8}$ measurements were extracted, rather than the 15 minute period allowed in the current measurement protocol.
    - BS4142 methodology: $L_{Aeq} – L_{A90}$ with entertainment noise not present for L_{A90} measurement
- Noise Rating (NR) Curves
    - NR based on Octave Band L_{eq} measurements
    - NR based on Octave Band L_{10} measurements
    - NR based on Octave Band L_{90} measurements
    - NR based on Octave Band L_{max} measurements
- Absolute L_{Aeq}
- The Moorhouse modification of the DIN 45680 methodology for investigating low frequency noise
    - Maximum exceedance of 1/3rd-octave band L_{eq} measurements over reference curve in the range 12.5 Hz to 160 Hz
- C-Weighted
    - Absolute L_{Ceq}
    - $L_{Ceq} – L_{C99.8}$ with entertainment noise present for both
    - $L_{Ceq} – L_{C90}$ with entertainment noise not present for L_{C90} measurement
- Comparative L_{90}
    - L_{A90} (with entertainment noise) – L_{A90} (without entertainment noise)
    - L_{C90} (with entertainment noise) – L_{C90} (without entertainment noise)
- Short temporal averaging (using $L_{eq,125ms}$ measurements to assess the quietest period with entertainment noise on – e.g. the quietest 125 ms being the $L_{99.95}$ for a 5-minute measurement)
    - $L_{Aeq} – L_{A99.95}$
    - $L_{Ceq} – L_{C99.95}$
- Inaudibility (assessed directly from responses to questionnaires)

An Excel spreadsheet was developed for use in both laboratory and field trials to calculate all of the above 18 noise metrics (excluding inaudibility as this was assessed from the questionnaire responses) for each noise condition (and for each measurement/assessment in the field trials), to ensure that the same calculation approach was used in all cases.

The distribution of responses to questionnaires was examined, and extreme and outlier responses were identified. From an initial review of the spread of data, it was clear that entertainment noise at levels 1, 2 and 3 would not be considered a major disruption by most subjects, but that at level 4, the disturbance is becoming more obvious.

2.6 Analysis

The data for noise metrics versus acceptability for the four different sound types are shown in Table 2. The results indicate that the best across-the-board metric was the Absolute L_{Aeq}. This metric had the strongest two correlations for all four noise types. No other metric had such a consistent predictive performance with subjective response. For the other noise metrics, different ones were strong for different noise types - e.g. the C-weighted metrics only made a showing for the dance music.

Table 2 - Spearman's rho coefficients for acceptability of level of sound and noise metrics

	Spearman's Rho				
Metric	**All Sounds**	**Sound A (Rock)**	**Sound B (Dance)**	**Sound C (Sport)**	**Sound D (Karaoke)**
IOA A-weighted[3]	**0.765 (3)**	0.801	**0.779 (3)**	0.698	**0.769 (3)**
IOA Max 1/3rd octave exceedance[3]	0.598	0.724	0.728	0.550	0.657
IOA max exceedance[3]	0.621	0.724	0.728	0.632	0.680
Noise Act L_{Aeq}-$L_{A99.8}$	0.732	0.763	0.757	0.682	0.741
BS4142 L_{Aeq}-L_{A90}(no music)	0.756	0.800	0.762	0.697	0.750
NR L_{eq}	0.735	0.800	0.752	0.648	0.724
NR L_{10}	**0.776 (2)**	**0.811 (3)**	**0.804 (1)**	0.698	**0.775 (2)**
NR L_{90}	0.529	0.769	0.397	0.468	0.469
NR L_{max}	0.576	0.633	0.623	0.280	0.739
Absolute L_{Aeq}	**0.781 (1)**	**0.828 (1)**	**0.784 (2)**	**0.720 (1)**	**0.781 (1)**
Moorhouse max exceedance	0.499	0.717	0.761	0.107	0.540
L_{Ceq}	0.571	0.762	0.774	0.264	0.687
L_{Ceq}-$L_{C99.8}$	0.399	0.660	0.766	-0.213	0.493
L_{Ceq}-L_{C90}(no music)	0.534	0.739	0.766	0.148	0.582
L_{A90}-L_{A90}(no music)	0.761	**0.815 (2)**	0.778	**0.702 (2)**	0.754
L_{C90}-L_{C90}(no music)	0.610	0.777	0.734	0.430	0.587
L_{Aeq}-$L_{A99.95}$	0.745	0.776	0.756	**0.699 (3)**	0.753
L_{Ceq}-$L_{C99.95}$	0.397	0.655	0.771	-0.250	0.493

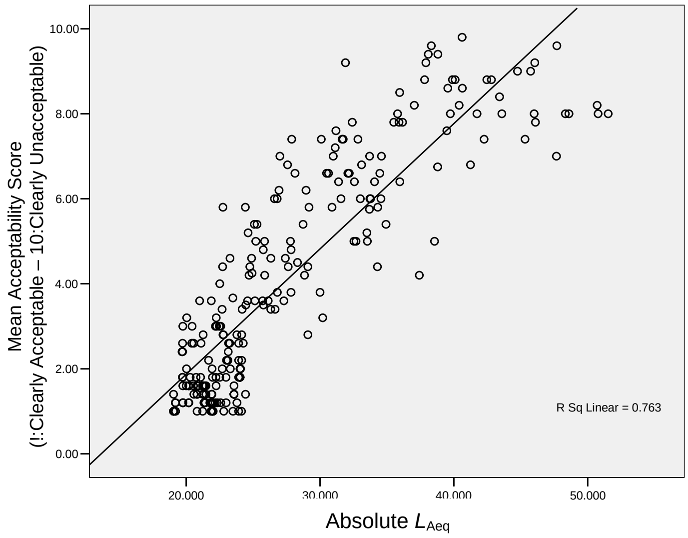
Key for correlation tables:
- \# (1) : strongest correlation
- \# (2) : 2nd strongest correlation
- \# (3) : 3rd strongest correlation

Note: The Noise Act assessment was based on a total 5 minute measurement from which both the L_{Aeq} and $L_{A99.8}$ measurements were extracted, rather than the 15 minute period allowed in the current measurement protocol.

All of the correlations are significant, and almost all are positive, indicating a strong positive linear relationship between the level of noise and the rating of unacceptability. Figure 1 shows a plot of mean acceptability score for each Absolute L_{Aeq} value experienced. The linear regression line through the data explains around 76% of the variance in the data. This graph can be used to determine appropriate noise targets.

The second best predictive performance in the laboratory testing was L_{A90} minus L_{A90} (no music). Although this was not in the top three for all noise categories, the correlation coefficients were consistently above 0.7, and it also performed well in the field tests. For completeness, Figure 2 shows the scatter plot of acceptability vs. for the laboratory data. The variance explained by this regression is much lower than with Absolute L_{Aeq}, and it is clear by inspection that the regression line is a poorer predictor of the acceptability rating.

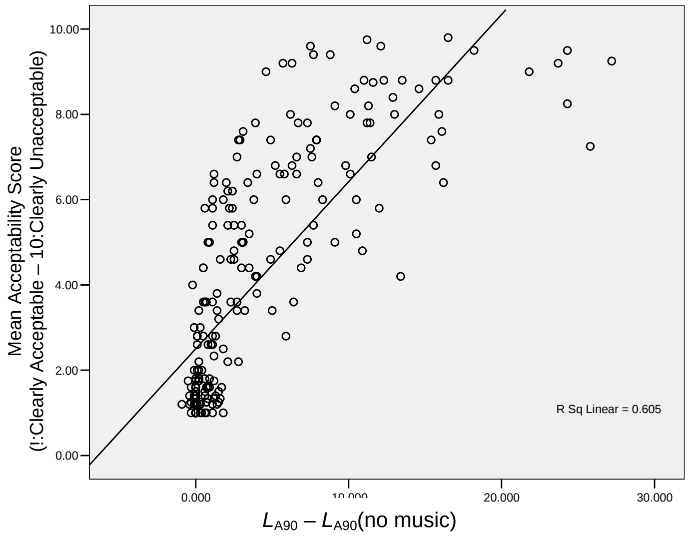
Figure 1 - Acceptability ratings in the laboratory for Absolute L_{Aeq}



Acceptability Ratings

Score	Semantic descriptor
1	Clearly acceptable
2	
3	
4	
5	Just acceptable
6	Just unacceptable
7	
8	
9	
10	Clearly unacceptable

Figure 2 - Acceptability ratings in the laboratory by L_{A90} minus L_{A90} (no music)



Acceptability Ratings

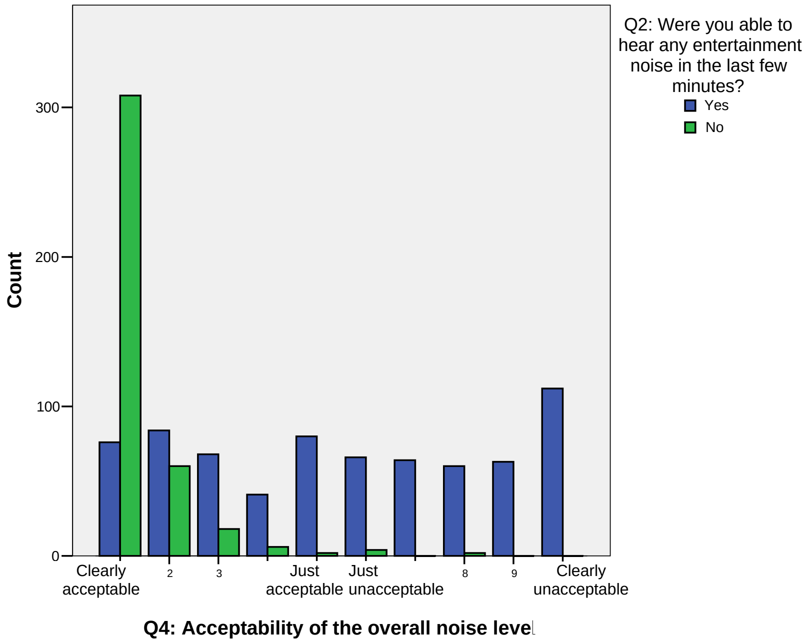
Score	Semantic descriptor
1	Clearly acceptable
2	
3	
4	
5	Just acceptable
6	Just unacceptable
7	
8	
9	
10	Clearly unacceptable

2.6.1 Inaudibility

One of the suggested noise metrics tested was inaudibility, i.e. an assessment where acceptability is presumed to be linked with inaudibility. Figure 3 shows the frequencies at each acceptability rating, split by whether or not the subject reported hearing the entertainment noise. It is clear that in many cases, subjects who were able to hear the entertainment noise nonetheless considered it to be acceptable.

This indicates that an assessment method based on inaudibility would significantly underestimate the acceptability ratings of the people experiencing the noise.

Figure 3 – Acceptability and audibility



2.7 Conclusions from the laboratory testing

The noise metric that appears to provide the best prediction of subjective response across the board for different entertainment noise types is the Absolute L_{Aeq}. This noise metric provided consistently high correlation coefficients when compared with the subjects' ratings of acceptability. According to the regression between subjective acceptability rating and noise level in absolute L_{Aeq}, the table below shows that L_{Aeq} levels associated with each value of acceptability. For example, therefore, if the objective is that the new criterion reflect the level at which householders feel the noise is "just unacceptable", the target absolute $L_{Aeq,5\ minutes}$ should be 34.0 dB.

Table 4 - Semantic descriptor and associated value of acceptability

Semantic descriptor	Score	Absolute $L_{Aeq,5min}$
Clearly acceptable	1	17.0
	2	20.4
	3	23.8
	4	27.2
Just acceptable	5	30.6
Just unacceptable	6	34.0
	7	37.4
	8	40.8
	9	44.2
Clearly unacceptable	10	47.5

3 FIELD TESTS

Field trials were undertaken following the laboratory tests. The primary objective of these was to assess the practicability of using the assessment methods identified in the lab-testing phase as having the best correlation with subjective response to entertainment noise, in real world conditions. The field trials were undertaken at 10 venues around the UK providing a good range of venues (pubs, clubs and town halls), locations (urban, towns and rural) and types of music and venues were selected such that they covered the following noise issues:

- Having a recognised noise problem
- Being borderline
- Having an acceptable noise climate

The equipment used for the field trials was the same as that used for the laboratory tests. An assessment questionnaire was completed by Environmental Health Practitioners (EHPs) regarding their perception of the noise both inside and immediately outside each selected residential location. At each venue there were at least 2 and in most cases 3 EHPs present. Where possible, EHPs from neighbouring Local Authorities were used to provide an opinion as well as the local EHPs, as existing noise issues at the venue may have affected their judgement of the noise measurements during the specific assessment periods.

Further details of the field testing and analysis can be found in the full project report.

4 CONCLUSIONS

The “highest performers” in the laboratory testing also have potential downsides in field testing, so there is no clear best option for recommendation. The following options are considered the best of the available options for assessing noise from one-off or very infrequent events after 2300 hours.

Absolute L_{Aeq} with a subjective judgement in addition. Absolute L_{Aeq}, at a single action level, would be less relevant in the context where the ambient noise level is at or close to the action level even without the entertainment noise. Therefore, we would recommend an action level Absolute L_{Aeq}, with an additional subjective requirement that the entertainment noise itself is a clearly audible (songs/tracks recognisable to a listener familiar with the music or words intelligible) contribution to the overall noise. In terms of an action level, a table is provided (table 4) showing that the level at which subjects felt the noise was “just unacceptable” in the context of a one off or very infrequent event in a habitable room with windows closed was at 34 dB $L_{\mathrm{Aeq,5\ minute}}$. The range for the first two scores of unacceptability was $L_{\mathrm{Aeq,5\ minute}}$ 34 to 37 dB.

L_{A90} – L_{A90} *(no music).* This allows consideration of the background level, but requires a measurement without noise on the night of the event and this may not be possible. This in itself may be problem enough to make the metric unusable for one-off or very infrequent events.

L_{Aeq} – $L_{\mathrm{A99.95}}$ or *Noise Act*. These metrics include some consideration of the underlying noise level, without requiring a separate “no music” measurement to be made. The former is slightly more effective in prediction of subjective response than the latter, but not substantially so, and using the latter has logistical advantages. The performance of both these noise metrics was less good than the previous two options, but they also avoid the practical disadvantages of the Absolute L_{Aeq} with a subjective judgement and L_{A90} – L_{A90} (no music).

5 REFERENCES

1. Noise from Pubs and clubs (Phase II), Final Report, Defra contract NANR 163, Capita Symonds and Building Research Establishment, May 2006.
2. Noise from Pubs and Clubs, Final Report – Phase 1: Defra contract NANR 92, University of Salford and Hepworth Acoustics, March 2005.
3. Draft Good Practice Guide on the Control of Noise from Pubs and Clubs – Annex 1: Criteria and Measurement Guides, IOA