BEL ACOUSTIC

REPORT ON

NOISE FROM MAIN FIRING RANGE: POLICE COLLEGE, PORIRUA

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ABSTRACT

The level of noise emitted from the types of guns used in training at the main indoor firing range was measured.

The level of exposure of both the students firing the weapons and the instructors is high and exceeds the recommended and legal limits by as much as 26dB. This requires the use of high grade hearing protectors.

The Protac 2 hearing protectors in current use at the range should be inadequate but hearing protectors with a Classification less than 4 are inadequate.

Although there is insufficient reduction in the level of noise using the suppressors available, to achieve a level of sound less than the limits stated in the Regulations, the use of suppressors on the rifles needs to be implemented to reduce the exposure in accordance with the HSE Act.

The recommendation is for the use of one type of protector for use with all the types of guns that exceed a level of 140dB L_{peak} or a level of 116dBA SEL, and therefore this should be based on the level of noise produced by the Glock pistol. Hearing protectors should be selected so that there is a minimum amount of over-protection. Any more protection than this can be the cause of the problems.

Based on the current state of knowledge and best practicable option, the most suitable type of hearing protector for use until guns can be modified with a suitable silencer is as follows:

- A Class 5 earmuff (preferred), or
- A Class 5 earmuff with any class earplug in combination

In addition, use eye protection of a type that minimises the leakage of sound into the earmuffs i.e. goggles with an elastic headband

The use of screens in training does not affect the level of noise exposure.

The further acoustic treatment of the range is considered as unnecessary since additional treatment will not significantly affect the level of noise exposure.

A range of management protocols needs to be implemented for the firing range.

INTRODUCTION

There are two indoor ranges at the College – the Main Range where there are essentially two types of weapons used and the Lower Range where two weapon types are also used. This report is concerned with the assessment of the main range only. There is a requirement to ensure the safety of the firing ranges at the college in all respects before they can be used. Part of these requirements is to ensure that the correct procedures and safety equipment is used during the operation of the ranges.

In order to assess these issues the level of exposure of both students and the instructors to the noise from the firing of weapons during training and other sessions is required to be determined. This will then enable the determination of suitable hearing protectors or operational procedures that will minimise the likelihood of excessive exposure to the noise from the use of the weapons.

The legislation and OSH standards dealing with noise in the workplace specify a maximum exposure to noise in terms of both an A-weighted $L_{eq,8h}$ level and an unweighted Peak level, L_{peak}. It is important to recognise that it is the daily average level of noise exposure (including peak levels) that determines the risk of hearing damage.

In order to determine the normal exposure, the noise emitted by samples of the weapons that are actually used in the training sessions was measured.

The results of those measurements was then used to develop appropriate procedures that would be required to ensure that hunters in normal daily operations would not be exposed to excessive levels of noise taking into account the conflicting requirements for stalking animals.

The measurements were carried out on the afternoons of 14th and 19th September 2006 at the Main firing range at the Police College, Porirua.

The purpose of the measurements was to determine the following:

- The noise levels in terms of Peak level and spectrum levels at ears of the firer and other nearby locations
- Recommendations for hearing protectors and their use

There were two different weapons available for the testing – those commonly in use in the training exercises.

The rifle had two types of silencer available for testing for comparison with unsilenced weapons.

RANGE

The Main range is a rectangular shaped concrete and steel fabricated space measuring approximately 50 x 30 metres with a roof height at the centre of about 6 metres. The floor and walls are concrete with steel beams supporting a metal roof. The surfaces of the walls and ceiling have been treated with 100mm polyester acoustic absorbent material covered with perforated aluminium foil. The stop-butt behind the target area consists of shredded rubber tyres; the target wall above the stop-butt is treated with the same material as the rest of the walls and ceiling.

LEGAL REQUIREMENTS

The Health and Safety in Employment Act 1992 (the Act) places obligations on employers to ensure the safety of employees. This includes the identification of significant hazards of which excessive noise is one. The Act is binding on the Crown.

The Health and Safety in Employment Regulations 1995 (the Regulations) specifies in Regulation 11, the level of noise exposure that is deemed to be excessive and that is likely to result in serious harm following a period of exposure to such a level.

This maximum level of exposure to noise is stated in Regulation 11 as a Noise Exposure Level ($L_{Aeq,8h}$) of 85dBA or a Peak level (L_{peak}) of 140dB (see glossary of terms in Appendix 2 for an explanation of these terms).

Therefore where the Noise Exposure Level exceeds 85dBA and the Peak Level of noise exceeds 140dB, an employer is required to follow a hierarchy of steps to protect employees from the harmful effects of excessive noise.

Where it is not practicable to eliminate, reduce or isolate the excessive noise, there is a duty to take all practicable steps to minimise the likelihood of the noise being a source of harm. Part of this minimisation process is to provide for suitable protective equipment (hearing protectors) for the use of exposed employees and to provide training in their use.

Such hearing protectors are required to be of a type and quality that will give sufficient protection against the amount of noise to which the person is exposed. In essence the protectors should be capable of reducing the level of noise exposure to less than the limits stated in the Regulations as indicated above.

This assessment should be considered as the first step in a series of steps required by the Act, being to identify and assess the noise hazard concerned with the use of this type of weapon.

OTHER RELEVANT INFORMATION

The Research and Technology Organisation of NATO has published reports dealing with Damage Risk from Impulse Noise. The relevant documents are:

- Report RTO-EN-11 AC/323(HFM)TP/31 *Damage Risk from Impulse Noise* (Published in September 2000)

- RTO TECHNICAL REPORT TR-017 HFM-022 *Reconsideration of the Effects of Impulse Noise*
(Published in April 2003)

The conclusions from this research work with regard to the matter here, include the following details:

> The objective of RSG-029 was to assess the risk of hearing loss from exposure to impulse sounds, by identifying occurrences which are hazardous, and to develop measures which will protect hearing under such circumstances. In order to do this, one must be able to identify, from their physical parameters, exposures that are deemed hazardous.
>
> In view of the data sets available, the analysis had to be restricted *to unprotected exposures to rifle noise (normal incidence)* and *to protected exposures to blasts (measured under the hearing protector, near the ear canal)*. In terms of the impulse properties, this should be interpreted as short shock waves on unprotected ears and slow rise-time pressure waves on protected ears, respectively.

1. At present RSG-029 cannot propose a single measure, or assessment method, that enables adequate prediction of auditory hazard from impulse noise for impulses from light calibre weapons with impulse durations of 0.2 ms to those from large calibre weapons or blasts with durations up to 5 ms.

2. The data available today allows for assessment of auditory hazard only on the basis of a temporary shift in hearing threshold shortly after exposure and its recovery. The present analysis is based on full recovery within 24 hours at 4 and 6 kHz. According to the data available, this criterion can be met at either frequency when the temporary threshold shift, 2 minutes after exposure, (TTS2) does not exceed 25 dB. The limit of 25 dB applies to 95% of the population exposed. Limited statistics do not allow an extension of the protected fraction of the population exposed to more than 95%. This criterion is more stringent than the criterion of 15 dB of TTS, averaged across a 1, 2, and 3 kHz, two minutes after the exposure, not to be exceeded by more than 10% of the population exposed, which was adopted in a previous study (RSG.6).

3. Sound exposure level (SEL – level which, if maintained constant for a period of 1 s, would convey the same sound energy as is actually received from a noise event) can be used as a measure to describe impulses. This avoids the sometimes difficult assessment of impulse duration. Comparison of different frequency weightings, the widespread use and general availability of the A-weighting, and consideration of the equal-energy concept implicit in the use of SEL, suggest that A-weighted energy expressed as dBA SEL is an appropriate measure. A further advantage is that dBA SEL can be directly obtained from standard measuring equipment, available in military facilities and companies.

4. For both impulse noise from rifles, and blast from explosions and large-calibre weapons, there is a critical exposure level that should not be exceeded.

- For impulses from rifles (unprotected ear, normal incidence) this critical level is 116dBA SEL *per impulse*, measured in free field at the location of the ear. This critical level applies for a number of impulses, N, up to 50 at a rate of one impulse per 5 to 10 seconds.
- For impulses from blasts (under the hearing protector, near the ear canal), this critical level is 135dBA SEL *per impulse*. The critical level for blasts applies when $N \leq 100$ at a rate of about one per minute.

5. The critical level *for rifles* of 116dBA SEL corresponds to about 153dB peak level (in the free field). This level exceeds the instantaneous sound pressure of 140dB, up to which ISO 1999 applies, by 13dB. Due to differences in impulse duration, no unequivocal translation to peak level can be made for the critical level *for blasts* of 135dBA SEL.

6. The equal energy principle can be applied to impulse sounds from rifles and blasts if the critical number of impulses (50 and 100, respectively) is exceeded.

- For rifles, if N>50, the exposure limit becomes 124dBA SEL or $L_{eq,8h}$ = 80 dBA.
- For blasts, if N>100, the exposure limit becomes 143dBA SEL or $L_{eq,8h}$ = 98.4 dBA.

The above limits apply to *N impulses together*.

7. When one wishes to use the equal energy principle for smaller numbers of impulses one should stay with the critical levels (per impulse) given above for $N \leq 5$. For N> 5 the present data suggest that application of the exposure limit in terms of equal energy given above implies an overprotection of at most 10 dB, both for rifles and for blasts.

8. The equal energy principle (formally applicable to PTS data, i.e., permanent threshold shifts) implies that the exposure level has to be decreased by 10dB for every tenfold increase of the number of impulses. The present analysis of TTS data shows that the number should be smaller than 10 dB. Numbers between 2dB and 7dB are found; 5dB was proposed in the CHABA document based upon TTS data (1968). However, the present data suggest the concept of a critical level introduced above, rather than the application of a smaller level-number trade-off function.

9. The analysis shows that a frequency weighting function putting more emphasis on the contribution from high-frequency energy to the exposure measure will improve the accuracy of auditory hazard prediction. The 19-dB difference between exposure limits for rifles and blasts when applying A-weighting decreases to about 13 dB when a weighting function is applied that follows the threshold of human hearing (T-weighting in this report). It decreases to about 10 dB when the weighting function is based on bands of noise producing the same TTS (Eq TTS weighting in this report). Modern sound level meters can be equipped with alternative spectral weighting functions. However, in principle there is no weighting function that can account for the finding that TTS in animals decreases with increasing duration of well controlled impulse wave forms. The 10 dB difference between the exposure limits for rifle noise and blasts, remaining with the most suitable Eq TTS-weighting function, must be related to this finding in animals.

10. A single measure of impulse sound exposure enabling adequate prediction of auditory hazard from impulses with durations from 0.2 to 5 ms, or longer in reverberant conditions, should ideally be based on nonlinear elements in exposure assessment that account for the protective action of high-level low-frequency energy in the impulse. The only method based on this principle, which is presently available, is the Auditory Hazard Assessment Algorithm for the Human ear (AHAAH). However, RSG-029 disagrees on the general validity of this method (see Chap. I, Sec. 7 and Chap. II for different views).

11. Hearing protection should be evaluated for impulse sounds from which the ear has to be protected, at the relevant levels, using a representative angle of incidence. The standard specifications of hearing protector attenuation apply to low-level random-incidence noise. Hearing protectors may give lower effective attenuation for high-level impulse noise.

12. Hearing conservation programs must aim at preserving good hearing of today's soldiers. Apart from the crucial role in readiness and survivability, effective conservation programs result in substantial reduction of training costs and costs for compensation of hearing loss.

13. Recent animal studies on the treatment of acute noise trauma have shown (partial) recovery of threshold shift. Depending on the (combinations of) medication, recovery can be improved. Future experiments should focus on the development and validation of local application of drugs directly into the cochleas of human subjects.

A critical level of exposure appears to be as follows based on this advice, and the following limits should be applied:

- Exposure to a level from a single shot of 116dBA SEL
- A daily total exposure level of 124dBA SEL for numbers of shots greater than 50 (This is equivalent to an exposure level of 80dBA $L_{Aeq,8h}$)

This should be considered as an appropriate criterion level for the energy content of gunfire in addition to the limit for Peak noise level.

In the Joint Australian/New Zealand Standards (Series AS/NZS1269, 2005) the recommendation for protection against impulse noise takes note of the fact that the high impulse level can cause instantaneous injury, thus the Standard is being conservative in its' approach. Where individuals are exposed to multiple levels and events of impulse noise it is presumed that they will be more cautious than if there is only one event. Certainly in the case of one event at 140dB Peak the individuals could get away with a Class 1 protector but they may only get one go and if injury occurs the Standard would appear to be inadequate. With exposure to "continuous" types of noise the time period for damage to occur is in the order of years so there is an opportunity to correct for any deficiencies in the Hearing Protector program before damage is likely to occur.

HAZARD IDENTIFICATION

The focus of this assessment was on measuring the noise emitted from the weapons normally used by officers in the course of training and field work. Because the type of noise produced is impulsive in nature, that is to say, it is very short in duration and very high in sound level, the type of measurements necessary are also special in nature and require the use of specialised equipment. The information derived from the measurements will then enable the establishment of the exposures of the person firing the weapon and anyone close by.

At present in New Zealand two main terms are used for expressing the amount of noise to which a person is exposed: *Noise Level* and *Noise Exposure Level*. A third parameter used and that stated in the Regulations is *Peak Noise Level*.

NOISE LEVEL (symbol $L_{Aeq,T}$) is simply the strength or physical magnitude of noise, expressed in dBA (the A-weighted noise level). For example, the noise level in a vehicle is 82dBA.

NOISE EXPOSURE LEVEL (symbol $L_{Aeq,8h}$), on the other hand, is the total amount of noise energy a person is exposed to in the course of their working day, expressed as an 8-hour average. It takes account of both the noise level and the length of time the person is exposed to it.

To attain a noise exposure level of 85dBA, a person would have to be exposed to a noise level of 85dBA for 8 hours (or to some other combination of noise level and exposure duration having the same total energy).

It is possible for the noise exposure level to be less than 85dBA even though the noise level is greater than 85dBA. This happens, for example, if a machine creates a noise level of 90dBA but people were exposed to it for only 2 hours a day. In this case the noise exposure level would be 84dBA.

The 3dB rule is worth noting. The rule is that when determining noise exposure level, halving the exposure duration is equivalent to decreasing the noise level by 3dBA and doubling the exposure duration is equivalent to increasing the noise level by 3dBA. It follows from the 3dB rule that the combinations of noise level and exposure duration shown below all produce the same Noise Exposure Level of 85dBA:

85dBA for 8 hrs	88dBA for 4 hrs	91dBA for 2 hrs	94dBA for 1 hrs
.... and so on to:	120dBA for 10 secs	130dBA for 1 sec	

The preferred approach of determining the Noise Exposure Level of people is to measure the actual noise level at their operating locations.

Because of the nature of the gunfire noise (impulse – short duration), the measurements consisted of measuring the Sound Exposure Level (SEL) both directly and indirectly together with the Peak sound pressure level (L_{peak}). SEL is a special sort of L_{eq} measurement. From the determination of SEL for single shots the $L_{Aeq,8h}$ can be determined for any number of shots and compared with the limit in the Regulations. The Peak level is compared with the regulatory limit directly.

The Regulations require action when the Noise Exposure Level exceeds 85dBA or the Peak level exceeds 140dB. The immediate action should be to determine the type of hearing protector to protect the exposed people from the excessive noise exposure. This is the principal aim of this assessment.

So, the measured noise levels can be used to determine the type of hearing protector to be worn by those exposed, to ensure that the wearer is exposed to no more than 85dBA $L_{Aeq,8h}$ or 140dB peak no matter what the duration of exposure is.

This is the procedure that is recommended and has been assumed in the measurement work for this assessment.

PEAK NOISE LEVEL (symbol L_{peak}), is determined by sound measuring equipment with a "Peak" response (or time-weighting). It is effectively the level of the highest sound pressure produced by the weapon. For a weapon such as the one under consideration here this peak level of noise is present for a very short period of time during the total duration of the impulse of sound which itself is of extremely short duration. A typical duration of the peak is less than one millisecond (one thousandth of a second) in a total duration of several milliseconds or so. Even for durations of sound as short as this, it is considered that when the peak level exceeds 140dB, damage is likely to occur to the hearing mechanism within the ear.

At the present time, there are no National nor International Standards that quantify the attenuation that hearing protectors can provide against impulse sound. This is because the attenuation obtained from a protector when exposed to impulse sound is not necessarily the same as that obtained from "normal" continuous sound. There are difficulties in formulating a standard test procedure to measure the attenuation in the laboratory, which is the principal reason for the lack of such documents.

The best information to date is that contained in AS/NZS 1269 Part 3. In Paragraph B2.1 in Appendix B (which deals with the selection of a Hearing Protector when L_{peak} exceeds 140dB) the recommendation is that hearing protectors having a classification of 5 should be used for protection against impulse noise from small-calibre weapons.

In the absence of anything more definitive, this is the best advice available.

MEASUREMENT PROCEDURES

The measurements were conducted in accordance with the Joint Australian/New Zealand Standard AS/NZS 1269.1, 2005: *Occupational Noise Management - Measurement and Assessment of Noise Immission and Exposure*.

Because of the high level of sound produced by the weapons at the firer and close-by positions, a normal microphone simply cannot be used for these measurements. A special microphone capable of measuring peak levels up to 170dB was used.

The instruments used to conduct the noise measurements during this assessment are listed in Appendix 1. The meter was calibrated immediately after turning it on and immediately before the meter was turned off both before and after the series of measurements. The calibrator used was that listed in the table of instruments in Appendix 1.

The CEL-573 meter is a real time frequency analyser. It is capable of measuring the noise in octave or $^1/_3$ octave bands. $^1/_3$ octave band measurements were made with this meter at each ear of the person firing each weapon and also at locations nearby. This enabled a detailed analysis of the hearing protector and procedures requirements for each of the weapons. This is a procedure recommended in AS/NZS 1269.3, 2005: *Occupational Noise Management – Hearing Protector Program*.

The reverberation time of the range was measured using an M4 rifle as the impulse source.

Exposure measurements were taken with the microphone at approximately 100mm away from the left and right ears of the person firing the weapons. Measurements were also taken at other locations where the tutor would often be located during weapons firing. These locations are indicated in the diagram below.

Two types of gun were tested:

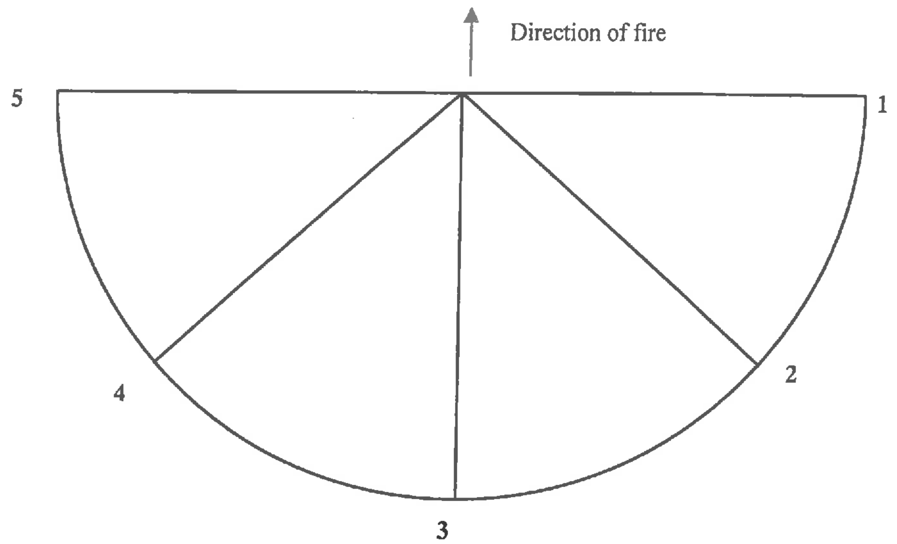
- Glock 17 Pistol – using frangible 9mm ammunition
- Bushmaster M4 rifle – 0.223 calibre RHT ammunition

The M4 was also tested with a PES suppressor and a ZIG suppressor.

Other measurements were located to assess the exposure of the instructors to the fire from the various students. These locations were:

- Close to the student to enable the inspection of the trigger finger (Finger)
- Adjacent to the student being instructed (Location 1)
- At the location of the adjacent student firing position (Location 2)
- Two more remote students (Locations 3 and 4)

Tests were also conducted in an arc around the firer at a distance of 3 and 5 metres as indicated below.



The instructors normally have four students each and move between them during the training exercises.

MEASUREMENT RESULTS

Peak and Sound Exposure Level Measurements

The measured Peak and SEL noise levels are tabulated below. The levels are rounded to the nearest whole decibel.

The Standard Deviation (SD) is a measure of the variability of the measurements. The smaller the number is, the more consistent were the results.

A value of 130dBA for a single SEL is the equivalent of a level of 85dBA for a duration of 8 hours – in other words it is the same as 85dBA $L_{eq,8h}$.

It can be seen from the results in Table 1 that the amount of variance in the amount of noise emitted from the different types of guns when fired was low.

The silencers used on the 0.223 calibre M4 rifle reduced the level of noise emitted by approximately 15dB.

The M4 when not fitted with a silencer produced noise levels between 156dB and 162dB L_{peak} at the ear of the person firing the gun. This is up to 22dB above the statutory limit. The level was higher than this for the instructor at the "finger" location observing the student's finger action. These guns should be silenced using a silencer with an attenuating factor of at least 26dB in order to avoid exposing the firer and the instructor to excessive levels of noise. This may not be possible with a practical design of a suppressor.

TABLE 1: MEASURED NOISE LEVELS – MAIN RANGE

WEAPON USED	AVERAGE L_{peak} (dB)	STANDARD DEVIATION (Peak)	AVERAGE SEL (dBA)	STANDARD Deviation (SEL)
GLOCK				
Right Ear	161	0.4	122	0.5
Left Ear	163	0.2	122	0.6
Finger	166	1.1	126	0.6
1	159	1.0	120	0.9
2	157	0.8	118	1.0
3	153	0.4	117	0.8
4	150	0.3	115	0.7
BUSHMASTER M4				
Right Ear	156	1.1	122	0.6
Left Ear	160	1.2	123	0.5
Finger	164	0.4	124	0.3
1	158	0.8	121	0.3
2	157	0.8	119	0.2
3	154	0.5	118	0.1
4	152	0.7	117	0.2
M4 WITH PES				
Right	141	1.6	106	0.6
Left	143	0.7	109	0.6
Finger	144	1.0	110	0.5
1	142	1.6	107	0.6
2	140	1.1	106	0.7
M4 WITH ZIG				
Right	141	0.5	107	0.8
Left	144	1.2	109	0.7
Finger	146	1.2	110	0.4
1	141	1.3	106	0.3
2	137	1.0	103	0.2

These results are consistent with reported levels from other sources of noise from these types of weapons.

There is a significant difference between the exposure of the right and left ears of the firer of the gun. For a right-handed person the left ear has a greater exposure than the left ear and conversely for a left handed person.

There was little fall off in the level of sound from the guns at close distances. For example, at a distance of 1.5 metres (location 2 - where the instructor is often located, about 1½ metres from the firer) the Peak level of sound was between 2 and 4dB lower than at the firer's ear for the Glock and M4.

The change in the SEL was similar – at this location the level dropped between 3 and 4dBA.

The measurements show that the use of screens does not have any effect on the received level of noise.

Taking into account the above information, any operational procedure will need to include all bystanders in the hearing conservation protocols adopted.

Reverberation Time

The reverberation time (RT) of the main range was measured using an M4 as the impulse source. The reverberation time of sound in the 500Hz octave was found to be about 1¼ seconds. This is relatively short for a space of this volume and is due to the reasonably large amount of absorption already present. Additional acoustic absorptive treatment will need to be substantial to reduce the RT significantly. Reduction in the reverberation will not significantly reduce the level of exposure of the people and is therefore considered as unnecessary.

Determination of the Noise Exposure of Firers and Instructors

The level of exposure at any of the measured locations can be calculated for any number of shots in a day. The relationship is:

$$\mathbf{L_{Aeq,8h} = Average\ SEL + 10Log(N) - 44.6\ dBA}$$

where N = the number of shots in a day (See table in Appendix 4).

The value for the 10Log(N) relationship can be determined from the table in Appendix 4.

So, for example, if an instructor is exposed to 150 shots from the Glock at "finger" location at an average level of 126dBA SEL and 100 shots from the Glock at "location 1" at 120dBA SEL in a day and 100 shots at "location 2" at 118dBA SEL in a day, the total exposure is:

Glock (finger location) $L_{Aeq,8h}$ = 126 + 10Log(150) – 44.6
= 126 + 21.8 -44.6
= 103dBA (103.2 rounded)

Glock (Location 1) $L_{Aeq,8h}$ = 120 + 10Log(100) – 44.6
= 120 + 20.0 – 44.6

$= 95dBA$ (95.4 rounded)

Glock (Location 2) $L_{Aeq,8h} = 118 + 10Log(100) - 44.6$

$= 118 + 20.0 - 44.6$

$= 93dBA$ (93.4 rounded)

So, **Total $L_{Aeq,8h}$** $= 103 + 95 + 93 =$ **104dBA (104.0 rounded)**

This is 24dB above the 80dBA SEL criterion suggested by NATO. The Class of hearing protector required can thus be determined from this level of exposure.

In this particular example the required Class is 5, since the criterion level is 80dBA rather than the normal 85dBA used in the Classification table.

Any combination of partial exposures can be determined using this method, simply adding up the partial $L_{Aeq,8h}$ from the numbers of shots for each weapon and/or location. The total numbers of shots that the students and the instructors are exposed to will probably be several times the number of shots (possibly three of four times) that each student fires in a day. Both the students and the instructors are exposed to the shots from the adjacent students firing. Though this level may be slightly lower than from their weapon, it is still highly significant. This additional contribution probably adds at least 5dB to the total SEL of the students and the instructors.

SPECTRUM MEASUREMENTS

The measured SEL spectrum levels are tabulated in graphical format in Appendix 3.

The frequency analysis measurements were obtained using the CEL Real Time Frequency Analyser. The measurements were taken at the left ear (being generally the ear receiving the highest exposure). Measurements were taken on 5 shots for the M4 with and without the silencer attached. All the results are to 1 decimal place as read off the meter.

The average spectra for the various guns are illustrated in Appendix 3 in a graphical format. They show the average un-weighted spectra for the shots used. The overall "Linear" noise level is the sum total of the $^1/_3$ octave band levels of the "linear" spectrum. Similarly, the overall "A-weighted" noise level is the sum-total of the A-weighted $^1/_3$ octave band levels of the spectrum.

These spectra show that the overall A-weighted noise level is principally determined by the frequencies above 250Hz. The lower frequencies do not contribute significantly to the overall A-weighted level of noise.

The level of noise produced is very high and certainly warrants the use of hearing protectors, even though the exposure of individuals may be limited to a relatively low number of shots on any one day.

ASSESSMENT

GENERAL

There may be difficulties involved concerning the wearing of safety equipment that should be worn by the people using guns and those situated close by. Either the level of noise exposure from the gun needs to be limited to a safe level or hearing protectors that enable the firer or instructor to listen normally whilst wearing the protector but when a gun is fired the protector then provides adequate protection from the impulsive sound produced.

The measurements show that the M4 gun when fitted with two types of silencer is not quite capable of limiting the level of noise produced to within the limits. This means that some form of hearing protection is still required unless there is a suppressor available capable of reducing the noise emitted to a greater extent.

The Health and Safety in Employment Act requires this reduction of noise at source course of action and to a level of reduction that results in the level of exposure being "safe", where this is practicable.

The use of a suppressor on a gun extends the length of the gun and places extra weight on the end of the gun. This can affect the balance of the gun and make it more difficult to handle and hold. However, these problems are outweighed by the benefit that results, in that the level of sound emission is minimised as required by the Act.

The Glock pistol is not capable of being fitted with a suppressor.

Protection Against Noise Hazards

It should be appreciated that the Noise Exposure Level legal limit of 85dBA $L_{Aeq,8h}$ and 140dB L_{peak} is not a level that has a zero associated risk. The sensitivity of people to hearing damage from a given level of noise exposure varies. There is approximately a 10% risk of hearing damage at a Noise Exposure Level of 85dBA. There is probably also a similar level of risk to peak noise levels. Internationally it is generally considered that there is some risk associated with exposure at Noise Exposure Levels above 75dBA. At levels below 75dBA it can be assumed that there is no risk of hearing damage for all persons.

There is no equivalent data available for exposure to peak levels of noise above or below 140dB.

In order to avoid <u>any</u> risk of hearing damage to <u>anybody</u>, exposure to levels of noise above 85dBA, even though the exposure duration is short, or to peak levels above 140dB on even a single occasion, should be avoided or suitable protectors provided and worn.

For gunfire, the hearing protector needs only to be worn at times when the gun is fired. If it is practicable, the protector should be put on immediately prior to firing and it can be removed immediately afterwards if no other shots are expected for some time. However it is appreciated that this procedure will be impracticable in most instances.

It should be recognised that there is a "down-side" to the wearing of hearing protectors. It is usually more difficult to hear other sounds in the (working) environment when hearing protectors are being worn. Some acoustic isolation of the wearer is almost inevitable when standard type hearing protectors are worn. This almost undoubtedly will cause problems associated with the training procedures. This is one of the main reasons why it is not advisable to wear hearing protectors that reduce the level of noise more than necessary to achieve adequate protection. If hearing protectors are to be used, they should therefore be selected on this basis.

Hearing Protectors

The two methods used to determine the appropriate type of hearing protector for use in the workplace are essentially:

1. The new Classification Method: where the Noise Level is checked against a Class List to determine the suitable Class of Hearing Protector,
2. Octave Band Method: where the octave band levels of the noise , together with the attenuating characteristics of the Hearing Protector are used to calculate whether the particular hearing protector will reduce the level of noise to less than 85dBA.

Hearing protectors are assigned to one of five hearing protection classes according to their acoustic performance. When using the Classification System, a personal hearing protector should be selected on the basis of the L_{Aeq} to which an employee is exposed during a working day.

The hearing protector classes and the levels to which they will provide adequate protection are shown below in the Table 2 below:

Table 2: Classes of Hearing Protectors

Hearing Protector Class	$L_{Aeq,T}$ (dBA)
1	Less than 90
2	90 to less than 95
3	95 to less than 100
4	100 to less than 105
5	105 to less than 110

The Octave Band method is more accurate than the classification method since it takes account of the frequency content of the noise. In addition because in this case the level of noise is high and impulsive in nature, it is recommended in AS/NZS1269 that the octave band method of assessment and selection be used.

Octave-Band Calculations

By using the octave band frequency data, the level of protection can be calculated for the different Classified hearing protectors in accordance with AS/NZS1269 standard. This has been done and is illustrated below in Table 3 as spreadsheet data for both the Glock pistol and the M4 rifle.

TABLE 3: OCTAVE-BAND HEARING PROTECTOR SELECTION - GLOCK

GLOCK

Using Leq,8h 500 shot spectrum

	SPECTRUM:								
Frequency	125	250	500	1k	2k	4k	8k	A	C
OB Level (dB)	83.3	92.5	97.9	100.0	96.5	95.8	94.0	104.1	104.3
A-weighting (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0	-1.1		
A-weighted Level (dB(A))	67.2	83.9	94.7	100.0	97.7	96.8	92.9		

Hearing Protector (Grade/ Number)	Effective Attenuation (dB)							Inside Level	Assumed Protective Value	SLC80
	125	250	500	1k	2k	4k	8k	(dBA)	(dBA)	
Peltor ProTac II (MT15H7*2)	16.3	22.9	27.6	32.8	28.6	34.9	38.5	73.4	31	31
CLASS 5										
3M 1427	15.8	16.3	20.8	30.8	33.4	32.7	31.8	76.6	28	28
3M1425	7.9	12.2	24.5	33.9	30.8	27.5	28.6	76.7	27	27
3m1435	12.2	16.4	25.6	28.3	31.8	33.1	30.0	75.7	28	29
3M1440	14.5	17.8	25.1	29.7	31.6	35.9	40.6	74.7	29	30
Moldex M1	13.2	18.9	26.7	33.8	34.1	33.7	32.8	72.8	31	32
Moldex M2	8.9	15.4	21.8	29.9	30.3	33.4	29.0	76.8	27	28
Bilsom 847 NST II	17.5	20.0	29.7	25.9	26.0	30.7	31.3	77.2	27	28
Bilsom 822 NST	14.8	20.5	25.7	24.4	26.1	24.7	25.4	79.2	25	26
Peltor H520A Headband	9.8	16.0	27.9	31.7	31.6	36.6	35.8	73.8	30	30
Peltor H529B Neckband	7.1	15.0	24.7	30.1	29.4	34.3	35.6	75.8	28	28
Peltor H520E Folding	10.7	17.4	28.4	33.4	32.2	36.2	34.4	72.8	31	31
Peltor H530A Headband	11.7	19.4	31.2	34.9	32.4	34.6	34.5	71.6	33	32
Peltor H540A Headband (New H10A Prototype)	14.7	20.8	32.5	36.1	31.6	38.4	36.7	70.6	34	33
Peltor H540B Neckband (H10B Prototype)	14.3	20.6	31.9	36.9	33.5	38.2	34.9	70.1	34	34
EAR Model 5000 (Model # 331-5002)	6.6	14.3	25.4	31.7	32.3	32.3	28.6	75.4	29	28
CLASS 4										
3M 1425	6.5	6.9	19.1	28.1	30.1	30.5	29.8	80.6	24	23
Bilsom 817 NST Muff	12.1	16.9	20.8	21.3	22.5	27.3	28.8	81.7	22	23
Bilsom 815 Muff	14.2	20.2	25.3	20.5	23.8	31.8	26.8	81.2	23	24
Peltor H6xA Headband (Modified H6A)	5.4	6.5	17.5	27.9	23.1	28.7	25.9	82.2	22	22
Peltor H6xF Folding headband (H6F prototype)	6.5	6.8	19.3	27.9	26.7	27.5	28.7	81.0	23	23
Peltor H6xB Neckband (H6B prototype)	6.1	6.7	16.6	26.9	25.1	28.7	25.0	82.3	22	22
Peltor H510xF Folding Headband (H9F Prototype)	8.6	10.5	21.7	31.4	26.6	27.3	26.6	78.8	25	25
Peltor H510xB Neckband (H9F Prototype)	5.8	9.8	18.0	28.0	26.8	28.9	28.0	80.5	24	24
Peltor H510A headband with modified ear pads and foam infill (New H6A prototype)	4.4	8.9	21.2	29.9	25.4	27.0	26.9	79.9	24	24
E-A-R Earmuff Model 1000	9.6	9.2	17.2	30.5	28.1	35.3	29.8	80.3	24	24

	125	250	500	1k	2k	4k	8k	A	C
Glock SEL Spectrum	100.9	110.1	115.5	117.6	114.1	113.4	111.6	121.7	121.9
Glock 500 shots Leq,8h	83.3	92.5	97.9	100.0	96.5	95.8	94.0	104.1	104.3

TABLE 4: OCTAVE-BAND HEARING PROTECTOR SELECTION – M4

M4 — Using Leq,8h 500 shot spectrum

	SPECTRUM:								
Frequency	125	250	500	1k	2k	4k	8k	A	C
OB Level (dB)	87.3	98.0	100.3	99.0	99.0	96.7	95.6	105.2	105.9
A-weighting (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0	-1.1		
A-weighted Level (dB(A))	71.2	89.4	97.1	99.0	100.2	97.7	94.5		

Hearing Protector (Grade/ Number)	Effective Attenuation (dB)							Inside Level	Assumed Protective Value	SLC80
	125	250	500	1k	2k	4k	8k	(dBA)	(dBA)	
Peltor ProTac II (MT15H7*2)	16.3	22.9	27.6	32.8	28.6	34.9	38.5	**75.4**	**29**	31
CLASS 5										
3M 1427	15.8	16.3	20.8	30.8	33.4	32.7	31.8	**79.0**	**25**	28
3M1425	7.9	12.2	24.5	33.9	30.8	27.5	28.6	**80.0**	**24**	27
3m1435	12.2	16.4	25.6	28.3	31.8	33.1	30.0	**77.7**	**26**	29
3M1440	14.5	17.8	25.1	29.7	31.6	35.9	40.6	**76.8**	**27**	30
Moldex M1	13.2	18.9	26.7	33.8	34.1	33.7	32.8	**75.3**	**29**	32
Moldex M2	8.9	15.4	21.8	29.9	30.3	33.4	29.0	**79.3**	**25**	28
Bilsom 847 NST II	17.5	20.0	29.7	25.9	26.0	30.7	31.3	**78.3**	**26**	28
Bilsom 822 NST	14.8	20.5	25.7	24.4	26.1	24.7	25.4	**80.2**	**24**	26
Peltor H520A Headband	9.8	16.0	27.9	31.7	31.6	36.6	35.8	**76.7**	**27**	30
Peltor H529B Neckband	7.1	15.0	24.7	30.1	29.4	34.3	35.6	**78.5**	**26**	28
Peltor H520E Folding	10.7	17.4	28.4	33.4	32.2	36.2	34.4	**75.7**	**28**	31
Peltor H530A Headband	11.7	19.4	31.2	34.9	32.4	34.6	34.5	**74.2**	**30**	32
Peltor H540A Headband (New H10A Prototype)	14.7	20.8	32.5	36.1	31.6	38.4	36.7	**73.3**	**31**	33
Peltor H540B Neckband (H10B Prototype)	14.3	20.6	31.9	36.9	33.5	38.2	34.9	**72.9**	**31**	34
EAR Model 5000 (Model # 331-5002)	6.6	14.3	25.4	31.7	32.3	32.3	28.6	**78.4**	**26**	28
CLASS 4										
3M 1425	6.5	6.9	19.1	28.1	30.1	30.5	29.8	**84.4**	**20**	23
Bilsom 817 NST Muff	12.1	16.9	20.8	21.3	22.5	27.3	28.8	**82.9**	**21**	23
Bilsom 815 Muff	14.2	20.2	25.3	20.5	23.8	31.8	26.8	**81.7**	**22**	24
Peltor H6xA Headband (Modified H6A)	5.4	6.5	17.5	27.9	23.1	28.7	25.9	**85.7**	**18**	22
Peltor H6xF Folding headband (H6F prototype)	6.5	6.8	19.3	27.9	26.7	27.5	28.7	**84.7**	**19**	23
Peltor H6xB Neckband (H6B prototype)	6.1	6.7	16.6	26.9	25.1	28.7	25.0	**85.7**	**18**	22
Peltor H510xF Folding Headband (H9F Prototype)	8.6	10.5	21.7	31.4	26.6	27.3	26.6	**82.0**	**22**	25
Peltor H510xB Neckband (H9F Prototype)	5.8	9.8	18.0	28.0	26.8	28.9	28.0	**83.5**	**21**	24
Peltor H510A headband with modified ear pads and foam infill (New H6A prototype)	4.4	8.9	21.2	29.9	25.4	27.0	26.9	**83.3**	**21**	24
E-A-R Earmuff Model 1000	9.6	9.2	17.2	30.5	28.1	35.3	29.8	**83.7**	**20**	24

	125	250	500	1k	2k	4k	8k	A	C
M4 SEL Spectrum	104.9	115.6	117.9	116.6	116.6	114.3	113.2	**122.8**	123.5
M4 500 shots Leq,8h	87.3	98.0	100.3	99.0	99.0	96.7	95.6	**105.2**	105.9

Since the Peltor Protac II protector has not been Classified, data from the instruction sheet that comes with the protector was used as the basis for the calculations for that device. It must be appreciated that since this protector has not yet been tested to AS/NZS 1270: 2002 the protection calculated is likely to be optimistic (by up to 3dB or perhaps more) and the numbers therefore cannot be compared directly with the number associated with the other protectors in the table.

The table shows the probable level of exposure ($L_{eq,8h}$) underneath the hearing protector in the column labelled "Inside Level" for the 500 shot regime stated previously. The exposure level will be pro-rata for other exposure regimes.

Other Classes of hearing protectors give a lower level of protection and should therefore not be used.

It can bee seen that the protective value results for the M4 rifle are a little lower that for the Glock. This is primarily due to the different spectra from the two weapons – the M4 spectrum has more low frequency energy that the Glock.

PROTECTION AGAINST NOISE EXPOSURE – AS/NZS STANDARD

There are the two aspects of noise exposure when dealing with impulse noise, the Noise exposure level ($L_{Aeq,8h}$) and the Peak sound pressure level L_{peak}. These need to be considered separately and this has been done by the measurement of both the SEL and the L_{peak} for each of the available shots.

Because of the difficulties involved in ensuring that any worn hearing protector is properly fitted and giving the best protection, particularly in the case of earplugs, it is vital that training in the fitting and use of all hearing protectors is given. This training should be in accordance with the requirements of AS/NZS 1269.3, 2005: *Occupational Noise Management – Hearing Protector Program.* A suitable hearing protector program needs to be set up and implemented.

AUDIOMETRIC TESTING

Because of the difficulties involved with high levels of noise exposure and the possibility that even with the recommended hearing protectors being used correctly, noise exposure may be still excessive and may cause hearing loss in people firing guns, it is important to monitor any effects on the individuals concerned. In the first instance this could be done for all users of guns where practicable so that as large a sample of individuals as possible is obtained. This health monitoring can be achieved through the use of audiometric testing of the people using guns immediately after their exposure. AS/NZS1269 Part 4, 2005: *Auditory Assessment* includes a procedure that can detect relatively small changes in hearing loss. When this procedure is used immediately following noise exposure, it is capable of determining whether there has been any Temporary Threshold Shift (TTS) in the hearing of the people concerned.

A program of audiometry testing should therefore be implemented in conjunction with the use of the recommended hearing protectors. This testing should be considered as an essential element in the hearing protector program and should be conducted in accordance with AS/NZS1269 Part 4, 2005: *Auditory Assessment.* The testing should be conducted immediately after the firing of guns on the people directly involved. The testing should be conducted (ideally) at 2 minutes after the exposure (or some other stated suitable and practical time delay) to determine whether there has been any Temporary Threshold Shift in the hearing of the individuals. This type of testing presupposes that there is a reference audiogram available for each of the people concerned.

PROCEDURES POLICY

The management of the noise exposure should be based on the information provided in this report. The principal basis for the policy should be the requirements of the New Zealand legislation (HSE Act and Regulations), the Code of Practice on the Management of Noise in the Workplace and the Joint New Zealand/Australian Standards on the Management of Noise in the Workplace.

The Act requires the minimisation of exposure to noise and in this context the solution to the problem of noise from the use of firearms is to install effective silencers on all firearms where possible when the sound level exceeds the legal limits. This may result in an exposure to noise from that firearm that does not exceed the legal limits. Even if it does not (if the level of noise still exceeds 140dB L_{peak} or $L_{Aeq,8h}$ 85dBA) the installation should still be carried out since the Act requires the minimisation of the noise exposure. Such installation may have associated problems such as additional difficulties with gun handling but the benefits outweigh the additional costs and difficulties.

Additional training in the use of such adapted weapons may be required. This should be considered as a practicable option and should also be considered as the preferred option for the management of noise exposure to gunfire noise. The level of noise emission from any type of gun fitted with a silencer should be measured prior to general modification of the Department's guns to ensure that the types of silencers chosen do limit the level of noise emitted to the lowest practical level or less than the regulatory limits.

The operator of the gun, and any instructing persons, whenever there is a possibility of the gun being fired, must be wearing suitable and properly fitted hearing protectors. A suitable hearing protector is one that will reduce the amount of noise that the wearer receives "at ear" to no more than 140dB L_{peak} and 116dBA SEL for each shot. In addition the daily exposure from all shots should not exceed a total of 130dBA SEL.

Based on the current state of knowledge and best practicable option, the most suitable type of hearing protector for use until the M4 guns can be modified with a suitable silencer is as follows:

- A Class 5 earmuff, or
- A Class 5 earmuff with any class earplug in combination

The use of earplugs as well as earmuffs is not required but will act as a "backup" in the event of a failure to wear the earmuffs correctly. However, the combination will acoustically isolate the wearer and possibly cause other problem concerning communication.

Because the frequency spectrum of these weapons is high, Class 5 hearing protectors are very effective at reducing the level of sound overall.

All people required to wear hearing protectors must have had appropriate training in the use of hearing protectors. Such training should be in accordance with the requirements of AS/NZS 1269, 2005 — *Part 3: Hearing Protector Program.*

All people required to wear hearing protectors must have health monitoring in the form of audiometric testing in accordance with AS/NZS1269 Part 4, 2005: *Auditory Assessment* at regular intervals not exceeding one year.

CONCLUSIONS/RECOMMENDATIONS

1 Suppressors are the best practicable means of reducing noise exposure for the M4 and other rifles and should therefore be used during any range exercises.

2 The level of noise reduction from the examples of PES and ZIG suppressors was insufficient to reduce the level of exposure to less than the recommended and legal limits.

3 The "Peak" level of noise emitted from the unsilenced guns at the firers ear or the "finger" location of the instructor is high. The peak level from the Glock is as high as

166dB and from the M4 is as high as 164dB. With a suppressor the M4 emits as high as 144dB with the PES suppressor and 146dB with the ZIG suppressor. It is important to ensure that all people who are exposed to levels of noise above 140dB L_{peak} are supplied with and wear suitable hearing protectors. This should be based on the frequency spectrum measurements taken and on the recommendations in Appendix B of AS/NZS 1269, 2005 — *Part 3: Hearing Protector Program.*

4 The energy level of noise (SEL) emitted from the unsilenced guns at the firers ear or the "finger" location of the instructor is also high. The SEL from the Glock is as high as 126dBA and from the M4 is as high as 124dBA. With a suppressor the M4 emits as high as 110dBA with the PES suppressor and 110dBA with the ZIG suppressor. It is important to ensure that all people who are exposed to levels of noise above 116dBA SEL per impulse are supplied with and wear suitable hearing protectors. This should be based on the frequency spectrum measurements taken and on the recommendations in AS/NZS 1269, 2005 — *Part 3: Hearing Protector Program.*

5 The recommendation is for the use of one type of protector for use with all the types of guns that exceed a level of 140dB L_{peak} or a level of 116dBA SEL. This should therefore be chosen for the highest noise producing guns – the Glock. This will avoid any confusion about which protector should be used with which gun. It should not produce an excessive amount of overprotection in any situation.

6 There is no Standardised data available on how much attenuation can be obtained using any Classified hearing protectors when used to protect against impulse noise from gunfire. The recommendation in AS/NZS 1269.3, 2005 is to wear a Class 5 hearing protector. Though this may be considered a conservative approach it is necessary in the case of the Glock pistol.

7 Based on the current state of knowledge and best practicable option, the most suitable type of hearing protector for use until guns can be modified with a suitable silencer is as follows:

- A Class 5 earmuff (preferred), or
- A Class 5 earmuff with any class earplug in combination

In addition, use eye protection of a type that minimises the leakage of sound into the earmuffs i.e. goggles with an elastic headband.

8 The Protac 2 hearing protectors have not been classified but calculations have been conducted to determine the likely level of protection that this protector will give. Based on this information and data from the instruction manual that is included with the protector, they should give adequate protection for the firing regime assumed in this report.

9 The level of noise emitted from the unsuppressed guns when fired is high at a Sound Exposure Level (SEL) of up to 126dBA (depending on location). This translates to a Noise Exposure Level, $L_{Aeq,8h}$ of up to 81dBA for each firing. So, in the example given in this report, a total exposure could be of the order of 104dBA $L_{Aeq,8h}$. Exposure to a greater number of shots would increase the level of exposure. This level of exposure exceeds the NATO criterion level by about the same amount as the Peak level of noise exceeds the 140dB criterion level.

10 Hearing protectors should be selected so that there is a minimum amount of over-protection. Any more protection than this can be the cause of the problems described earlier.

11 A program of audiometry testing should be implemented in conjunction with the use of hearing protectors (where required). This testing should be considered as an essential element in the hearing protector program and should be conducted in accordance with AS/NZS1269 Part 4, 2005: *Auditory Assessment*. The method of testing should be in line with the method described in this report in the section headed *Audiometric Testing*.

12 If TTS is observed, a suitable modification to the hearing protector program to overcome the problem causing the hearing loss should be investigated and implemented. Monitoring should continue on a regular basis until all problems have been overcome.

13 The use of screens has no significant effect on the levels of noise received at the firer's and instructor's locations.

14 Additional acoustic treatment of the range will not significantly reduce the level of noise exposure of the students or instructors and is therefore unwarranted.

15 There should be reviews of hearing protection as better performing models become available.

G Bellhouse

APPENDIX 1

INSTRUMENTATION USED

Instrument	Make	Model	Serial Number
Sound Level Analyser	CEL	CEL-573	2/0581378
Calibrator	Quest	QC-10	QE2110131
Microphone	B&K	4136	890973

APPENDIX 2

Glossary of Terms

L_{Aeq} The level of the steady continuous noise that has the same sound energy as the noise under consideration whose level varies with time, over some time interval, T.

It is the **average level** of the varying noise that is present.

$L_{Aeq,8h}$ The steady noise level that would, in the course of an 8-hour period, cause the same A-weighted sound energy as that due to the actual noise over the actual working day.

It is the noise level normalised to an eight hour period that is equivalent to the actual noise present. It is normally called the **Noise Exposure Level** and is the quantity used in the Regulations.

Sound Exposure Level, SEL

The steady noise level that would, if maintained for 1 second, contain the same sound energy as that in the noise event concerned. It is a 1 second L_{eq}.

L_{peak} The instantaneous highest level of the peak sound pressure present over the measurement interval, T.

In other words it is the highest level of sound that is present, even for an extremely short period of time.

A-weighting The frequency weighting applied to noise measurements designed to approximate to the response of the human ear.

A-weighting essentially gives the sound level meter the ability to respond to sound in approximately the same way as the human ear.

APPENDIX 3: MEASURED SEL NOISE SPECTRA

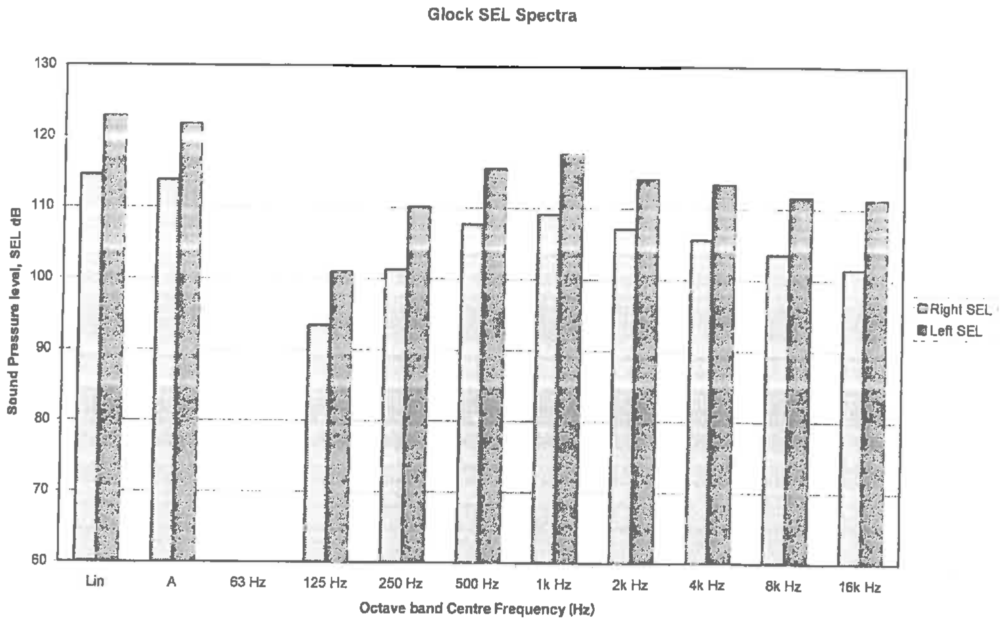


Figure A1: Average SEL ⅓ Octave Band Spectrum for Glock measured at the left ear of a right handed person

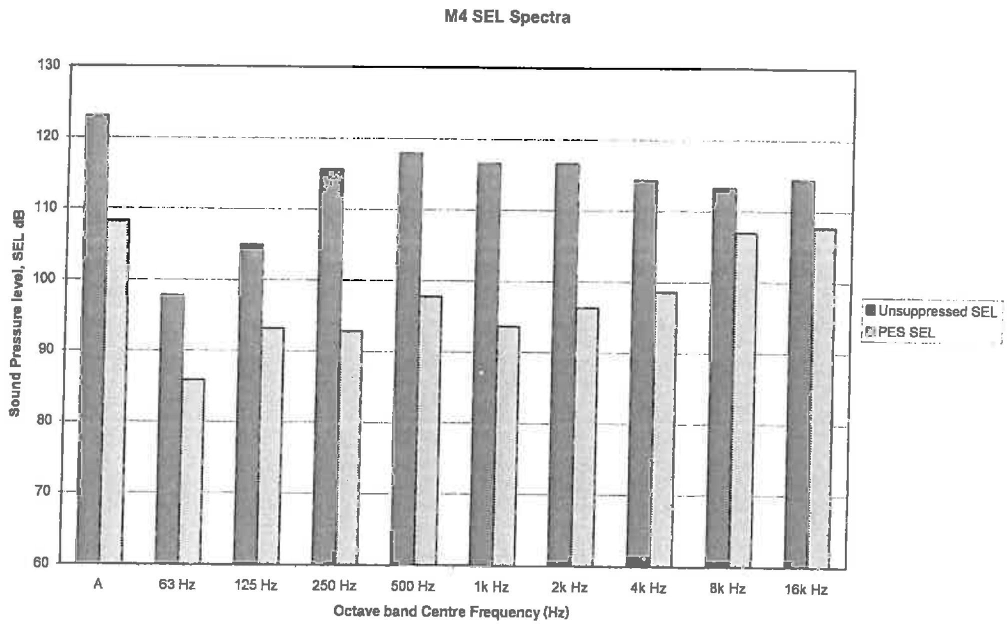


Figure A2: Average SEL⅓ Octave Band Spectra for M4 0.223 calibre rifle measured at the left ear of a right handed person

APPENDIX 4: TABLE OF VALUES FOR THE NUMBER OF SHOTS FACTOR

To determine the 10Log(N) factor in equation 1 simply look up the factor from the table below.

N	Factor for **Equation 1**
1	0.0
2	3.0
3	4.8
4	6.0
5	7.0
6	7.8
7	8.5
8	9.0
9	9.5
10	10.0
20	13.0
30	14.8
40	16.0
50	17.0
60	17.8
70	18.5
80	19.0
90	19.5
100	20.0
200	23.0
300	24.8
400	26.0
500	27.0
600	27.8
700	28.5
800	29.0
900	29.5
1000	30.0
2000	33.0
3000	34.8
4000	36.0
5000	37.0
6000	37.8
7000	38.5
8000	39.0
9000	39.5

CALCULATIONS FOR THE DETERMINATION OF THE A-WEIGHTED LEVEL WITHIN HEARING PROTECTORS
Input the unweighted octave band sound pressure levels into the cells outlined with a double border.

GLOCK

Using Leq,8h 500 shot spectrum

	SPECTRUM: 125	250	500	1k	2k	4k	8k	A	C
Frequency	125	250	500	1k	2k	4k	8k	A	C
OB Level (dB)	83.3	92.5	97.9	100.0	96.5	95.8	94.0	104.1	104.3
A-weighting (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0	-1.1		
A-weighted Level (dB(A))	67.2	83.9	94.7	100.0	97.7	96.8	92.9		

Hearing Protector (Grade/ Number)	Effective Attenuation (dB) 125	250	500	1k	2k	4k	8k	Inside Level (dBA)	Assumed Protective Value (dBA)	SLC80
Peltor ProTac II (MT15H7*2)	16.3	22.9	27.6	32.8	28.6	34.9	38.5	73.4	31	31
CLASS 5										
3M 1427	15.8	16.3	20.8	30.8	33.4	32.7	31.8	76.6	28	28
3M1425	7.9	12.2	24.5	33.9	30.8	27.5	28.6	76.7	27	27
3m1435	12.2	16.4	25.6	28.3	31.8	33.1	30.0	75.7	28	29
3M1440	14.5	17.8	25.1	29.7	31.6	35.9	40.6	74.7	29	30
Moldex M1	13.2	18.9	26.7	33.8	34.1	33.7	32.8	72.8	31	32
Moldex M2	8.9	15.4	21.8	29.9	30.3	33.4	29.0	76.8	27	28
Bilsom 847 NST II	17.5	20.0	29.7	25.9	26.0	30.7	31.3	77.2	27	28
Bilsom 822 NST	14.8	20.5	25.7	24.4	26.1	24.7	25.4	79.2	25	26
Peltor H520A Headband	9.8	16.0	27.9	31.7	31.6	36.6	35.8	73.8	30	30
Peltor H529B Neckband	7.1	15.0	24.7	30.1	29.4	34.3	35.6	75.8	28	28
Peltor H520E Folding	10.7	17.4	28.4	33.4	32.2	36.2	34.4	72.8	31	31
Peltor H530A Headband	11.7	19.4	31.2	34.9	32.4	34.6	34.5	71.6	33	32
Peltor H540A Headband (New H10A Prototype)	14.7	20.8	32.5	36.1	31.6	38.4	36.7	70.6	34	33
Peltor H540B Neckband (H10B Prototype)	14.3	20.6	31.9	36.9	33.5	38.2	34.9	70.1	34	34
EAR Model 5000 (Model # 331-5002)	6.6	14.3	25.4	31.7	32.3	32.3	28.6	75.4	29	28
CLASS 4										
3M 1425	6.5	6.9	19.1	28.1	30.1	30.5	29.8	80.6	24	23
Bilsom 817 NST Muff	12.1	16.9	20.8	21.3	22.5	27.3	28.8	81.7	22	23
Bilsom 815 Muff	14.2	20.2	25.3	20.5	23.8	31.8	26.8	81.2	23	24
Peltor H6xA Headband (Modified H6A)	5.4	6.5	17.5	27.9	23.1	28.7	25.9	82.2	22	22
Peltor H6xF Folding headband (H6F prototype)	6.5	6.8	19.3	27.9	26.7	27.5	28.7	81.0	23	23
Peltor H6xB Neckband (H6B prototype)	6.1	6.7	16.6	26.9	25.1	28.7	25.0	82.3	22	22

Peltor H510xF Folding Headband (H9F Prototype)	8.6	10.5	21.7	31.4	26.6	27.3	26.6	78.8	25	25
Peltor H510xB Neckband (H9F Prototype)	5.8	9.8	18.0	28.0	26.8	28.9	28.0	80.5	24	24
Peltor H510A headband with modified ear pads and foam infill (New H6A prototype)	4.4	8.9	21.2	29.9	25.4	27.0	26.9	79.9	24	24
E-A-R Earmuff Model 1000	9.6	9.2	17.2	30.5	28.1	35.3	29.8	80.3	24	24

	125	250	500	1k	2k	4k	8k	A	C
Glock SEL Spectrum	100.9	110.1	115.5	117.6	114.1	113.4	111.6	121.7	121.9
Glock 500 shots Leq,8h	83.3	92.5	97.9	100.0	96.5	95.8	94.0	104.1	104.3

M4

Using Leq,8h 500 shot spectrum

Frequency	125	250	500	1k	2k	4k	8k	A	C
	SPECTRUM:								
OB Level (dB)	87.3	98.0	100.3	99.0	99.0	96.7	95.6	105.2	105.9
A-weighting (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0	-1.1		
A-weighted Level (dB(A))	71.2	89.4	97.1	99.0	100.2	97.7	94.5		

Hearing Protector (Grade/ Number)	Effective Attenuation (dB) 125	250	500	1k	2k	4k	8k	Inside Level (dBA)	Assumed Protective Value (dBA)	SLC80
Peltor ProTac II (MT15H7*2)	16.3	22.9	27.6	32.8	28.6	34.9	38.5	75.4	29	31
CLASS 5										
3M 1427	15.8	16.3	20.8	30.8	33.4	32.7	31.8	79.0	25	28
3M1425	7.9	12.2	24.5	33.9	30.8	27.5	28.6	80.0	24	27
3m1435	12.2	16.4	25.6	28.3	31.8	33.1	30.0	77.7	26	29
3M1440	14.5	17.8	25.1	29.7	31.6	35.9	40.6	76.8	27	30
Moldex M1	13.2	18.9	26.7	33.8	34.1	33.7	32.8	75.3	29	32
Moldex M2	8.9	15.4	21.8	29.9	30.3	33.4	29.0	79.3	25	28
Bilsom 847 NST II	17.5	20.0	29.7	25.9	26.0	30.7	31.3	78.3	26	28
Bilsom 822 NST	14.8	20.5	25.7	24.4	26.1	24.7	25.4	80.2	24	26
Peltor H520A Headband	9.8	16.0	27.9	31.7	31.6	36.6	35.8	76.7	27	30
Peltor H529B Neckband	7.1	15.0	24.7	30.1	29.4	34.3	35.6	78.5	26	28
Peltor H520E Folding	10.7	17.4	28.4	33.4	32.2	36.2	34.4	75.7	28	31
Peltor H530A Headband	11.7	19.4	31.2	34.9	32.4	34.6	34.5	74.2	30	32
Peltor H540A Headband (New H10A Prototype)	14.7	20.8	32.5	36.1	31.6	38.4	36.7	73.3	31	33
Peltor H540B Neckband (H10B Prototype)	14.3	20.6	31.9	36.9	33.5	38.2	34.9	72.9	31	34
EAR Model 5000 (Model # 331-5002)	6.6	14.3	25.4	31.7	32.3	32.3	28.6	78.4	26	28
CLASS 4										
3M 1425	6.5	6.9	19.1	28.1	30.1	30.5	29.8	84.4	20	23
Bilsom 817 NST Muff	12.1	16.9	20.8	21.3	22.5	27.3	28.8	82.9	21	23
Bilsom 815 Muff	14.2	20.2	25.3	20.5	23.8	31.8	26.8	81.7	22	24
Peltor H6xA Headband (Modified H6A)	5.4	6.5	17.5	27.9	23.1	28.7	25.9	85.7	18	22
Peltor H6xF Folding headband (H6F prototype)	6.5	6.8	19.3	27.9	26.7	27.5	28.7	84.7	19	23
Peltor H6xB Neckband (H6B prototype)	6.1	6.7	16.6	26.9	25.1	28.7	25.0	85.7	18	22
Peltor H510xF Folding Headband (H9F Prototype)	8.6	10.5	21.7	31.4	26.6	27.3	26.6	82.0	22	25
Peltor H510xB Neckband (H9F Prototype)	5.8	9.8	18.0	28.0	26.8	28.9	28.0	83.5	21	24

Peltor H510A headband with modified ear pads and foam infill (New H6A prototype)	4.4	8.9	21.2	29.9	25.4	27.0	26.9	**83.3**	21	24
E-A-R Earmuff Model 1000	9.6	9.2	17.2	30.5	28.1	35.3	29.8	**83.7**	**20**	24

	125	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**A**	**C**
M4 SEL Spectrum	104.9	115.6	117.9	116.6	116.6	114.3	113.2	122.8	123.5
M4 500 shots Leq,8h	87.3	98.0	100.3	99.0	99.0	96.7	95.6	105.2	105.9