NOISE MEASUREMENT THE PAST AND THE PRESENT

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1. INTRODUCTION

This paper gives a brief history of the development of statistical levels and the equivalent continuous level, it will also document how acoustic instrumentation has advanced in the last 47 years.

2. BUILDING ACOUSTICS

In 1946 a small team tasked with researching the whole topic of building acoustics, was established at the Building Research Station (BRS). Initially their work concentrated on developing techniques for acoustic measurements, since at the time no specialised equipment was available commercially. However towards the latter of the 1940’s through to the early 50’s, the focus of their research shifted to sound insulation between dwellings. The efforts of this group provided the framework for sound insulation control by Building Regulations and led to the creation of most of the principles we use today.

An early example of field measurement equipment

A mobile acoustics laboratory was required to transport the large quantity of heavy mains operated instrumentation necessary for measuring the sound insulation between dwellings; lots of cables were needed to go from the laboratory to the rooms under test.

3. THE DEVELOPMENT OF STATISTICAL LEVELS

In the 50’s there was a growing awareness about noise from:

- transportation,
- industry,
- domestic noise sources,

This was acknowledged by the Government in 1960 by the setting up of the Wilson Committee. The Committee made important recommendations and also identified the need for further study of the problem. Some of these recommendations were taken up and incorporated into legislation, standards or design targets. Another important consequence of the work of the Committee was the stimulus it gave to research.

One of the research projects was the London Noise Survey; the measurements were made during 1961/2 by BRS with the co-operation of the London County Council and involved the measurement of noise over 24 hours at 540 positions in the London area, and an associated social survey . This work provided the main stimulus to the now universal practice of rating environmental noise levels and was the first major application of a suggestion for describing noise levels in statistical terms, L_{A10}, L_{A50}, L_{A90}. The Committee interpreted the data and made the following recommendations for noise levels inside living rooms and bedrooms, which should not be exceeded for more than ten percent of the time:

Situation	Day	Night
	L_{A10} (dB)	L_{A10} (dB)
Country areas	40	30
Suburban areas, away from main traffic routes	45	35
Busy urban areas	50	35

NB – it was also established 55 dB L_{A10} should be the upper limit to be tolerated in buildings in which communication by speech is of great importance.

Further research work on industrial noise was carried out specially for the Committee as was the measurement of sound insulation and the measurement on noise from construction plants. The latter provided data on the noise levels from a range of plant and some key insights into how the reduction in noise levels could be achieved by various control measures.

The report of the Wilson Committee, published in 1963, brought into focus a general concern with sound insulation and noise; for example consideration was being given to the inclusion of sound insulation requirements into Building Regulations, the setting up of the Heathrow Airport Grants Scheme and the preparation of BS 4142.

In the mid 60's a small BRS team of psychologists turned its attention to environmental noise and the in-house research at BRS began to cover both the measurement of noise and the human response to noise.

Two major field experiments one on the effects of noise barriers used a localised noise source which was considered relevant to traffic noise peaks and the other a measurement of traffic noise coupled with a social survey were carried out. A report drawing together the results of this research proposed that, "for traffic noise, the unit used to describe the noise exposure of a dwelling should be the value L_{A10} measured at 1 m from the facade and averaged over a weekday period of 6 am to 12 midnight." This was the first recommendation for a $L_{A10\ 18\ h}$ for assessing road traffic noise. The report also describes a method for predicting $L_{A10\ 18\ h}$ for road traffic noise.

Towards the end of the 1960s there was a growing widespread concern with the environment as a whole, including noise of course, and in 1970 Government set up the Noise Advisory Council.

Thus in 1970 BRS was able to put forward to the recently formed Noise Advisory Council a complete package covering free-flow traffic which usefully related dissatisfaction in dwellings to noise levels outside and which included a reasonably accurate procedure for calculating the external levels.

The NAC endorsed the use of the index and recommended that 70 dB $L_{A10\ 18\ h}$ should be regarded as 'the upper limit of the acceptable' and that wherever possible planners should aim at lower noise levels.

Research had been in progress, aimed at improving the accuracy of the noise level prediction method. Part of this was the second barrier experiment using motorway traffic as the source. In this event the experiment confirmed the theoretical extrapolation of the earlier localised-source barrier experiment results. It was agreed they were relevant to $L_{A90,\,T}$ and, with a modification to the allowance for ground effect, the original BRS prediction method formed the main basis of the prediction of exposure to noise from traffic 1972 which together with work from NPL, TRL and Travers Morgan produced the Calculation of Road Traffic Noise 1975.

The contribution on industrial noise was a suggested procedure for assessing the validity of complaints from householders about noise from factories. This procedure was endorsed by the Committee and subsequently Local Authorities began to use it and it was later incorporated in to BS 4142:1975. In this version of the standard it gave the "preferred measurement of background level shall be that level which is exceeded for 90% of the time" measured in dB $L_{A90,\,T}$

The evolution of the measurement of statistical levels.

In the 1950's and early 60's statistical levels were determined by reading a measuring amplifier or sound level meter at 5 second intervals to obtain the level distribution. Percentile levels (L_{AN}' s) and the were subsequently calculated by hand. By the early 70's the BRS had developed a modification that fitted onto the meter's display that flashed a light every 5s indicating when to take a reading.

An alternative was to make a tape recording of the noise on-site and play it back through a level recorder to obtain a paper trace of the time history of the level. The sound level distribution was determined by reading the sound levels at regular intervals. This was a time consuming and laborious task, taking many hundreds of results, for the traces were frequently many tens of metres long.

A major advance in the early 60's was for a mechanical attachment to the level recorder that could automatically, at preset time intervals, produce a distribution of levels. This mechanization was a significant advance primarily due to the increase in sampling rate and an improvement in the reliability of gathering the results. However the statistical distribution analyser (a purely mechanical device) could not automatically produce sequential hourly statistics. The BRS used a camera to take photographs of the analyser's display at preset time intervals to automatically record the distribution of the levels. The following equipment was required to obtain a series of hourly L_{AN}'$_{S}$: microphone, measuring amplifier (or sound level meter), level recorder, statistical distribution analyser, camera and controlling unit. This all fitted into a large box and required mains power.

The introduction of the statistical sound level meter in the early 70's made field measurements very much easier. This type of meter could be battery operated, and although larger than a sound level meter they were very much smaller and more portable than the level recorder and statistical analyser setup.

The development of Equivalent Continuous Sound Level $L_{Aeq,T}$

In the late 60's the use of L_{Aeq} as the preferred measurement for the assessment of noise in the workplace was established: in particular to situations involving hearing impairment.

In 1970 a number of countries proposed hearing conservation programs on noise exposure rather than noise levels. In 1972 the Code of Practice for reducing the exposure of employed persons to Noise was published; it stated that people should not be exposed to an 8 hour equivalent continuous sound levels exceeding 90 dB (unprotected ear).

In the mid 70's the NAC published a report "Noise Units"

They stated in their recommendations that "there is no strong evidence to support the use of any other measure of noise level for general purposes than the A-weighted sound level. Therefore the Working Party recommends that the A-weighted sound level should be adopted for measurement of all sources of environmental noise." Further "no unified scale of environmental noise has been proposed which fully meets all the requirements specified by the Working Party. Nevertheless it is possible to adopt a unified scale for the present and the Equivalent continuous Sound Level $L_{\mathrm{Aeq},T}$ is recommended for this purpose."

The determination and measurement of $L_{\mathrm{Aeq},T}$

There was no direct reading environmental noise $L_{\mathrm{Aeq},T}$ meter until the mid 70's . A rough estimation of the value could be obtained by visually averaging the display of an analogue meter providing that the level fluctuated through a range of 8 dB or less.

Measurements from a statistical distribution analyser could be used to give a reasonable estimate of the value providing there were sufficient samples in each of the ranges.

The early L_{Aeq} meters were aimed at the health and safety market in the early 70's. By the mid 70's the semi portable meters came onto the market.

It was not long before instruments that could measure both the L_{AN}' s and L_{Aeq} became available.

Around the late 70's portable sound level meters started to appear with linear and larger display ranges; some were able to measure L_{Aeq} directly. The meters tended to become smaller and lighter; and as chip technology improved the first of the digital display meters arrived.

During the 80' s reduction in component size and improvements in computer memory meant that portable hand held sound level meters could calculate a number of different parameters such as L_{AN}, L_{Aeq} and store the periodic values. Storage tended to be volatile; that is the results were lost when the instrument was turned off or its batteries failed.

The 90's have seen further developments of the sound level meter. Digital filtering and very fast sampling has given a quantum leap in the meter's ability to measure, display and store real time octave and third octave band levels using a number of measurement parameters; some meters can store the time histories and download them to PC or directly to printer.

The continuing development in the speed, power and memory of and electronics together with the development of neural networks make it probable that we will have an intelligent sound level meter in the future

4. MODERN RESEARCH TECHNIQUES

Sound Intensity

Sound Intensity can be used as a diagnostic tool to find the important flanking paths. One method, Very short $L_{eq,}$ can be used to separate the crucial difference between projectile noise and muzzle blast.

Firearm noise

Projectile noise is the supersonic noise produced by the projectile (travelling faster than the speed of sound) and radiated out from the path of the projectile – forming a cone. Muzzle blast which expels high temperature, high pressure gases from the muzzle of a firearm from the propellant (which propagates at the speed of sound). These noises can be measured using a very short L_{Aeq} and having the microphone is within the cone of projectile radiation.A twin channel meter can be used to assist in identifying transient sources in the presence of other sources.

If two microphones are connected to a twin channel meter and one microphone is placed 68 m closer to the impulsive noise source than the microphone at the assessment position then assuming speed of sound is 340 ms^{-1} then if both traces show similar traces and are 200 ms apart then the sound comes from the same source.

Verification of prediction

Making accurate predictions is absolutely essential when undertaking any fieldwork. When generating predictions it is important to consider key factors such as the source strength, barrier attenuation and topography of the area. Topography in particular is an area that has benefited from advancements in digital mapping which allows far greater accuracy.

Wherever possible it is highly desirable that having made a noise prediction that subsequent measurements be made to verify the predictions. Multiple measurements should idealy be part of the prediction process as it will lend greater confidence to your results.

Human response research programme.

Human response research is of vital importance as it allows us to measure real human responses against specific parameters. With these experiments it is crucial to create an environment that is a believable real world simulation with as true-to-life conditions as achievable. In order to achieve this, the below are just some of the extraneous variables that should be considered during research design process.

- What should be considered in researching into noise of music coming from outside the premises affecting people trying to get to sleep?

- What time of day are you going to test the subjects? You may get different answers if they are tested in the morning. You can probably move the time by an hour or so.

- Are you going to stabilize the test subject? They will need briefing and it would be good to have the test subjects in a place with a similar environment to the test space so that they can stabilize.

- Where are you going to test the subjects in a listening room or a house? A house can have some advantages in setting the scene and giving the subjects clues like walking up the stairs to one of the test bedrooms.

- Are you going to allow them to eat and or drink?

- How long is the whole test going to take?

- Is the noise coming from say a wine bar in a shop below or is it from an outside source? Are you going to 'shape' the noise presented to the subjects? Are you going to present the noises in a random order? Are you using a variety of music types?

- Are you going to filter the test subjects? Are you going to use a restricted age range?

By ensuring the above factors are taken into account, the overall reliability and validity of the research will be greatly improved.

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