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THE MEASUREMENT, ASSESSMENT AND SOLUTION OF A NOISE NUISANCE FROM A RIFLE RANGE, USING NEW COMPUTER-BASED INSTRUMENTS

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1. INTRODUCTION

This paper describes a noise nuisance, experienced at a rifle range, and how the measurements were approached using Short Leq techniques implemented on a notebook computer platform. Based on these measurements, several solutions have been proposed, and their performance measured, resulting in a reduction of the noise problem.

Although a complete case study is described, the paper is intended to focus on the measurement techniques used, rather than to suggest a new method for the assessment of noise nuisance from gunshot noise. However, the results may provide some pointers to future work in this area, at a time when there is considerable uncertainty about the use of other descriptors for this type of noise problem.

2. BACKGROUND

This work results from an invitation to the Environmental health Department of Dinefwr Borough Council, from the West Wales Muzzle and Rifle Association, to attend a shooting event at Cincoed Quarry in Llandyfan, during November 1994. This event was arranged to allow noise monitoring during firing activities, and to assess the impact of this firing on nearby property at Garnfach, Llandyfan.

Several different types of firearms were used, ranging from small pistols up to large muzzle loaded 0.577" guns, and it provided an ideal opportunity to evaluate different measurement techniques.

A map of the area is shown in Figure 1, with the monitoring point around 400 metres from the firing range itself, which is located at the bottom of a disused quarry. Initially, it was thought that the features of the quarry would minimise the noise nuisance, but as can be seen from the measurements, the topography caused distinct features in the noise signature.

Complaints had been received about the noise, although planning permission was already granted for these types of activities, and to the Association's credit, these measurements were set up with a view to reducing the noise problem.

3. THE MEASURING PROCEDURE

For the noise measurements, a Concerto environmental noise analyzer from 01dB was used [1]. This features a small battery powered data acquisition unit, linked up to a portable notebook computer, to create a Type 1 analyzer, using the Windows-based dBENV measuring software.

This virtual instrument logs noise samples to disk, at a predetermined sample rate, and in addition,

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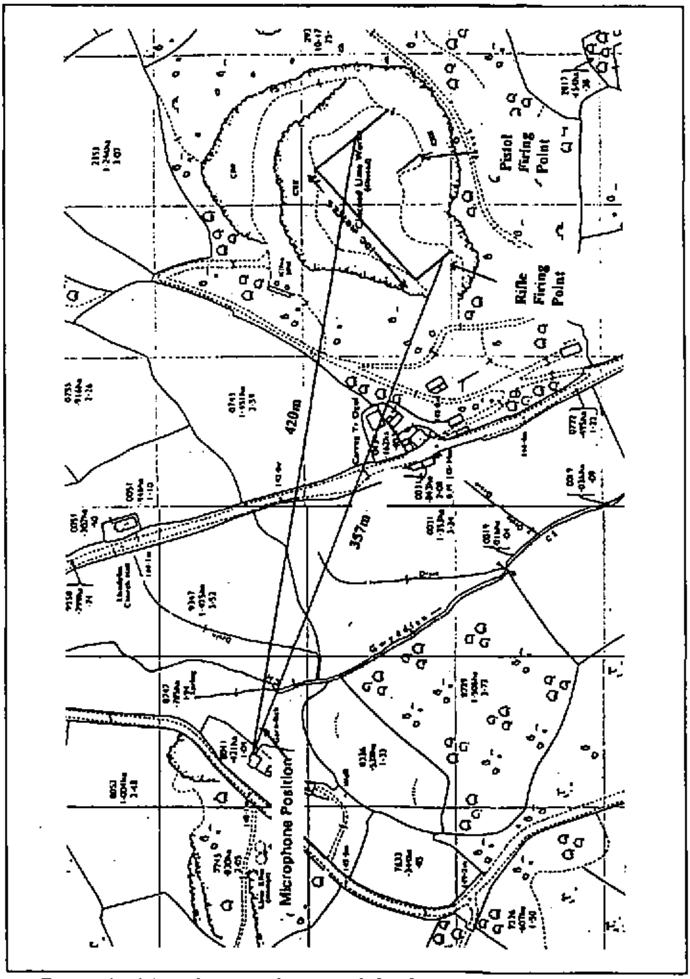

Figure 1 : Map showing the site of the firing range and the nearest affected property

can stream raw audio data to computer disk, either as a function of manual control, or alternatively, thresholds can be set, above which the audio recording is triggered, giving 16-bit recording quality, rather like that of a digital audio tape (DAT) recorder.

These audio records, taken for each type of firearm, prove invaluable for assessing the subjective impact of the noises, as they can be played back through headphones or loudspeakers, and tied in to the measured noise levels. Additionally, frequency analysis can be performed, and the results used for possible noise control measures.

For the measurements described, a B&K Type 4155 Type 1 microphone was used as the transducer, calibrated with a Type 4230 calibrator, both before and after the measurement series.

The results stored on the notebook were then transferred to a similar software package, dBTRAIT, running on a desktop computer back at the office, for detailed analysis, and playback of audio through a SoundBlaster card system.

During the measurements, a time history display is shown on the notebook computer screen, and samples of Short Leq were taken every 20 milliseconds, to give detailed resolution of the noise events. The advantage of the Short Leq technique is that these samples may be combined to give longer term L_{Aeq} values, for comparison with more traditional measuring techniques, as well as calculating statistical parameters such as L_{A90}.

The microphone was placed remotely from the operators, using a 20 metre extension cable, mounted on a tripod 1.5 metres high, and more than 20 metres from the rear elevation of the farmhouse, minimising the effects of local reflections.

Although the noise measurements themselves were A-weighted, the audio samples are recorded with Linear response, giving a realistic replay of the sounds, as well as a valid frequency analysis down to low frequencies, often important for impulsive noise.

To synchronise the measurements, the operator of the system was in two-way radio contact with an officer at the firing range, so the firing sequence could be monitored, and the noise data coded with the correct firearm identification.

During the noise monitoring, normal environmental background noises were also experienced, such as traffic noise, and bird song, and the logging technique proved invaluable for identifying these events, and excluding them from any subsequent analysis.

4. MEASUREMENT RESULTS

4.1 Ten Rifles : Shot Individually

The rifle marksmen were lined up in sequence at the rifle range, and the weapons discharged in sequence over a period lasting around 3 minutes.

Figure 2 shows a time history of the whole procedure, and each event is identified by the type of weapon used. In addition to the firing noise, it can be clearly seen that the general background noise is varying slowly as a result of other noise sources, such as traffic, although it is still easy to pick out the individual events. For each of the events, audio records were taken, for playing back the sounds at a later date.

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For the period chosen, the basic noise level parameters were calculated and are shown in Table 1. Note that because a high number of samples were taken, even over such a short period, it is still valid to calculate $L_{A,90}$ and it should also be noted that the maximum and minimum values will not necessarily correlate to 'traditionally' measured values which use F, S or I time weightings. However, the Short Leq technique provides very consistent results for this type of measurement, as it is independent of any tolerances in time weighted detector implementation.

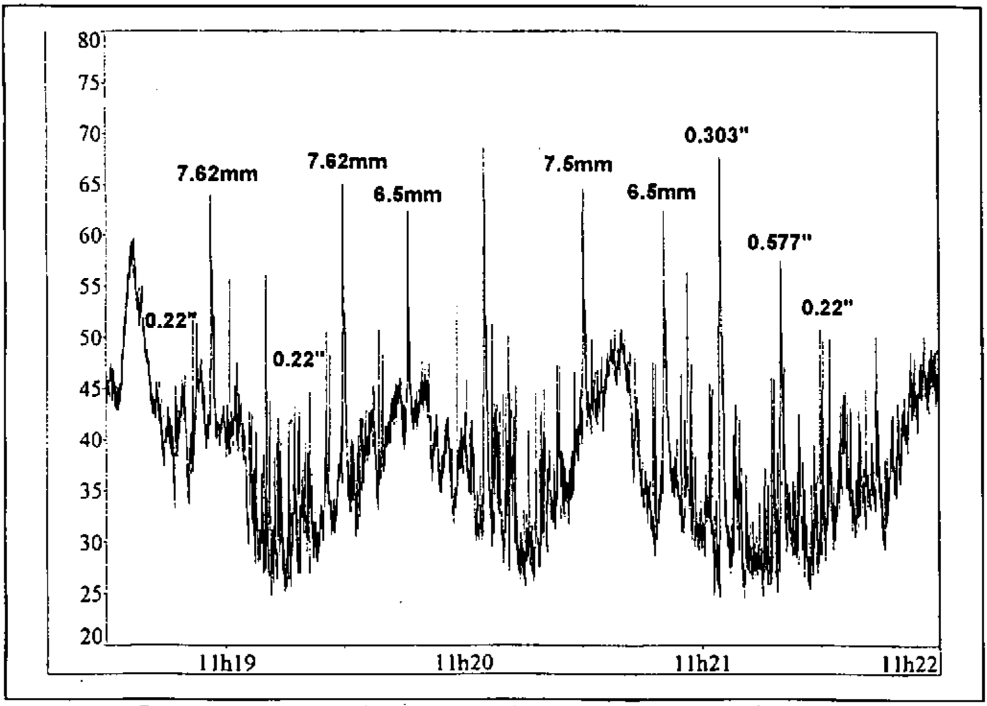

Figure 2 : Time history of noise level against time in 20 ms intervals, showing different calibre weapons

During the shoot, it can be seen that the background noise was very low at 29dB $L_{A,90}$ whereas the maximum noise level $L_{A,max}$ is high for a rural area, reaching a maximum of 68.7 dB. The overall $L_{A,eq}$ of 44.4dB is lower than might be expected, as the gunshots are spread out over the whole period, and the length of the shots is short compared to the overall monitoring period.

File	STEVE001.LEQ				
Start	11:18:39:600 26/11/94				
End	11:21:34:400 26/11/94				
Channel	dB	Leq	Lmin	Lmax	L90
guns	dBA	44.4	24.5	68.7	29

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Objectively, the $L_{A,max}$ level of 68.7dB was approximately 40dB above the background noise level over the monitoring period. Such differences in level can certainly produce a 'startle effect' on persons being subjected to it and can consequently lead to complaints. Sorensen and Magnussen [2] noted such annoyance effects. The rural location of the rifle range only exacerbates this effect.

Some shots were not perceived as objectionable by the complainant as they were barely audible. although the majority were objectionable, as they were clearly audible.

The following Table 2 shows the subjective response to the different types of weapon expressed on a scale of 0 to 3:-

0 = Not objectionable
1 = Quite objectionable
2 = Objectionable
3 = Very Objectionable

It is clear that the different guns have different noise levels due to the size, loading method, propellant and ammunition.

As the data was recorded with very fine detail, it is possible to extract the time histories for each type of gun, and compare them graphically, to evaluate differences in overall level, and also the length of appearance of each event.

Shot	Name	Manufacturer	Calibre	Load	Objectionability	Rating
1	Llewellyn	Not Known	0.22"	Breech	No	0
2	Morgan	No.4	7.62mm	Breech	Yes	3
3	Long	Not Known	0.22"	Breech	No	0
4	Davies	Mauser	7.62mm	Breech	Yes	3
5	Richards	Swedish Mauser	6.5mm	Breech	Yes	3
6	Gimblett	Schmitt-Roben	7.5mm	Breech	Yes	3
7	Swire	Mauser	6.5mm	Breech	Yes	3
8	Poole	Enfield	0.303"	Breech	Yes	3
9	Jones	Enfield	0.577"	Muzzle	Yes	2
10	Colvin	Not Known	0.22"	Breech	No	0

Table 2: Details of the individual shots and objectionability

This is graphically shown in Figure 3, and the resolution of the measurement also shows the effects of echoes, caused by the high sides of the quarry, which may contribute to the annoyance effect, as compared to a pure free field.

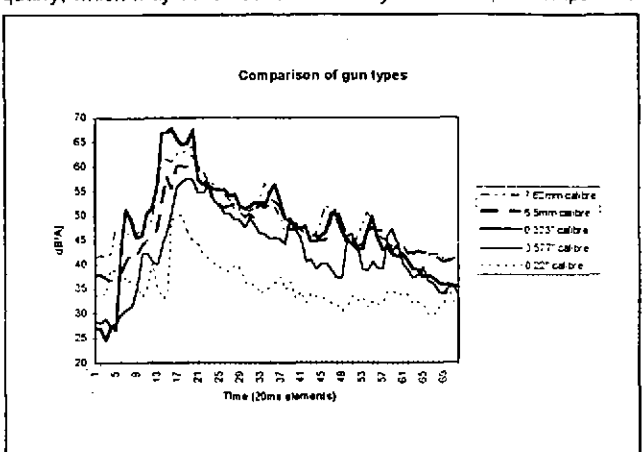

Figure 3 : Comparison of types of gun

This data was extracted from the time history plot in dBTRAIT, and pasted into the Windows clipboard, for use by a MS-Excel spreadsheet, which features very powerful graphics options.

The graph shows individual Short Leq values calculated every 20ms, and it is possible to see distinct echoes in the traces. The width of the peaks may relate to the subjective 'strength' of the source, and the echoes may be perceptible, being outside the 80ms window for perceiving distinct peaks subjectively.

It is clear from the table that the least objectionable shot correlates to the lowest level, and as the 0.22" rifle was not classed as objectionable, this implies that the noise level at the complainants property should be reduced to an $L_{A,max}$ of 50dB or below. This means an overall reduction of the loudest gun, the 0.303" calibre Enfield, by over 18dB.

This may not be achievable in the context of *Best Practicable Means*, in view of the fact that planning permission has already been granted for the site, and a compromise needs to be reached regarding the level of noise abatement employed.

4.2 Ten rifles : Shot randomly

In order to measure the effects of the firing of ten rifles at random intervals, a further set of measurements was taken, this time over approximately 3 minutes, and during this period, over 50 shots were fired. A representative one minute period was taken, to allow comparisons of all randomly shot events.

Figure 4 shows the time history, and the standard noise indices were calculated as before. The $L_{A.eq,1min}$ for this period was 53dB, around 22dB above the notional background level, and each shot lasts around 1.5 seconds before the level returns to ambient.

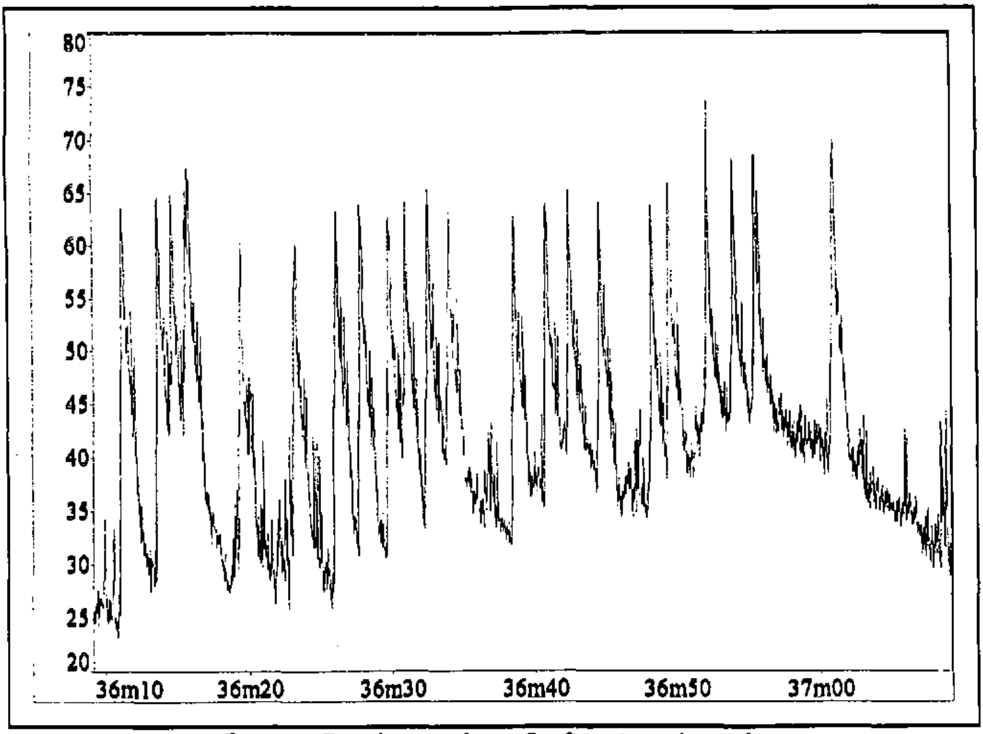

Figure 4 : Time history of ten rifles firing in random order

The subjective response to the noise was described as 'very objectionable', and the measured $L_{A,max}$ of 74dB justifiably would give cause for complaint. Because of the random nature of the firing, the startle effect is more severe, and in general, it can be concluded that if the $L_{A,max}$ is above 50dB in this situation, then complaints would be justified.

Several more measurements were taken, with different calibre weapons, and the full results are available in [3], if more background information is required.

5. NOISE REDUCTION MEASURES

As a result of the above noise measurements, it was evident that the levels measured constituted a statutory noise nuisance at the monitoring property. It was agreed to implement noise control measures to reduce the noise radiation from the firing, and the levels re-measured at a later date.

It was decided to develop silencers for the weapons, through which the marksman could fire. The problem was to achieve a satisfactory reduction of noise, whilst not seriously impinging on the freedom of the marksman, during the aiming and firing process. Similarly, noise treatment was specified for the building containing the firing range, which was split into 10 discrete lanes around 1.7m wide, 2 m high and 2 m long.

Several types of silencer were tried, an example of which can be seen in Figure 5, and each silencer measured in-situ to establish the effect on the measured noise levels.

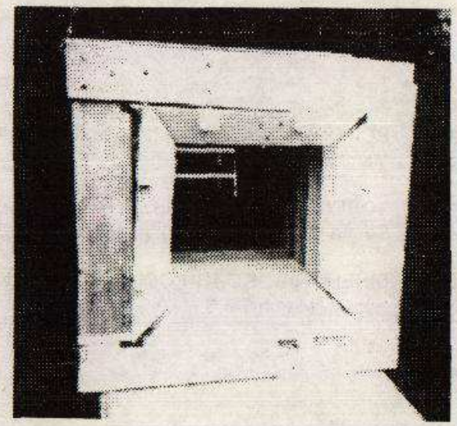

Figure 5 : Example of silencer design

A similar measurement procedure was used, with the Concerto noise analyzer, and gun shots were used as a source each time, with and without the silencer fitted.

The silencer shown in Figure 5 was chosen as the best design, and consisted of a 3/8" hardboard woodframe, with 12" internal baffles inside a 12" square hole, with the baffles angled back towards the firer at 45 degrees.

The results of this silencer design were calculated on the two most powerful rifles, the 0.303" Enfield and the 0.243" calibre rifle, and showed a reduction of the levels by around 19dB(A).

Subjectively, it was felt that all the silencers made a significant difference to the loudness of the rifle shots, and the shots which were attenuated below 55dB $L_{A,max}$ were not sufficiently loud and 'startling' to constitute a noise nuisance. This was with a background level given by $L_{A,90\ (5\ min)}$ of 35dB.

As a result of these tests, the approved silencer will be built into the structure of the firing range, and further monitoring performed to ensure the control of the noise from the site.

6. CONCLUSIONS

The measurements of noise from a rifle firing range have been described, and some results presented. The technique employed shows a detailed history of firing noise, and provides a means of assessing the subjective annoyance of gun shot noise in a rural environment.

The results have been used to suggest and verify noise control measures, by using silencers of varying design, and may provide some pointers for future assessment methods for this type of noise.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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[3] DINEFWR BOROUGH COUNCIL, 'Noise Assessment of Rifle and Pistol Shooting Range', Internal Report, March 1995