Proceedings of The Institute of Acoustics

A NEW METHOD FOR CONCERT HALL NOISE CONTROL

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Control of noise both inside and outside concert halls is a long term continuing problem. Inside, there are the problems of excessive noise levels causing hearing damage to workers and performers,together with levels often too high for the audience to enjoy. This is a problem often overlooked and even more often ignored, by some performers who seems to equate volume with quality.

Outside, there is the perennial problem of noise affecting neighbours. Often if the concert hall is a commercial operation, profit is more important than nuisance to others. If it is a non-commercial occasion, i.e. a charity, the organisers often take the view that their noise nuisance is unimportant set against the good that is done by the money raising of the event.

In either case, external noise control by a statutory body is required and to do this a system must be evolved and many methods have been proposed for this, many based on BS 4142 and it's equivalent in other countries.

In this paper we are proposing a new method based on Short Leq both as a real time control and, much more importantly, as a possible legislative method. Short Leq, itself, has been adequately described elsewhere [1] & [2] and is simply a whole series of Leq taken at very short intervals one after another. Each Leq is independant of all others and is directly related to the energy involved over the period.

Originally Short Leq was devised by Luquet & Komorn [3] as a method of time compressing raw data so as to allow storage of the data for subsequent reprocessing. Clearly as an archiving method Short Leq can do nothing that cannot be done with tape recording. Like tape recording, Short Leq keeps raw data and thus allows subsequent reprocessing in many different ways. However, to record a 12 hour rock concert using tape would take 12 C60 cassettes while a 1 second Short Leq data base over 3 whole concerts can be put onto one cassette. In other words Short Leq is giving about a 50:1 data compression without losing any vital information. Also, with tape recording techniques the whole measurement has to be made again in the laboratory by repeatedly playing the tape through the analysis equipment. Every time new data is required, the tape must be played again in real time. That is to say, 12 hours of recording takes at least 12 hours to analyse while with Short Leq 1 month of data can be analysed in minutes and it is here, on replay, that most of the time compression occurs.

We are now proposing other uses for the Short Leq concept and while some of these uses follow from the data compression, others follow from the ability to predict trends and reprocess the data using desktop computers. Two of these ideas are presented as case studies, one a new idea and the other a new method to utilise an old idea.

The first case study is using Short Leq to control the level inside a concert hall with benefits to both neighbours and workers. The problem is truly simple. The noise is totally under the control of the management and thus noise problems can be resolved at the twist of a knob. What other noise problem is so simple to resolve? In truth almost any. Firstly the spectrum of music, particularly rock music, is not well controlled using 'A' weighting because of the high level of low frequency energy. The attenuation of a concert hall usually emphasises these higher level low frequencies by anything up to 30dB.

The control method chosen was to take 3 octave bands and acquire Short Leq data in each one, in parallel, together with the 'A' weighted level. Thus 4 parallel channels are acquired at the same time using 125Hz, 250Hz and 500Hz bands, covering the spectrum from about 50Hz to 200Hz. The computer chosen was an Acorn BBC simply because it has 4 channels of analogue to digital conversion as standard, although any computer could in fact have been chosen with appropriate add-ons. 10 seconds was chosen as the time base for Short Leq acquisition thus each minute 24 Leq's are taken, 1440 per hour, from each microphone. Two microphones were used, one near the stage speakers and the second behind the building, mounted as remotely as possible from external noise such as traffic.

Having acquired data in this fashion control can be established. The software sums the 3 octave bands taken on the inside with a weighting determined by the programme itself. This decision is not updated except by human intervention so that sudden changes do not cause unnecessary modification. The computer now presents a series of warnings if the calculated level is likely to be such as to cause a noise nuisance outside or be excessive inside.

The 'weighting' of the 3 bands is done by a simple algorithm which checks the attenuation of the building in each band in response to a test signal. Naturally a sensible measurement time must be chosen so that the conditions relate sensibly to the 'live' conditions which will prevail while the concert is on. The algorithm also checks the A weighting attenuation and logs this, both as a reference and also to enable hand checks using normal sound level meters to be compared with the computer Short Leq values.

In use, the system is very simple. The computer scans the 8 input channels, that is the 4 bands from each microphone, and stores the 4 10 second short Leq values. As all 4 are totally time coincident, that is all 4 Leq channels are reset together, a new mini spectrum of Leq is available every 10 seconds. There is nothing magic about 10 seconds as a base time. The software and the system can accept any time base from 125mSec up, but for this purpose 10 sec is a good compromise between disc space and decision time. Clearly if 125mSec were used, 32 value would be stored every second and as each value is a 16 bit word, 64 bytes per second would give only 26 minutes of data on a 100K disc.

The 'decision' algorithm is complex but can be changed from the keyboard. Normally an averaging algorithm is used which adds the octaves in a controlled fashion but special algorithms can be called up which compare trends and only file the data when preset criteria are reached. The object of such control is to allow the acoustician to relate the control parameters to the actual situation and not be forced to a simple go - no go as he would have been with a crude limiter.

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What overall control is actually performed is at the whim of the installer. The electronics provide an almost infinite number of switches which can control almost any device. In practical operation the computer flashed strobes, lit the house lights, turned off the amplifiers, reduced the main volume and even automatically closed ventilation outlets. In fact the concept of this system is such as to allow almost any action to be taken based purely on acoustical parameters. It should not be thought that such a system is expensive. In fact the early prototype did not use a BBC computer but instead an ACORN ELECTRON, a reduced specification games computer which fortunately accepts BBC BASIC. Fig.1 shows the basic control system, for convenience only 1 microphone is shown. B channel, the second microphone, is identical.

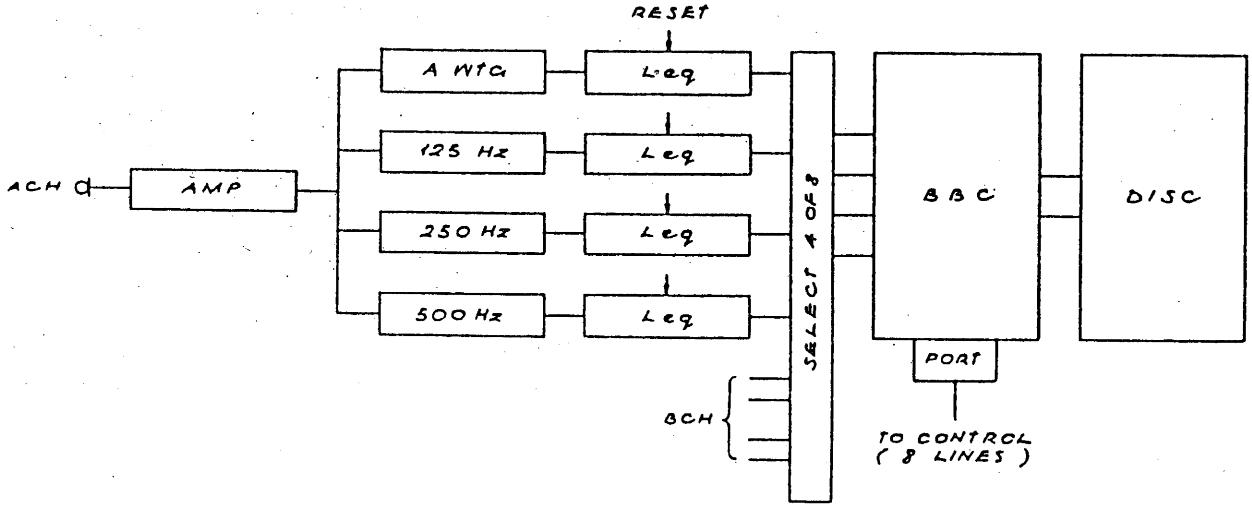

Fig.1. Basic Control System.

One of the initial units used slow response sound level as the acquisition parameter instead of a true Short Leq. In this unit, the global Leq in each band was calculated by the computer and the results added to give an effective Leq over 10 seconds. While this technique is perfectly acceptable for concert hall noise control, it does miss one of the main points of true Short Leq. This is that each true Short Leq sample truly reflects the energy in that sample whereas digital processing of Slow or even Fast response does not. Some argue that if the resulting data can meet IEC 804 criteria, then the result is acceptable. We do not take this view, regarding computation of a quasi Leq from sampling a retrograde step, when a true energy integral is available.

Using Short Leq as a real time control for a concert hall is an interesting side issue in some ways, but the use of an outside microphone also gave the ability to log the external noise levels over a long period and in one realisation of the system, the local city authorities were able to use the data to gain a knowledge of the daily variation of the sound level at a particular point. This was only possible because the city was the owner of the concert hall and thus owned the system. The results from the external microphone are very similar to those taken in our second case study; urban noise mapping.

This second case study came about when it was decided to map the noise pattern of various cities in France. The connection between the case studies for us was the fact that much of our work related to holiday towns where disco and concerts are a major form of noise pollution. Thus it was a natural progression from a single outside microphone to a survey. Many methods were proposed, but the obvious and simplest method was to acquire data at many sites in parallel and subsequently bring the data in-house for processing. Short Leq was the obvious method and was in fact chosen. Up to 7 integrating meters were used at one time, each one having 44K of memory. 45 ØØØ Leq values being stored if required.

TIME CONSTRAINTS

The method was in essence simple. Each meter possesses an accurate internal clock and as the software can recognise the relative times of incoming data there is no need for precise timing of the power-up to produce 45,ØØØ synchronised Leq values. 125mS sampling could give a maximum time of about 1.5hrs while 1 second Leq is used to give a measurement time of 12.5hrs. 1 or 2 second Leqs have proved to be the best timing periods to work on "event signatures" and time differences between two microphones. In almost every case, the use of the threshold and screen cursor coding are sufficient to give satisfactory source identification at process time. In more complicated cases, the use of the built-in coding switches on the meter may prove necessary, and if not, one must shorten the Leq period to as low as 1ØmS. This means that the memory needs to be proportionally higher for the same measurement period. At this time the largest proposal is 128K of 16 bit memory to give 36 hours at 1 second samples. This, however, requires an external computer with a very large memory and this in practice is the current limitation. If an MS.DOS machine such as the IBM PC is used the maximum RAM is of the order of 64ØK. If say 15ØK is used for the programme, only 25ØK 16 bit words can be held in memory at the same time.

METHOD OF MEASUREMENT

To make the actual measurement, only routine acoustic knowledge is required. The units are calibrated exactly as normal and set to zero as described. The technique is to simply place the units in the correct positions paying attention to the usual problems of local noise sources, weather and the tendency of people to borrow the meters. Typically, the local officers know the 'best' places and in any event a quick survey with a simple sound level meter would give an indication of where to start.

If it is desired and the necessary personnel are available, individual noise sources can be 'coded' during acquisition. For example, of the 4 code buttons one could be labelled "bikes", another "trucks", a third "concert" etc., This data is then stored either after the relevant Leq or, in the newer systems, in the same digital word.

THE DATA

As the raw data, in the form of discrete energy samples, has been recorded in the sound level meter's memory, it only remains to transfer this to disc for archival purposes and to facilitate analysis. This is done totally automatically by most Short Leq programmes and in the case study the Soeur Anne programme "LEQTRANS" was used. The data is filed in the form of a 16 bit word of 1Ø times the Leq value +1ØdB. Thus ØØ represents -1ØdB and 2ØØØ represents

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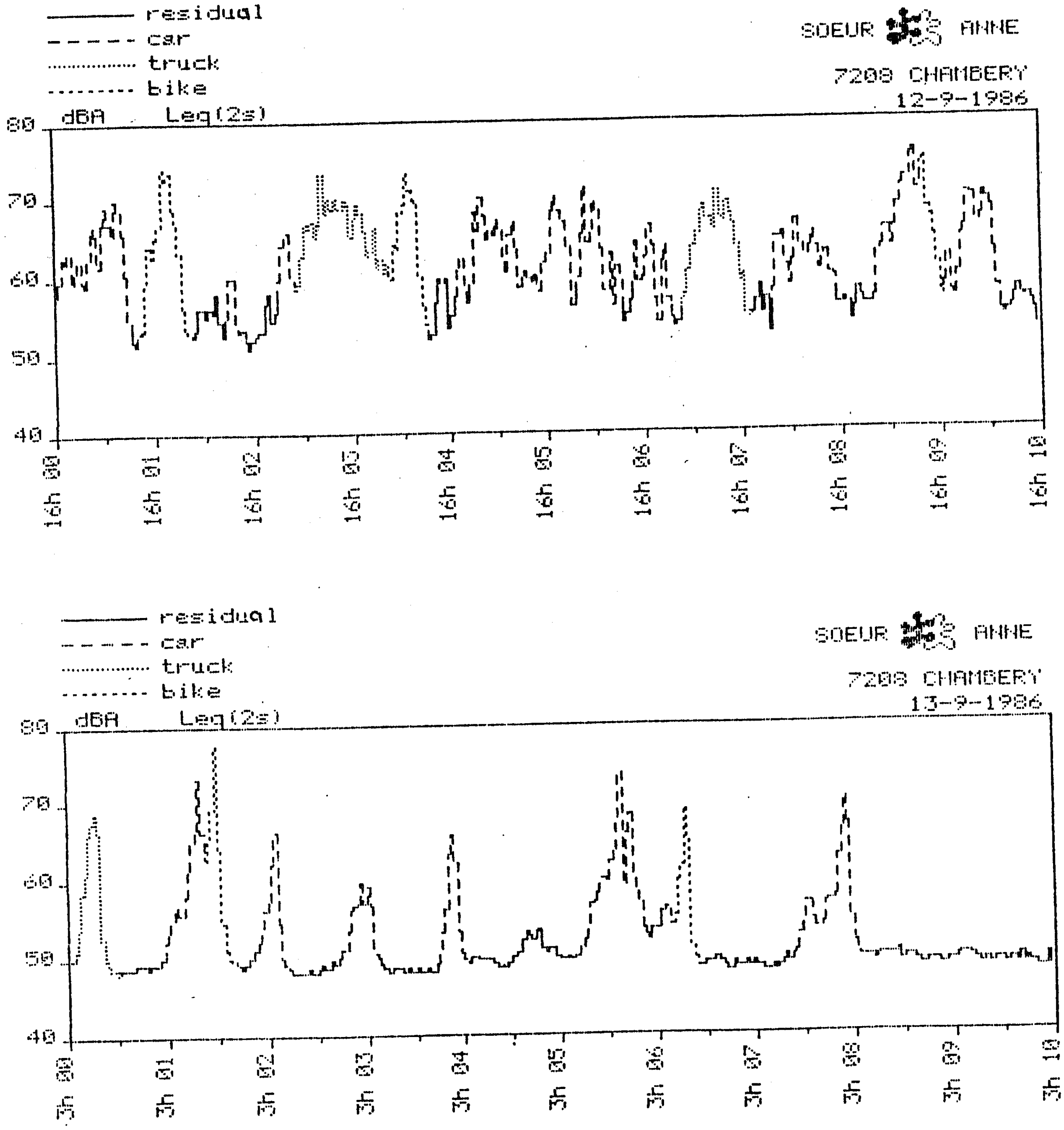

Fig.2. Examples of separate coding in a town survey

+190dB, the resolution being 0.1dB over this range. The rest of each 16 bit word is devoted to an overload flag for each Leq plus 4 bits of coding, referred to earlier. In case study 1, this coding was initially used to identify the octave bands but this was discontinued when better methods were found. In the latest variant of the concert hall control system, manual timing of events, for example a new act, can be signalled to the computer.

PROCESSING

In case study 2, the noise map was drawn by hand using data produced by the computer. But what data? This was one of the initial problems. What do we measure? In the UK we would expect L1Ø and L9Ø as well as overall Leq. In New Zealand L95 is popular, while many people like L99 as a background. While in France the partial and full Leq is used. In truth with Short Leq it simply doesn't matter. The raw data is on disc and nearly any of the currently available programmes can recalculate ANY parameter from this raw data if peak is not involved. Thus, results using L1Ø and L9Ø in Scarborough, England, have been compared with L95 and L5 in Rotorua, New Zealand. For the first time, like can be compared with like and the fact that the data is on a simple medium, i.e. a floppy disc, eases the transporting of data. On the town plan we have plotted simple Leq levels for the different times of day. These times - day, night and intermediate - are standardised in France but any other times could be used instead. For example, the actual times of a concert.

The computer can not only plot the overall Leq between any times but noise sources can be automatically resolved. For example the coding referred to earlier can be used to separate the sources, or a rate of change of level, or a simple level itself. In fact almost any algorithm can be used to differentiate between separate noise sources.

Having resolved these sources we can now calculate not only the Leq during the time the offending noise is on, but we can calculate what the level would have been if the source were not there or what the Leq would have been if only the source were there. Thus we have a method which can remove the affect of a noise for calculation purposes and it can do this long after the data is recorded.

COMMERCIAL PACKAGES

At this time only 3 packages are available which meet the full description of an analysis package for Short Leq. These packages use the TRS 8Ø, Apple, BBC HP and IBM/MS.DOS computers. All of them except the MS.DOS software suffer from lack of memory. For example, the Soeur Anne Apple programme using a 48K memory board, can only just download a 44K meter and simply cannot be used with the new generation of Leq meters. The BBC packages from Cirrus have similar problems. Not only does the BBC (model B) run out of memory quickly but it is really only available in the Commonwealth and thus the software is not truly international.

By far the most sophisticated is the Soeur Anne LEQCALC package which can download data from any existing Short Leq meter including the Quest Micro 15 the Cirrus CRL 2.36 and the Soeur Anne SA1Ø-11 and SA11-11. The main disadvantage of the Soeur Anne package is the complexity but to offset this only the Soeur Anne programme offers coding at this time, but no doubt others will follow. However, as all the Cirrus packages offer a 'Zoom time' facility, this can be used to separate sources visually, using the computer's time history display. This is not as powerful as full coding but a very good alternative at a lower cost. The Quest package on TRS8Ø is much more automatic than the others, but as a result is less sophisticated. Naturally, the Quest package will function with other Short Leq meters.

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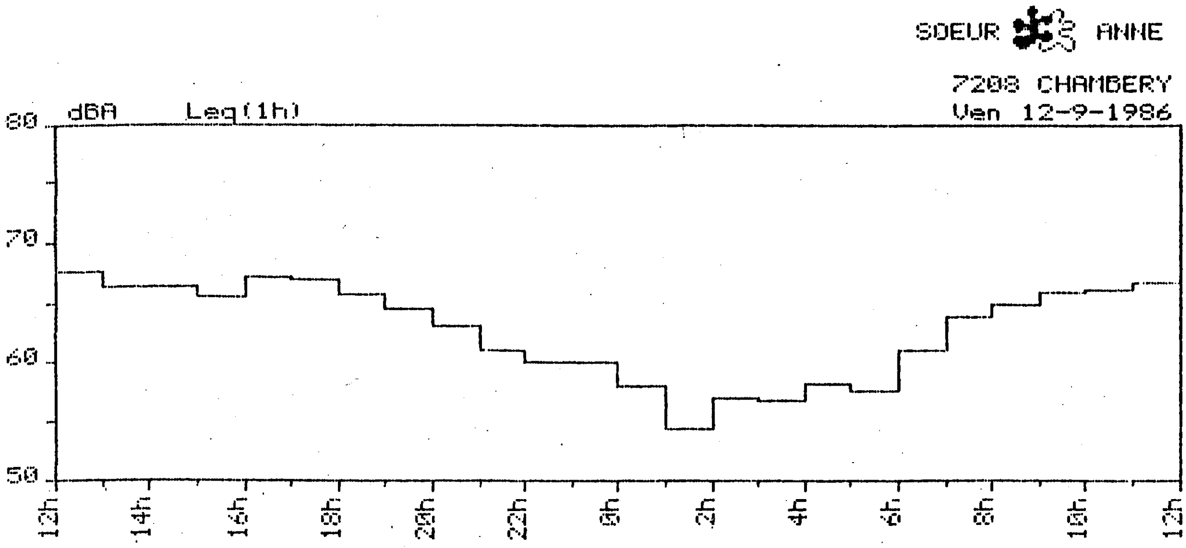

Place : 7208 CHAMBERY

from 12h 0 12-9-1986
to 12h 0 13-9-1986

Basic period : 2 s dBA
Listing sub-period : 1h

period	Leq	s.d.	L10	L90
12h 00mn	67.5	8.0	71.0	54.0
13h 00mn	66.3	6.8	70.0	55.0
14h 00mn	66.3	6.6	70.0	55.0
15h 00mn	65.6	6.4	69.5	54.5
16h 00mn	67.2	6.8	70.5	56.0
17h 00mn	66.9	6.0	70.0	56.5
18h 00mn	65.7	6.4	69.5	55.0
19h 00mn	64.5	6.5	68.5	53.5
20h 00mn	63.1	7.6	67.5	51.0
21h 00mn	60.9	8.3	65.5	48.5
22h 00mn	60.0	8.3	65.0	48.5
23h 00mn	60.0	9.0	62.0	48.0
0h 00mn	57.9	7.6	59.5	48.5
1h 00mn	54.4	5.7	54.0	48.0
2h 00mn	57.0	8.1	55.0	47.5
3h 00mn	56.7	7.4	56.5	47.5
4h 00mn	58.2	8.1	59.5	48.0
5h 00mn	57.7	7.2	60.5	48.0
6h 00mn	61.0	7.7	65.0	50.0
7h 00mn	63.9	6.4	68.0	53.5
8h 00mn	64.8	5.6	68.5	56.0
9h 00mn	66.0	6.0	69.0	56.0
10h 00mn	66.2	5.7	70.0	57.0
11h 00mn	66.7	5.8	70.0	57.0

Global Leq: 64.1 dBA

Fig.3. Example of a 24 hour noise analysis product

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SUMMARY

Naturally to treat a complex parameter such as noise, many options have to be provided and this, of necessity, means some learning time with the technique.

It is our view that the time saved on a single 12 hour measurement is just about equal to the learning time for the most complex programme. Certainly, after half a day we expect any competent acoustician or environmental health inspector to be able to get results he would have considered impossible without the package. This then is the relationship between the 2 different case studies. In both of them we are assuming NO computer knowledge and allowing a powerful piece of software to interface the user direct to the acoustic problem. In one case noise control, in the other noise reporting.

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