What you can get away with 90 per cent of the time!

An investigation into the basic requirements for environmental noise measurement parameters

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Introduction

This paper is set out to investigate the basic requirements for environmental noise measurement parameters to see what is required for the majority of cases. The idea is to try and identify a base set of measurements that will allow most environmental noise monitoring tasks to be carried out. In these austere times, this may well have an effect on the level of equipment needed by consultants or others, where simpler monitoring equipment could save time, energy and money.

Background study

Types of documents

The first part of the study was to determine the areas of investigation. Within the world of acoustics, there are many documents that detail measurement methods and parameters to be used. For this paper, it was decided to concentrate on standards, guidelines and regulations that specifically relate to the environment and how noise affects the public. The following areas have been listed as a guide to determining the documents to be considered. This will hopefully produce a comprehensive list of guidelines used by acoustics professionals in carrying out environmental noise surveys.

- British Standards
- Entertainment licensing and guidance
- Environmental acts of parliament
- EU Noise Directives relating to environmental noise
- Integrated Pollution Prevention & Control Guidance
- Noise & Statutory Nuisance Act
- Noise Insulation Regulations
- Town & Country Planning Acts
- World Health Organization (WHO) Guidelines

Data requirements

The data to be extracted from each of these documents is quite simply the parameters required for measurement that will allow the criteria of the document to be met in full. Additional information comes in the form of any post processing required on the data to produce information that need not be measured.

It is important to note a distinct difference in that some sound measuring equipment will produce data that is not actually measured but processed from other measurements. As this study is designed to look at the minimum requirements for sound measuring equipment, then it is assumed that any post processing can be carried out afterwards using PC software or a spreadsheet.

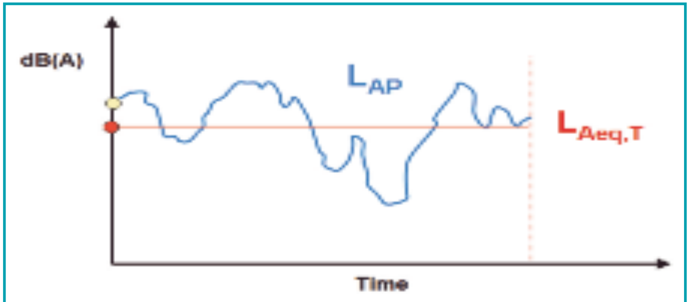

Figure 1

L_{Aeq} *Equivalent Level*

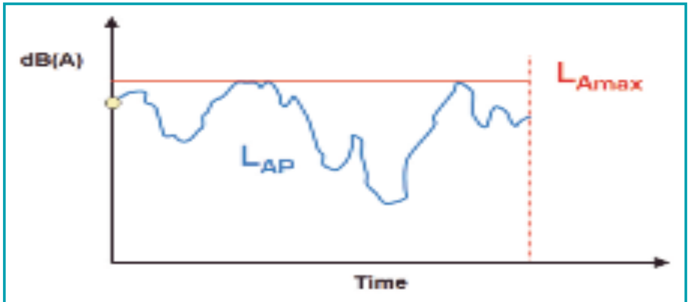

Figure 2

L_{Amax} *Maximum Level*

Methodology

Desk Study

The study for this paper simply involved a desk based analysis of as many standards as could be found relating to noise in the environment in the UK. From each of these standards, information was extracted looking at the measurement requirements in terms of what parameters are needed to produce the desired outcome for that document. These were then broken down into parameters that must be measured and those that can be calculated post-measurement.

Weighting Factor

Consideration was made as to whether a system of weighting should be used. This is because there is clearly a wider application of standards such as BS4142 that there is for the code of practice for water skiing and noise. This weighting factor would correct for this anomaly and allow the more regularly used standards to account for more of the result.

A simple system has been devised to account for this difference and ranks a document in the following way

1 Barely used document or standard for peripheral activity or minimal industry
2 Moderately well used document or standard relating to wider activity or industry
3 Heavily used document applied extensively in larger industries with widespread application

The weighting was simply applied to the occurrence of a required parameter to give a weighted representation of that parameter. This was then compared with the total available weighted score to give a percentage likelihood of that parameter being needed.

The process of measuring

State of the art in sound monitoring

Modern sound meters are capable of measuring multiple parameters

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simultaneously, whilst sending the data directly to a website or even a mobile phone. Many of these systems use high powered processing to do this meaning a high level of power requirement and often huge amounts of data being produced. Here is a brief background to the process of producing such measurements in a sound meter.

There is a cut-off, even with modern technology, where a leap is required in the processing technology employed in the monitoring equipment for certain types of parameters. For example, it is relatively simply to produce L_{eq} and 2 or 3 percentile measurement, but to add frequency measurement or multiple statistical parameters require a whole different class of technology.

Sound pressure level (L_p)

Although this measure is not mentioned in the study below, it is very important as it is the figure we are all used to seeing on the screen of most sound meters. It is the actual display of the current 'sound level' and is a number taken from a complicated calculation used to produce an rms (root, mean, squared) signal from the rapidly fluctuating signal created at the microphone. This measure is 'damped' to differing degrees (SLOW or FAST) to slow it down and then a number from this is displayed every 1 second or so. The damping is very important when it comes to certain other parameters as it will affect the number produced.

L_{Aeq}

L_{Aeq} is a fundamental measurement parameter designed to represent a varying sound source over a given time as a single number. This number is a measure of the energy contained within the sound at the point of the receiver. This is useful in terms of the potential for sound to damage or disturb and is extensively used in environmental noise standards as well as many other regulations and documents.

Creating L_{Aeq} in a sound meter requires very fast processing such that transient (quick) signals are not missed. The actual sound signal from the microphone might be sampled fifty or sixty thousand times every second, and then the L_{Aeq} will be sampled from that at about one thousand times per second. A modern processing chip will be amply powerful for this job although many will still have to be run as fast as they can go to do it. The samples are then integrated (added together) and then averaged as they are produced. This means that all these calculations must be performed very quickly indeed!

L_{Amax}

The maximum rms is a simpler parameter to determine and is taken from the same calculation as that used to create the sound pressure level on the display (the rms). The L_{Amax} is simply the largest rms number produced by the processor (although this may not actually be displayed as the sound meter only displays the number every so often so your eyes can keep up!). This feed is basically the same as the L_{Aeq} although for the L_{Amax} it is very important that the correct damping is used as this will change the result!

L_{An}

Statistical measurements are completely different to the rms type parameters as they require (although they use the same feed as the L_{Amax}) a large number of samples to be stored and then counted by the processor. If you imagine a number of bins or boxes and each box is labelled with a decibel number from, say 30, to 50 and they go up in 0.1dB steps. Every time the sound meter samples a number that corresponds to a particular bin, it adds a marker to that bin. You end up with all the bins full of markers and then the processor can simply count the markers compared to how many there are in total, thus giving a percentage below which all the numbers occurred.

Analysis of the findings

There are a large number of documents dealing with the issues of noise in the environment, most of which relate to specific situations or are dedicated to an industry such as construction. It would also appear that there are situations for which there is no guidance or standard and in these cases, it is usual to work with a document that is either close to the situation, but not directly applicable or to use a more generic standard such as the World Health Organization Guidance.

The following Documents studied simply call up other documents or do not, in themselves prescribe measurement, for example in the case of

Parameters by order of importance				
	Weighted		Un-weighted	
	Percentage	Cumulative	Percentage	Cumulative
L_{Aeq}	53%		53%	
L_{Amax}	24%	77%	21%	74%
L_{A90}	8%	85%	9%	82%
1/3 Octave	6%	91%	6%	88%
Octave	5%	95%	6%	94%
Other L_n	3%	98%	3%	97%
Other	2%	100%	3%	100%

Table 1

Results as weighted and un-weighted percentages, from which a number of conclusions can be drawn and some observations made. The parameters have been listed in order of importance and the cumulative column shows the additional effect of each type of measurement.

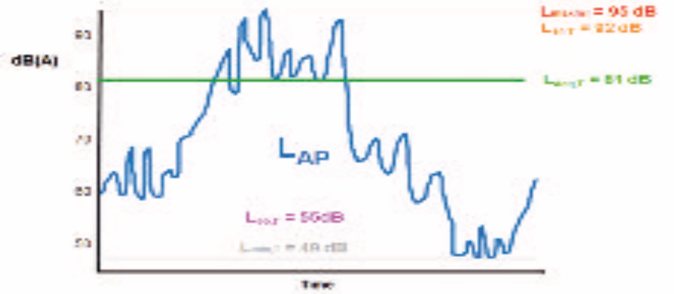

Figure 3

What the 'L' are you on about?

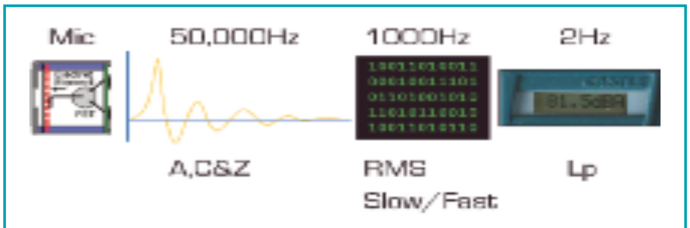

Figure 4

The basic stages in a modern sound meter required to measure sound pressure

ISO9613 – Additional types of attenuation, which is a predictive process using calculation methods:

- Environmental Protection Act, 1990
- ISO9613 – Additional types of attenuation
- Land Compensation Act, 1973
- Minerals Policy Statement 2: Planning, 2005
- Noise & Statutory Nuisance Act, 1993
- The Use of Conditions in Planning Permission, (1/85, 1985) 11/95, 2006
- Town & Country Planning – Assessment of Environmental Effects

The full set of data can be seen further on, but this can be summarized quite simply in Table 1.

The actual results listed above are in order of percentage importance, and it shows that 85% of tasks to the documents listed can be carried out with 3 basic parameter; L_{Aeq}, L_{Amax} and L90. Even un-weighted, this figure is as high as 82%.

The next highest measurement is 1/3 octave band, which certainly complicates the measurement process and doesn't account for a much increased scope, especially in the context that one of the standards using this only states that this kind of measurement 'may' be necessary.

The addition of L_{A10} to the 3 basic parameters increases the coverage to 88%

Conclusions

Even with the limited scope of this study and the necessity to include a somewhat arbitrary weighting system, it is possible to see that a very large percentage (up to 88%) of environmental noise measurement processes can be completed with 4 simple parameters; L_{Aeq}, L_{Amax}, L_{A90} and L_{A10}

Clearly this doesn't detract from the need for more complex monitoring where a standard calls for it and this will depend highly on the person responsible for the measurement. In the case of consultants, there will be a need to provide for many of these standards, in which case there is a necessity to have the ability to carry out these measurements. Where, however, an organization need only comply with a limited range of documents, it may only need relatively simple monitoring systems.

Measurement parameters

Definitions of parameters used in this study

$L_{Aeq,T}$ A-weighted equivalent continuous sound level over a stated time period

$L_{A90,T}$ A-weighted sound level exceeded for 90% of the measurement period (Background Noise)

$L_{A10,T}$ A-weighted sound level exceeded for 10% of the measurement period (Traffic Noise)

$L_{A01,T}$ A-weighted sound level exceeded for 1% of the measurement period (Maximum Noise Climate) similar to and normally measured as L_{Amax}

$L_{AMax,T}$ Maximum rms sound level

NNO Night Noise Offence parameter; the level not exceeded for a period of 0.6 seconds in a measurement of between 1 and 5 minutes.

SEL The L_{eq} with a reference period of 1 second for a given measurement duration.

Typical uses for parameters by application

Rail	SEL	Number and type of trains
	$L_{Amax,T}$	
Road	$L_{A10,T}$	Traffic counts, light & heavy vehicles
	$L_{Aeq,T}$	
Aircraft	SEL	Number & types
	$L_{Amax,T}$	
Industrial	$L_{Aeq,T}$	Occurrences of activities & periods
	$L_{A90,T}$	
	$L_{Amax,T}$	
	L_{APeak}	(Impulsive)
Construction	$L_{Aeq,T}$	Occurrences of activities & periods

References

1. BS 4142: 1997 Method of Rating Industrial Noise
2. BS 5228: 2009 Noise & Vibration Control on Construction
3. BS 8233: 1999 Code of Practice for Sound Insulation
4. Calculation of Railway Noise, 1995
5. Calculation of Road Traffic Noise, 1988
6. Code of Practice for Concert Noise - The Noise Council
7. Code of Practice for Water Skiing & Noise - UK Water Skiing Federation
8. Code of Practice on Noise from Clay Target Shooting, 2003
9. Control of Pollution Act 1974, Circular 2/76
10. Directive 2002/49/EC - The Assessment and Management of Environmental Noise (Lden)
11. Environmental Protection Act, 1990
12. Good Practice Guide on the Control of Noise from Pubs and Clubs
13. ISO9613 - Additional types of attenuation
14. Land Compensation Act, 1973
15. Minerals Policy Statement 2: Planning, 2005
16. Noise & Statutory Nuisance Act, 1993
17. Noise Mapping
18. Planning Guidance on Dog Kennels
19. Planning Policy Guidance PPG 24, 1994
20. Railway Noise and Insulation of Dwellings, 1991
21. The Noise Act 1996
22. The Use of Conditions in Planning Permission, (1/85, 1985) 11/95, 2006
23. Town & Country Planning – Assessment of Environmental Effects
24. World health Organization Guidelines on Noise

Data (see table below)

Specific Documents	Weighting	LAeq		LAmax		LA90		Other Ln		Octave		1/3 Octave		Other		Post Calc	Notes
		Required	weighted	Required	weighted	Required	weighted	Required	weighted	Required	weighted	Required	weighted	Required	weighted		
BS 4142: 1997 Method of Rating Industrial Noise	3	1	3			1	3										
BS 5228: 2009 Noise & Vibration Control on Construction	3	1	3	1	3												LA01, measured as Lamax
BS 8233: 1999 Code of Practice for Sound Insulation	1	1	1	1	1					1	1	1	1			SEL	
Calculation of Railway Noise, 1995	2	1	2														
Calculation of Road Traffic Noise, 1988	2	1	2					1	2								LA10
Code of Practice for Concert Noise – The Noise Council	1	1	1			1	1										
Code of Practice for Water Skiing & Noise – UK Water Skiing Federation	1	1	1	1	1											SEL	
Code of Practice on Noise from Clay Target Shooting, 2003	1	1	1													SNL	Shot Noise Level
Control of Pollution Act 1974, Circular 2/76	3	1	3														Normally LAeq
Directive 2002/49/EC - The Assessment and Management of Environmental Noise (Lden)	1	1	1													Lden	
Environmental Protection Act, 1990	3																No specified parameters
Good Practice Guide on the Control of Noise from Pubs and Clubs	2	1	2							1	2						May be required
ISO9613 – Additional types of attenuation	1																Predictive, not measurement
Land Compensation Act, 1973	1																
Minerals Policy Statement 2: Planning, 2005	3	1	3	1	3							1	3				Possible use of Octave
Noise & Statutory Nuisance Act, 1993	2																No specified measurement
Noise Mapping	2	1	2														
Planning Guidance on Dog Kennels	1	1	1			1	1										
Planning Policy Guidance PPG 24, 1994	3	1	3	1	3												
Railway Noise and Insulation of Dwellings, 1991	2	1	2	1	2												
The Noise Act 1996	1	1	1											1	1		NNO
The Use of Conditions in Planning Permission, (1/85, 1985) 11/95, 2006	1																Calls up other standards
Town & Country Planning – Assessment of Environmental Effects	1																Calls up other standards
World health Organization Guidelines on Noise	3	1	3	1	3												
Totals	66		35		16		5		2		3		4		1		
Weighted Percentages	100%		53%		24%		8%		3%		5%		6%		2%		
Unweighted Pergentages	34	18		7		3		1		2		2		1			
	100%	53%		21%		9%		3%		6%		6%		3%			

Table 1 (full)

Results as weighted and un-weighted percentages, from which a number of conclusions can be drawn and some observations made. The parameters have been listed in order of importance and the cumulative column shows the additional effect of each type of measurement.