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Development of a Muffler for Small Arms Range Noise Mitigation

by
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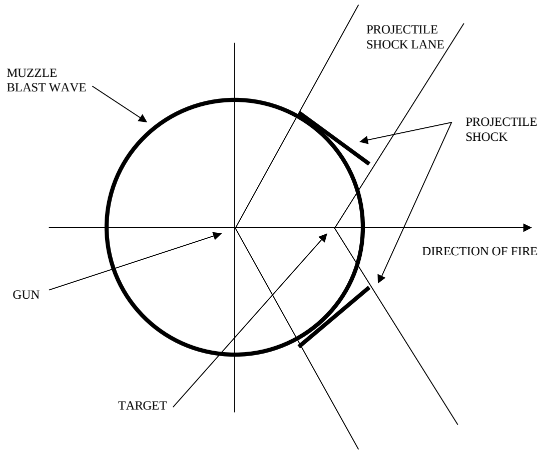
Small arms fire can result in noise complaints from nearby residents. The objective of the project reported herein was to provide a mitigation strategy to reduce small arms noise impact in the neighborhood of Camp Dodge, IA. The selected strategy was a low-cost muzzle blast muffler. The U.S. Army Construction Engineering Research Laboratories (USACERL) designed, constructed, and tested several variations of mufflers. The basic design consists of a tube about 0.5 meter (19 inches) in diameter and about 1.9 meters (6 feet) long that is lined with noise-absorbent material and has a bore large enough to afford the shooter an unobstructed view of the target. The performance tests showed that the muffler delivers a noise level reduction in the A-weighted sound exposure level (ASEL) of 10 to 20 decibels (dB) in most of the noise-sensitive regions around Camp Dodge.



Foreword

This project was sponsored by the Iowa Army National Guard Environmental Office, Camp Dodge, under MIPR # 96-001EE00, dated June 1996, “Practical Small Arms Noise Mitigation,” VS6. The point of contact was Curtis L. Madsen. The work was performed by the Planning and Mission Impact Division (LL-P) of the Land Management Laboratory (LL), of the U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Dr. Larry Pater. Mr. Anthony Krempin assisted in the data acquisition, data analysis, and report preparation. The Environmental Noise Program Office of the U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM), provided the report appendices. Valuable suggestions were provided during discussions with colleagues Paul Schomer, Jeff Mifflin, Richard Racioppi, Alan Rosenheck and Camp Dodge personnel. Dr. Harold E. Balbach is Chief, CECER-LL-P. Dr. John T. Bandy is Operations Chief, CECER-LL. The technical editor was Gloria J. Wienke, Information Management Team.

COL James A. Walter is the Commander and Dr. Michael J. O’Connor is the Director of USACERL.

Executive Summary

Small arms firing can result in noise complaints from nearby residents. In response to community concerns about noise, Camp Dodge, IA has reduced firing times and has stated an intent to review further potential noise mitigation techniques. The purpose of the project reported herein was to provide a mitigation strategy to reduce small arms noise impact in the neighborhood of Camp Dodge. The selected strategy was a low-cost muzzle blast muffler. The project objective was to develop and evaluate the performance of low-cost mufflers.

The basic muffler design consists of a tube that is about 0.5 meter (18 inches) in diameter and about 1.9 meters (6 feet) long. The tube is lined with noise-absorbent material and has a bore that is large enough to afford the shooter an unobstructed view of the target lane. The rifle is fired with the muzzle inside the tube as far as practical. Development efforts in Switzerland achieved noise reductions of 10 to 20 decibels (dB), and further demonstrated by extended testing that there is no significant explosion risk or safety hazard This device has been quite well accepted by military trainees in Switzerland. The device does not mitigate projectile projectile shock noise; however, this is a potential problem in only a small portion of the community around Camp Dodge.

The U.S. Army Construction Engineering Laboratories (USACERL) designed, constructed, and tested several variations of muzzle blast mufflers. Camp Dodge personnel were consulted during the design process. Initial tests were performed at USACERL to choose the most promising designs and to refine them. Final tests were done at Camp Dodge to document the amount of noise reduction achieved and to evaluate the mufflers' suitability for use during small arms training. To minimize the cost, the mufflers were designed to be constructed in-house at Camp Dodge using readily available materials. USACERL analyzed the noise data and prepared this report of results. The best mufflers were retained at Camp Dodge to evaluate their durability and shooter acceptance.

The performance tests showed that the mufflers deliver a noise level reduction in the A-weighted sound exposure level (ASEL) of 10 to 20 dB in most of the noise-sensitive regions around Camp Dodge. This is a significant reduction, since a 10 dB sound level reduction is perceived by humans as being about half as loud. ASEL is an accepted noise measurement quantity for judging human annoyance response to small arms noise.

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1 Introduction

Background

Small arms (rifles and pistols) are fired extensively at rifle ranges for purposes of military and law enforcement training and for recreational and competitive shooting. The noise of such firing can disturb people living in the surrounding community, which can lead to noise complaints and attempts to curtail the firing activity. The Operational Noise Management Capability Package of the U.S. Army Construction Engineering Research Laboratories (USACERL) includes developing methods for reducing community disturbance due to training noise. Additional background information, supplied by the Environmental Noise Program Office of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), is in the Appendices.

Each rifle shot can result in two distinct noise events; the muzzle blast wave and a supersonic projectile shock wave. Figure 1 shows the footprint on the ground of the two blast waves at an instant of time. The muzzle blast wave originates at the muzzle of the gun and expands spherically in all directions. It exhibits considerable “directivity,” being typically 10 to 15 dB louder in front of the gun compared to behind. To put this difference in perspective, a noise level increase of 10 dB is perceived by humans as being about twice as loud.

The projectile shock is emitted all along the bullet path as long as the projectile continues to travel supersonically. This shock front expands as a conic surface with the bullet at the apex of the cone. The projectile shock footprint exists only in part of the region around the gun, specifically in regions to each side and forward of the gun, as shown in the simplified diagram in Figure 1. At a rifle range, the projectile shock is produced only during the flight from the muzzle to the target (or impact with the ground). The width of the projectile shock lane is less than the distance from the guns to the target or backstop that stops the projectile.

Noise barriers (walls or berms) similar to those seen along freeways can be quite effective in reducing small arms noise. Barriers are most effective when they can be located close to either the noise source or the receiver. Barriers can be

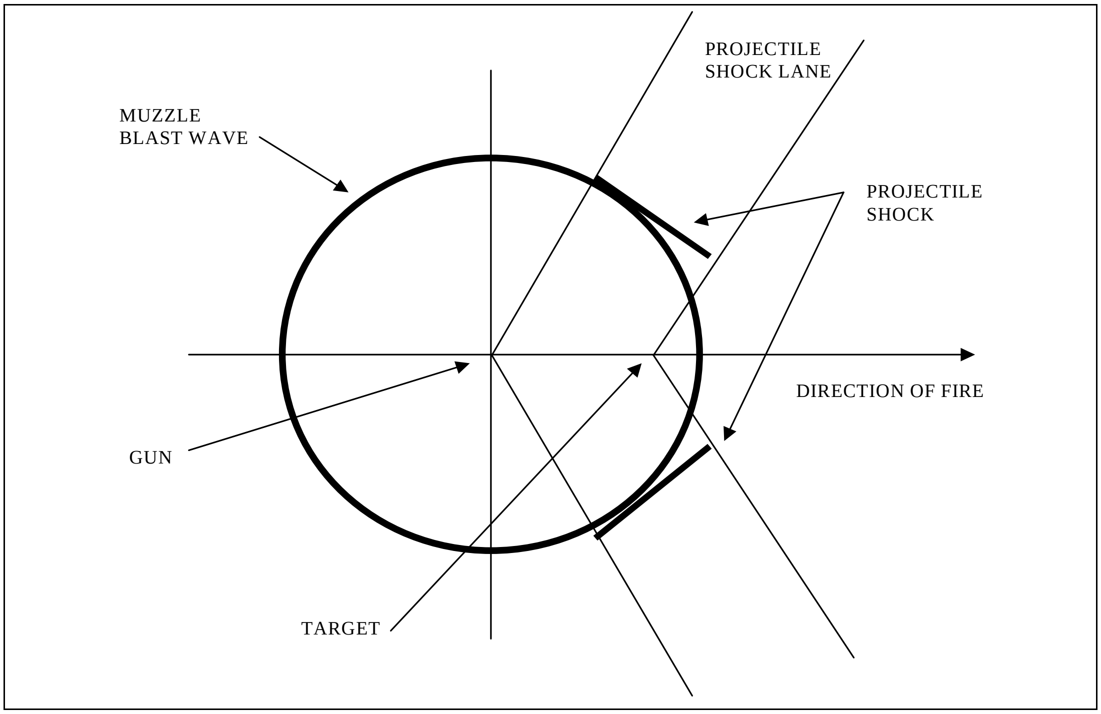

Figure 1. Gun blast footprint.

quite effective in reducing noise to the rear of a range, since a wall can be located so that it is close to all of the firing points. Barriers are less effective to the sides since they are quite far from most of the firing positions. Noise barriers can be placed between firing lanes to provide larger noise reduction to the side, but this may pose a safety problem since part of the range may be unobservable by the range safety officer.

Weather conditions can greatly affect received noise level. Weather can easily have a larger effect on community noise level than do changes in the number or size of noise events. A possible mitigation strategy is to avoid firing when weather conditions enhance sound propagation, and concentrate firing in times when propagation conditions minimize received noise level in a particular noise-sensitive area. This is, of course, not always convenient and can adversely affect busy training schedules. Certain general principles or rules of thumb are worth using. For example, noise impact can *usually* be reduced by avoiding firing very early in the day and at night when weather conditions enhance sound propagation. A more sophisticated approach requires weather monitoring and noise prediction or noise level remote monitoring, which require significant financial investment.

Remote noise monitoring is useful for real-time evaluation of the effect of propagation conditions and also for documenting noise exposure due to training. Documentation of the noise level is useful for objective judgement of noise impact, but requires long-term monitoring to obtain a meaningful average noise assessment over the full range of propagation conditions. A typical system would use one or more noise monitors located at a remote site, typically at a complainant site, with readout in the range control office via radio or telephone link.

An essential element of an effective noise mitigation program is a proactive and continuous long-term public relations strategy as an integral part of routine operations. The program should include complaint management procedures. Appendix D contains recommended complaint procedures and is based on experience at several installations. Complaints, properly recorded and analyzed, can tell where to concentrate noise mitigation efforts. Another useful public relations procedure is to notify residents in advance of particularly noisy operations and their expected duration.

USACERL and USACHPPM are jointly developing a computerized tool that can be used to calculate noise exposure contours for a small arms range complex. This tool, known as SARNAM (Small Arms Range Noise Assessment Model), accounts for the effect of barriers and noise-reflecting surfaces. It will facilitate the design, location, and orientation of new small arms ranges. It will also be useful for assessing the noise impact of existing ranges and planning noise mitigation modifications for them, and as a basis for influencing long-range land use decisions.

A muzzle blast muffler is an attractive means of reducing small arms noise. It offers muzzle blast noise reduction over a large portion of the environs of the gun. The device does not mitigate projectile projectile shock noise; however, this is a potential problem in only a small portion of the community.

The Camp Dodge small arms range complex has received noise complaints from nearby residents. Formal and informal community meetings have led to a reduction in firing times and to a stated intent to review additional noise mitigation techniques.

Objective

The objective of this project was to provide a mitigation strategy to reduce small arms noise impact in the neighborhood of Camp Dodge. The selected strategy is a low-cost muzzle blast muffler. The project objective was to develop and evaluate the performance of low-cost mufflers.

Approach

A small arms muzzle blast muffler has been developed in Switzerland (Rosenheck and Keller 1996). It consists of a box or tube that is about 0.5 meter (18 inches) in width or diameter and about 2 meters (6 feet) long. The box or tube is lined with noise-absorbent material such as fiberglass, and has a bore that is large enough to afford the shooter an unobstructed view of the target. The rifle is fired with the muzzle inside the box as far as practical. The Swiss reported noise reductions of 10 to 20 dB to the side of the rifle, and have demonstrated by extended testing that there is no significant explosion risk or safety hazard. An additional benefit may be a reduced risk of hearing damage to shooters. This muffler appears to be the best small arms noise mitigation method currently available to treat the noise problem at Camp Dodge. It offers muzzle blast noise reduction in important portions of the blast field. This device has been quite well accepted by military trainees in Switzerland. The device does not mitigate projectile projectile shock noise; however, this is a potential problem in only a small portion of the community.

USACERL designed, constructed, and tested several variations of the basic muzzle blast muffler. Camp Dodge personnel were consulted during the design process. Initial tests were performed at USACERL to choose the most promising designs and to refine them. Final tests were done at Camp Dodge to document the amount of noise reduction achieved and to evaluate suitability for use during small arms training. To minimize the cost, the mufflers were designed to be constructed in-house at Camp Dodge using readily available materials. USACERL analyzed the noise data and prepared this report of results. The best mufflers were retained at Camp Dodge for evaluation of their long-term durability and shooter acceptance evaluation.

Mode of Technology Transfer

The results of this project will be used at Camp Dodge for noise management. They will also be provided to USACHPPM and AEC (Army Environmental Center) for application at other small arms ranges, and will be furnished directly to known users for immediate use in ongoing planning and design of rifle ranges. The results will also be disseminated, with Camp Dodge approval, via technical papers, magazine articles and at noise workshops, and by inclusion in a planned future handbook of noise mitigation for Army noise sources. This report is available on the USACERL web page at http://www.cecer.army.mil

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

SI conversion factors		
1 in.	=	2.54 cm
1 ft	=	0.305 m
1 yd	=	0.9144 m
1 sq in.	=	6.452 cm^2
1 sq ft	=	0.093 m^2
1 sq yd	=	0.836 m^2
1 cu in.	=	16.39 cm^3
1 cu ft	=	0.028 m^3
1 cu yd	=	0.764 m^3
1 lb	=	0.453 kg
1 mile	=	1.6 km
°F	=	(°C x 1.8) + 32

2 Muffler Design

Because a muffler is required for each shooter on a rifle range, a practical muffler should be inexpensive. This project focused on developing a muffler design that could be built in-house using readily available materials. A series of preliminary field evaluation tests were conducted at USACERL to determine the suitability of various materials for each of the components of the muffler and to determine the required muffler size to obtain a useful noise reduction. Many materials and configurations were tried and rejected. Criteria during these preliminary tests included durability, cost, and reduction in noise level. Noise level metrics included unweighted peak and A-weighted sound exposure level (ASEL), measured by a sound level meter. The most promising configurations are described in Table 1. These configurations were selected for more extensive tests at Camp Dodge.

The outer housing for most of the selected muffler configurations was a length of 0.5-meter (18-inch) inside diameter corrugated plastic culvert. One muffler configuration used a 0.5-meter (18-inch) square cross-section wooden box constructed of treated plywood. This was heavier than the plastic culvert and required considerably more effort to construct. In all configurations the housing was lined by noise absorbing material, which was held in place by a bore liner of galvanized steel wire mesh, one-half-inch mesh size. A layer of hardware cloth (20 mesh per inch) or double knit polyester fabric was placed between the absorber material and the bore liner to retain glass fibers. Annular end plates protect the absorber material and provide an attachment surface for the bore liner. Removable end caps keep out rain, animals, and insects when the mufflers are not in use.

Table 1. Configurations and approximate materials cost of small arms mufflers tested in June 1997.

CONFIG. NO.	LENGTH (ft)	HOUSING	ABSORBER	END CAPS	LINING *	TOTAL COST
1	6	Treated plywood, 18" x 18" square cross-section. $ 50.	2" thick #705 (6 lb per cu ft) fiberglass board. $ 96.	$ 12	$ 36	$ 194
2	6	Corrugated black plastic tube, 18" ID. $55.	Rock wool tube, 14 x 2, $72.	$ 12	$ 36	$ 175
3	6	Corrugated black plastic tube, 18" ID. $55.	Aero-flex, 2". $ 20.	$ 12	$ 36	$ 123
4	6	Corrugated black plastic tube, 18" ID. $55.	Aero-flex, 2", double layer. $40.	$ 12	$ 36	$ 143
5	8	Corrugated black plastic tube, 18" ID. $80.	Aero-flex, 2". $ 26.	$ 12	$ 44	$ 162

* NOTE: Linings were either hardware cloth or supported by metal mesh screen.
heavy duty double-knit polyester cloth,

MATERIALS (prices are for small quantity):

Plywood, treated, 4' x 8', $25 per sheet.

Plastic culvert, corrugated, black, 18" ID x 20', $160.

*Aero-flex noise-absorbing duct lining, 2" x 48" x 50', $ 160. $.80 per sq. ft.

*Owens-Corning fiberglass board, # 705, 6 lb/cu ft, $2/sq. ft.

*Rock wool pipe insulation, tube form, 14" ID x 2", $12 per linear ft.

Double-knit polyester cloth, 4' wide, $ 2 per ft.

Hardware cloth, 20-mesh 4' wide, $ 2 per ft.

Galvanized steel 1/2-in.mesh, 4' wide, $4 per ft.

*Absorber material available from Illinois Insulation, 3636 S. Iron Street, Chicago, IL 60609, 773-376-3100. Citing manufacturer names does not imply endorsement by the Federal government or the U.S. Army.

3 Experimental Arrangement, Procedures, and Instrumentation

Close-in Measurements

Muffler performance tests were conducted at Camp Dodge, IA, on June 10, 1997, by measuring sound levels close to the guns. A measurement circle was set up on the floor of the range, ahead of the normal firing positions, in a level region well away from reflecting surfaces. The instrumentation was arranged to measure muffler attenuation as a function of azimuth, using microphones in a circular array at 10 meters radial distance from the gun muzzle. The microphones were located at 30° (degree) intervals, with the exception of the directly downrange microphone, which was located at an azimuth of 10 degrees from the line of fire. One additional microphone station was located at a distance of 200 meters at an azimuth of 30°. All azimuths are measured clockwise from the line of fire.

Each muffler was tested using M-16 and M-60 weapons and ammunition supplied by Camp Dodge. Approximately 10 shots were fired from each gun without the muffler, as shown in Figure 2. The M-16 shots were fired single-fire spaced at intervals of a few seconds, while the M-60 shots were fired both single-fire and in short bursts. The muffler to be tested was then put in position and each weapon was fired through the muffler. Two of the muffler configurations tested are shown in Figures 3 and 4. The attenuation provided by the muffler is the difference between the muffled and unmuffled sound levels.

At each measurement location the instrumentation consisted of professional quality B&K ½-in. condenser microphones, B&K model 2804 power supplies and model 2639 pre-amps, and a line driver amplifier to avoid signal degradation due to cable length. The signals were recorded on Sony professional DAT recorders. A reference for determining absolute sound level was provided by recording the signal from a pistonphone calibrator both before and after the recorded sound signals.

Figure 2. Unmuffled M-60 being fired at the center of the instrumentation circle during close-in noise level measurements.

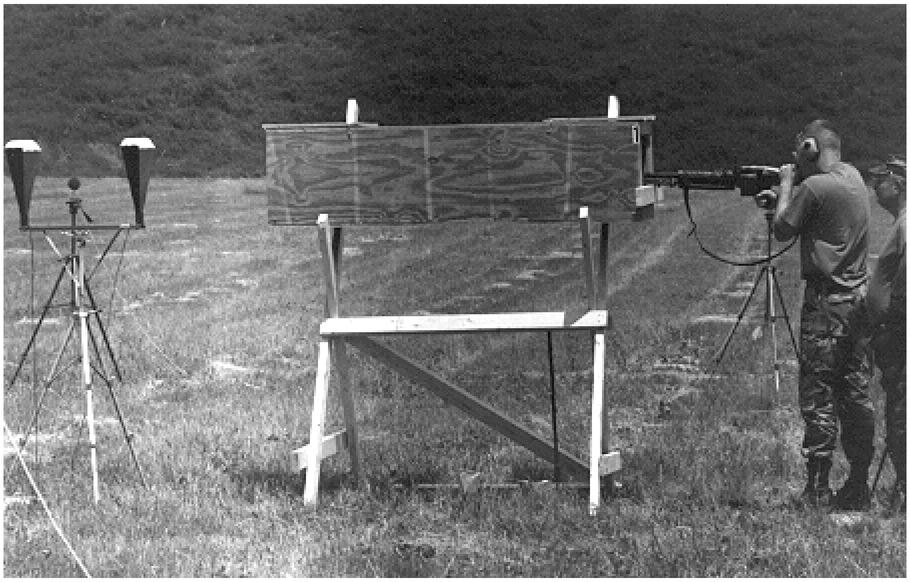

Figure 3. Muffler #1 during close-in noise level measurements.

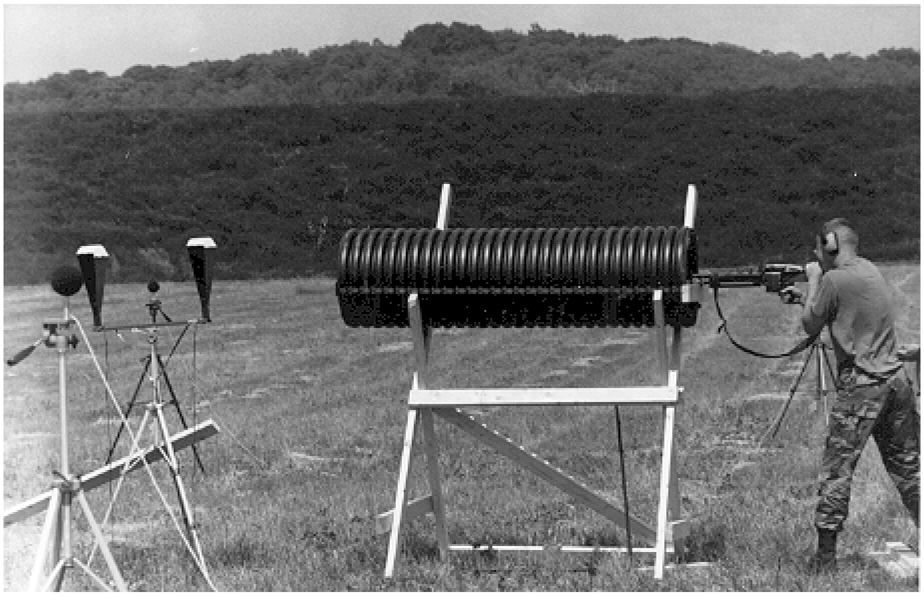

Figure 4. Atypical round configuration muffler during close-in noise level measurements.

Far Field Measurements

Two muffler configurations were chosen for far-field evaluation, based on close-in performance data, cost, and general suitability for small arms range training operations. These measurements were carried out on Wednesday, June 11, 1997, and were intended to also provide information regarding typical far-field noise levels. The two chosen muffler configurations were located at two firing positions near the middle of the firing line. Weapons used were the M-16 rifle and the M-60 machine gun. The procedure was to fire about 10 shots from the M-16 (Figure 5) at intervals of a few seconds between shots, then move the shooter and weapon to the adjacent firing position where one of the mufflers was located and fire the same program through the muffler (Figure 6). Next, a burst of 10 rounds was fired from the M-60; the weapon and shooter were moved to the adjacent firing position and the same program was fired through the second muffler. The shooter's view of the firing lane, as seen through the muffler, is shown in Figure 7.

Figure 5. Unmuffled shots on the rifle range during far field measurements.

Figure 6. Muffled shots on the rifle range during far field measurements.

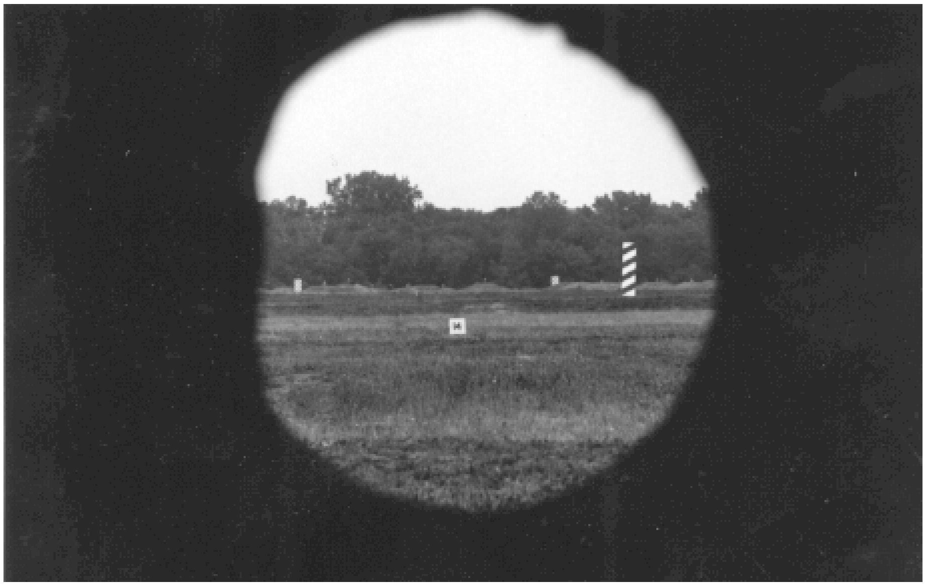

Figure 7. View of the firing lane through a typical muffler.

The firing program was repeated four times. Two field crews made measurements during the four firing programs at a total of eight selected sites at distances ranging from a few hundred meters to several kilometers from the firing range. Instrumentation consisted of the same microphones, power supplies, and preamps used for the close-in measurements. The sound signals were recorded on portable Sony DAT tape recorders. Pistonphones were used to provide absolute sound level reference on the tape before and after all measurements.

4 Data Reduction

The sound metrics used in this report are A-weighted sound exposure level (ASEL) and flat (unweighted) sound exposure level (SEL), with 20 micro-Pascals as the reference for sound level (ANSI S1.4-1983). Sound exposure is defined as the time integral of the squared pressure.

Data reduction was carried out by means of computerized automated equipment and procedures. The computer applications used were PCScan, MATLAB, and MS Excel. PCScan consists of a suite of interfacing hardware and software that Sony developed as a method of downloading a time-domain pressure signal from a digital audio tape directly into a binary file. With the aid of signal processing software written for MATLAB by Jonathan Benson of USACERL, the projectile shock and muzzle blast from each shot were individually analyzed. Included in this analysis was the calculation of SEL, ASEL, and 1/3-octave-band spectra. The recorded pistonphone signal for each setup was used as the reference level for calculating sound levels. The resulting data were imported into an Excel spreadsheet for analysis and for table and graph preparation.

As discussed earlier in this report, there are two noise events in some portions of the field around the guns. These events are the muzzle blast due to high-pressure propellant gases, and a shock wave associated with the supersonic projectile. The projectile shock exists only in a portion of the field, depending on the bullet speed. For the weapons used in this study, the projectile shock exists only at angles from the line of fire smaller than roughly 60°. Where the projectile shock was present, the noise events for the muzzle blast and supersonic projectile shock were analyzed separately, to enable accurate assessment of the effect of the muffler on the muzzle blast noise. For small angles from the line of fire, the two events were spaced far enough apart in time to allow them to be analyzed separately. For the 60-° location, the two blast waves arrived at the microphone at about the same time. This disallowed the separation of the projectile shock energy from the muzzle blast energy. This effect shows up in the radial attenuation curves as an apparent decrease, or “hole,” in attenuation at the 60-° microphone, since the projectile shock energy in included in both the “muffled” and unmuffled data.

5 Results and Discussion

Close-in

The primary goal of the close-in measurements was to quantify muffler performances in terms of attenuation of SEL as a function of azimuth around the shooter. The present definition of attenuation is the difference in measured sound exposure level of the muffled and the unmuffled shots at locations around the noise source. Due to the nature of the open-ended muffler shape, muffler geometry, and weapon tip intrusion, the attenuation performance varies significantly with azimuth angle from the line of fire. The mufflers were also evaluated for durability and general suitability for training operations for M-16 and M-60 single shots and bursts. The results presented in this section provide a synopsis of the calculated attenuation and muffler performance comparisons.

Due to a combination of instrumentation difficulties and very high sound levels directly in front of the unmuffled gun, the recorded sound levels for the 10-°, 30-° (and 330-°) and 60-° (and 300-°) microphones were not valid. The levels for these positions were carefully extrapolated based on measured levels at other azimuths and published source data that provides a good understanding of the azimuthal variation of sound level for unmuffled guns. The extrapolated data are shown in shaded cells in the data tables. There were no difficulties with the muzzle blast data for the muffled shots.

The attenuation data are presented in Tables 2 and 3 for the M-16 and M-60, respectively, for muffler configurations 1, 3, 4, and 5, in terms of SEL (unweighted) and ASEL. The data for muffler configuration number 2 were not analyzed because of the high materials cost and generally similar performance (as indicated by preliminary data) of this configuration compared to similar configurations (3, 4, and 5). The azimuth angle to the microphone location, presented in the first column of Tables 2 And 3 and labeled “Mic. Az.,” is measured clockwise from the line of fire, so that 0° is the direction of fire, 180° is directly behind the shooter, and 90° is to the shooter’s right. In the large data blocks labeled SEL and ASEL, the first column contains the sound level data for the bare muzzle gun. The second through fifth columns contain the measured sound levels for each muffler configuration, and the sixth through ninth columns contain the calculated attenuation for each muffler configuration. The attenuation data are also presented in graphical form in Figures 8 through 15. The data clearly show the degree of muffler attenuation and how muffler attenuation varies with azimuth from the line of fire.

Generally, the mufflers exhibited the highest attenuation directly to the sides and toward the front of the shooter. The attenuation at these azimuths is about twenty decibels reduction in ASEL. Starting at 120° and moving to 180°, the attenuation decreases to levels of about 2 dB, and rises again symmetrically. Symmetry does not hold for all angles; the levels at 210° are noticeably lower than at 150°. This may be due to a right-handed shooter's body shielding the 210° microphone.

The attenuation data showed significantly higher than expected attenuation forward of the gun muzzle, at 10°, 30°, and 330°. A possible explanation is that the muzzle blast wave is attenuated as it propagates in the forward direction and passes over the sound absorber material. To the rear, the blast wave interacts with the sound absorber material over a shorter distance. To reach locations to the side, the muzzle blast wave must diffract around the edge of the front and rear openings or sound must travel through the wall of the muffler, which would be expected to yield the larger attenuation.

These data include only the effects of muzzle blast, except for the 60-° azimuth, as has been discussed in more depth in the chapter on **Data Reduction**. The lower levels of attenuation seen at 60° and 300° are due to the measured levels, including projectile shock noise as well as muzzle blast noise. Since the muffler effects no reduction in projectile shock noise, the apparent attenuation is reduced.

Separately analyzing the muzzle blast noise and the supersonic projectile shock (sonic boom) noise is not only appropriate, but necessary. This is because the two noise events originate at different points in space and decay in different manners. Thus the two must be separately extrapolated to the far field, which can only be done if they are accounted for separately in the region close to the gun.

Table 2. Attenuation measured at 10 meters for the M-16 rifle.

Mic.	SEL									ASEL								
Az.	Bare	#1	#3	#4	#5	#1 Atten.	#3 Atten.	#4 Atten.	#5 Atten.	Bare	#1	#3	#4	#5	#1 Atten.	#3 Atten.	#4 Atten.	#5 Atten.
10	116.2	101.4	103.6	100.8	100.8	14.8	12.6	15.4	15.4	113.8	97.0	100.8	98.1	97.9	16.7	13.0	15.7	15.8
30	115.1	100.8	100.6	99.4	99.3	14.3	14.5	15.7	15.8	112.8	92.9	94.2	94.0	91.3	19.9	18.6	18.8	21.5
60	111.8	100.5	102.0	100.9	99.1	11.2	9.7	10.8	12.7	109.8	97.1	97.1	97.9	91.2	12.8	12.7	11.9	18.6
90	105.8	94.8	99.0	96.9	96.0	11.0	6.9	9.0	9.8	104.7	85.7	84.9	83.2	83.1	19.0	19.7	21.4	21.6
120	104.5	97.4	100.5	98.7	98.1	7.1	3.9	5.8	6.3	103.6	90.9	86.9	85.5	85.7	12.7	16.7	18.1	17.9
150	100.2	95.5	98.3	96.7	96.7	4.7	1.8	3.4	3.5	99.7	89.8	88.9	87.9	88.2	9.9	10.7	11.7	11.5
180	98.7	96.3	97.9	96.2	96.2	2.4	0.8	2.5	2.5	98.6	93.8	93.5	90.7	90.3	4.8	5.0	7.9	8.3
210	98.2	97.1	98.9	96.7	96.9	1.2		1.5	1.3	97.5	94.0	92.7	87.4	90.0	3.6	4.9	10.1	7.6
240	102.7	96.2	98.9	97.0	96.7	6.5	3.8	5.8	6.1	101.8	91.2	88.0	86.3	85.8	10.6	13.9	15.5	16.0
270	106.4	94.8	98.5	96.6	95.8	11.6	7.9	9.8	10.6	105.3	86.7	85.2	83.9	82.4	18.7	20.1	21.4	22.9
300	111.8	99.9	101.5	100.1	98.4	11.9	10.3	11.6	13.4	109.8	95.4	96.0	96.2	90.4	14.4	13.8	13.7	19.5
330	115.1	99.7	99.8	98.1	97.8	15.4	15.3	17.0	17.3	112.8	91.3	93.6	92.0	89.0	21.5	19.2	20.8	23.8

Table 3. Attenuation measured at 10 meters for the M-60 machine gun, single fire.

Mic.	SEL									ASEL								
Az.	Bare	#1	#3	#4	#5	#1 Atten.	#3 Atten.	#4 Atten.	#5 Atten.	Bare	#1	#3	#4	#5	#1 Atten.	#3 Atten.	#4 Atten.	#5 Atten.
10	115.7	104.1	105.6	102.2	103.4	11.6	10.0	13.5	12.3	113.5	98.6	101.4	97.5	99.8	14.9	12.1	15.9	13.7
30	114.8	103.5	102.6	100.8	101.8	11.3	12.2	14.0	13.0	112.7	94.5	94.8	93.5	93.0	18.2	17.9	19.3	19.7
60	112.3	102.1	103.3	100.9	101.2	10.2	9.0	11.3	11.1	110.4	95.4	95.9	94.3	92.0	15.0	14.5	16.1	18.4
90	107.3	97.4	101.0	98.9	98.4	9.8	6.3	8.3	8.9	105.9	87.8	87.0	87.3	86.7	18.2	19.0	18.6	19.2
120	105.5	100.1	102.8	101.0	100.6	5.4	2.7	4.5	4.9	104.3	93.6	90.6	93.0	91.0	10.7	13.7	11.3	13.3
150	101.3	98.2	100.7	99.7	99.7	3.1	0.6	1.5	1.6	100.5	92.1	92.5	95.1	94.3	8.4	8.0	5.4	6.2
180	99.3	98.4	99.8	98.7	98.9	0.9		0.6	0.4	98.5	94.6	93.7	94.4	93.7	3.9	4.8	4.1	4.7
210	100.0	98.9	101.0	99.0	99.6	1.1		1.0	0.4	98.8	94.3	92.9	92.3	93.9	4.4	5.9	6.5	4.9
240	105.6	98.7	101.6	99.2	99.3	6.8	4.0	6.3	6.3	103.7	92.3	91.1	91.2	91.3	11.4	12.6	12.6	12.4
270	109.9	97.4	100.9	98.7	98.0	12.5	9.0	11.2	12.0	108.5	88.7	87.6	88.5	88.0	19.9	20.9	20.0	20.5
300	112.3	102.3	103.2	100.9	100.3	10.0	9.1	11.4	11.9	110.4	93.9	94.1	94.5	90.5	16.5	16.3	15.9	19.9
330	114.8	102.4	101.5	99.6	100.5	12.5	13.3	15.3	14.3	112.7	93.2	93.0	92.1	91.5	19.5	19.7	20.6	21.2

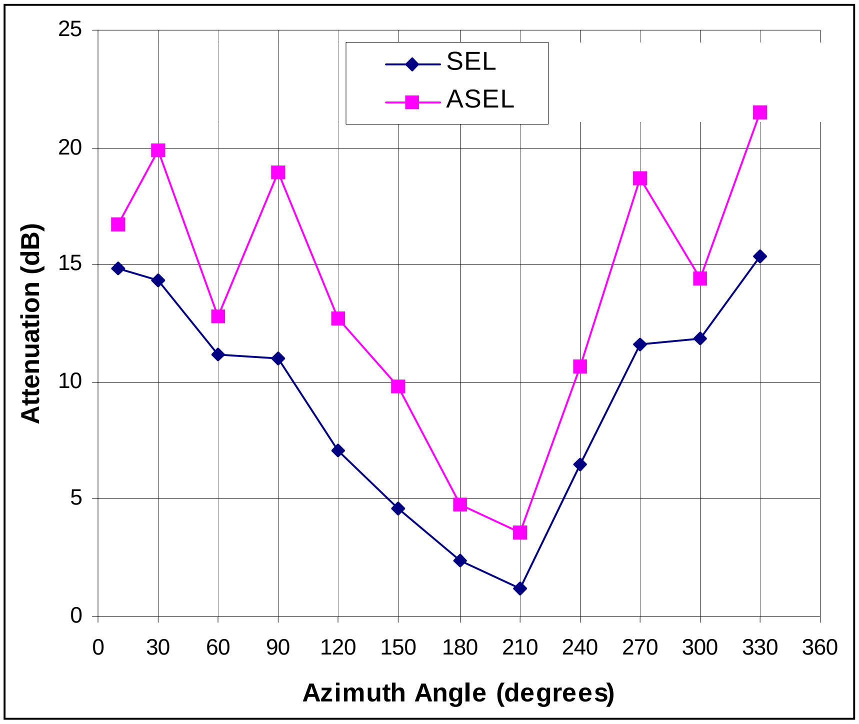

Figure 8. Muffler #1 attenuation for M-16.

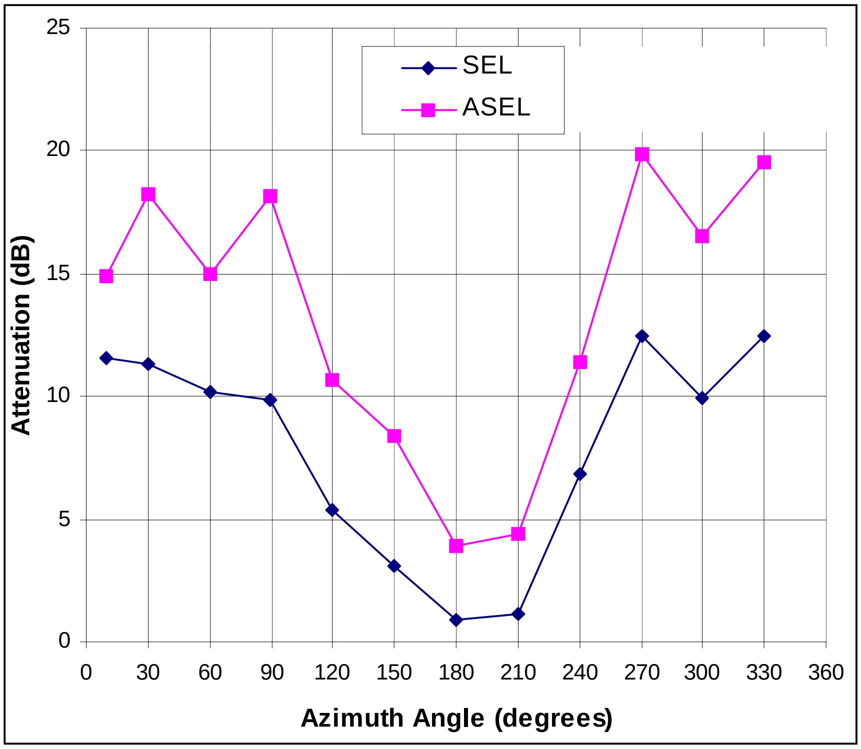

Figure 9. Muffler #1 attenuation for M-60.

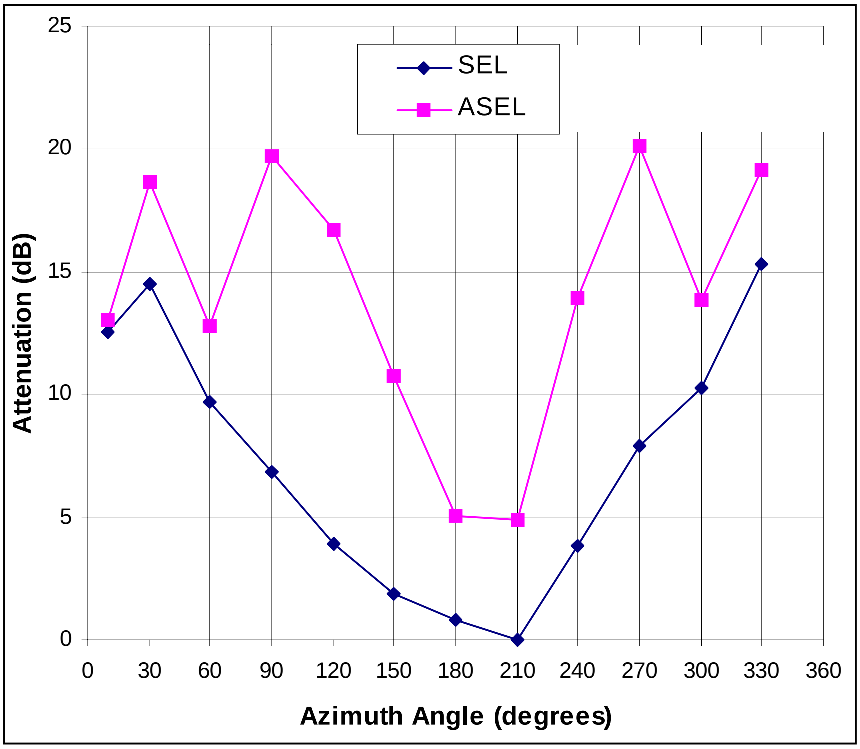

Figure 10. Muffler #3 attenuation for M-16.

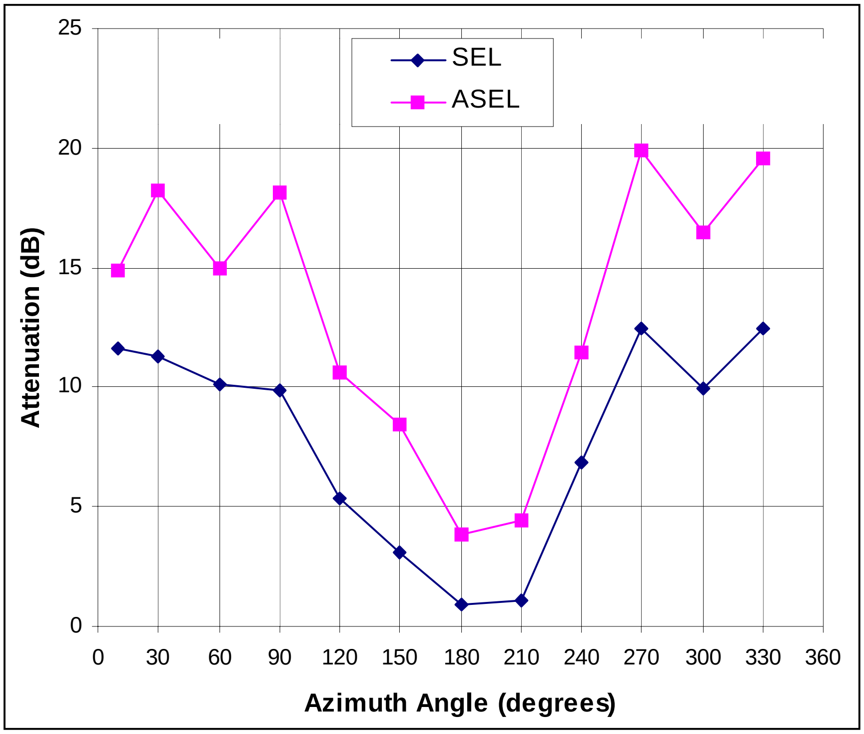

Figure 11. Muffler #3 attenuation for M-60.

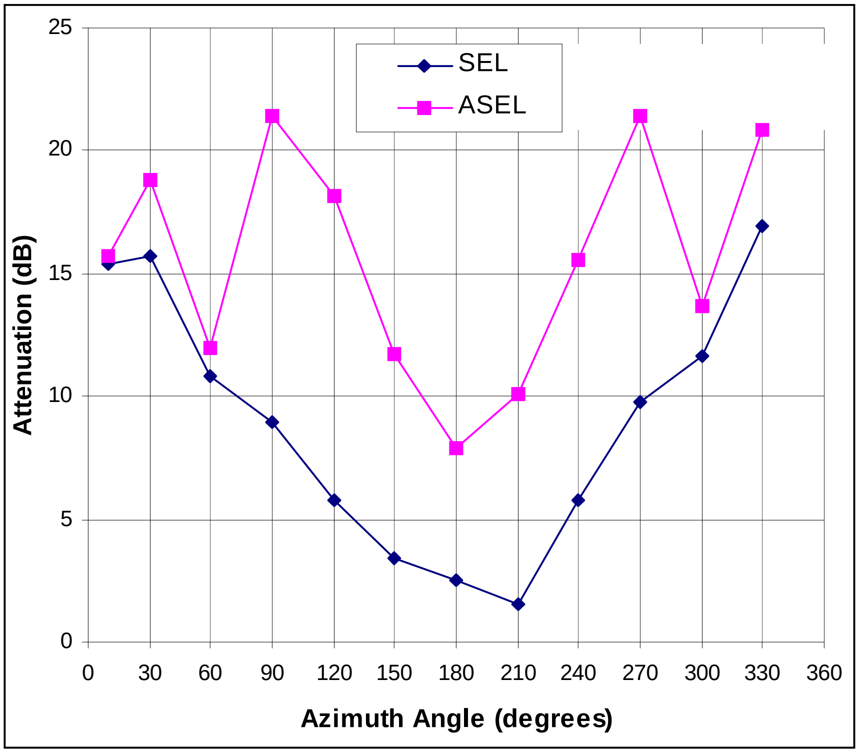

Figure 12. Muffler #4 attenuation for M-16.

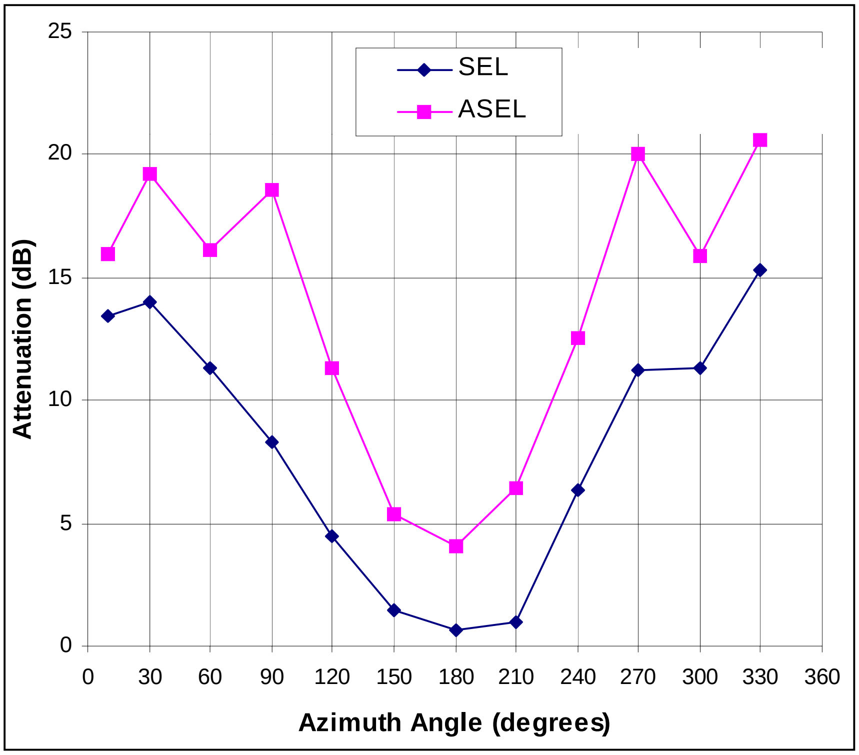

Figure 13. Muffler #4 attenuation for M-60.

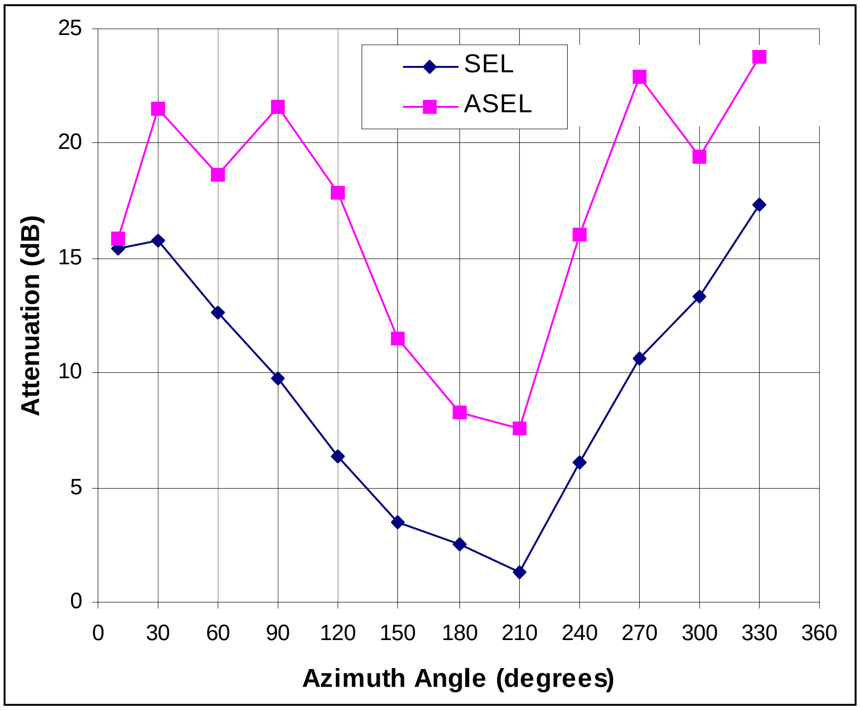

Figure 14. Muffler #5 attenuation for M-16.

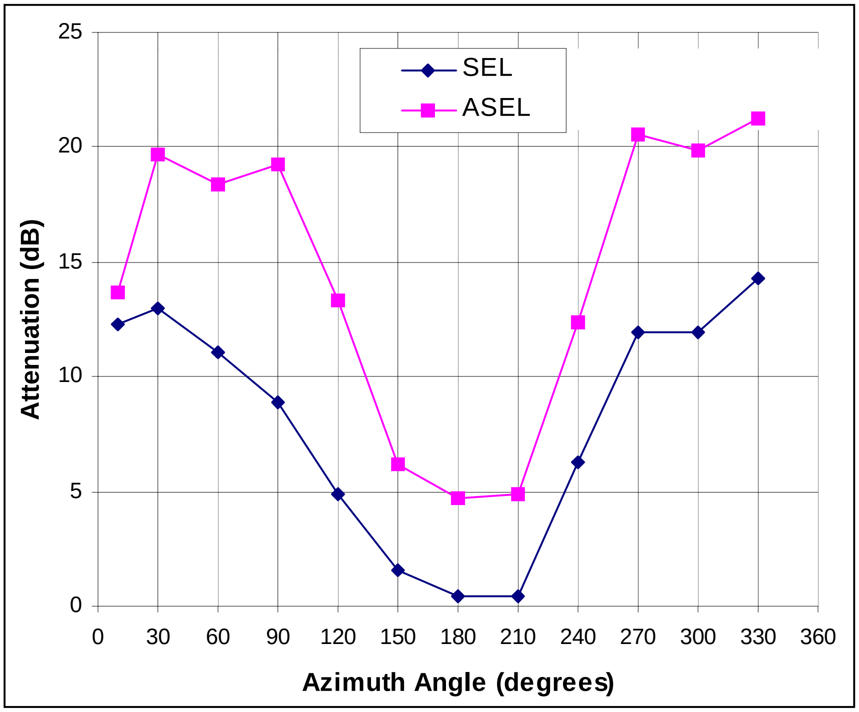

Figure 15. Muffler #5 attenuation for M-60.

The 200-meter downrange microphone located 30° off the firing line produced results comparable to that of the 10-meter 30° microphone. These data are presented in Tables 4, 5, and 6. These tables list the measured attenuation for the 200-meter microphone for the M-16 and M-60 single-round shots, and the M-60 three-round bursts.

The expected result that the mufflers would absorb the muzzle blast and not the projectile shock was clearly evident in both the 10-meter and 200-meter microphones. With the ability to separate out and analyze the separate effects of the muzzle blast and projectile shock, in all cases there was no muffling of the projectile shock. Keep in mind the fact that the projectile shock affects only a narrow strip of the surrounding area forward of the weapon. The performance of the mufflers measured in the close-in study was very good.

Table 4. 200m attenuation for M-16.

	Level		Attenuation	
Muffler	SEL	ASEL	SEL	ASEL
Bare	76.2	71.1	-	-
#1	71.1	57.5	5.0	13.6
#3	71.0	60.9	5.2	10.2
#4	70.9	61.8	5.3	9.3
#5	70.1	58.4	6.1	12.7

Table 5. 200m attenuation for M-60 single fire.

			Attenuation	
Muffler	SEL	ASEL	SEL	ASEL
Bare	77.7	72.0	-	-
#1	75.2	62.0	2.5	10.0
#3	74.5	63.6	3.2	8.4
#4	72.2	58.9	5.5	13.1
#5	73.9	59.6	3.8	12.4

Table 6. 200m attenuation for M-60 3-Rd. Burst*.

	Level		Attenuation	
Muffler	SEL	ASEL	SEL	ASEL
Bare	97.7	98.3	-	-
#1	86.5	85.7	11.2	12.6
#3	86.8	86.3	11.0	12.0
#4	83.8	82.7	14.0	15.6
#5	86.5	85.8	11.2	12.4

*NOTE: Burst includes bow shock effects.

The close-in data are adequate to make a comparison of overall muffler performance. Based on preliminary results and cost considerations, mufflers 1, 3, 4, and 5 were selected for the in-depth data analysis. The muffler performances were, on average, fairly consistent and similar. For the 10-meter circle, muffler 5 was, by a small margin, the best performer in SEL and ASEL comparisons for both weapons. Also the 200-meter comparisons showed solid performances for all, but muffler 5 had the overall best attenuation. Every tested muffler performed consistently with the group. The differences in overall performance are not sufficient to claim definitively the best design. Other factors such as construction costs, muffler durability, and ease of placement on-site should take on a higher priority. For example, muffler 5 is 8 feet long, which was judged to be somewhat awkward to handle and restricted the shooter’s view of the range noticeably more than the 6-foot configurations. Also, the plastic culvert is supplied in 20-foot lengths, which divides nicely into 3 6-foot lengths, whereas using 8-foot lengths results in more waste. Overall, muffler configurations 3 and 4 appear to offer the best combination of performance, cost, and ease of construction. This conclusion is made pending long-term durability testing results.

Far Field

The real performance test of the mufflers is their effects in the far field, in the community. Thus, far-field measurements were performed. These measurements were intended to also provide some indication of typical noise levels experienced by the community. Noise measurements at long distances are, however, always problematical. The human auditory system can easily discern noise events at levels that are near or even well below the ambient noise level. Such events are extremely difficult, if not impossible, to measure accurately. This is particularly true of impulse noise events. In addition, anomalous propagation conditions can have very large and sometimes puzzling effects on received noise levels. Unfortunately, both of these conditions occurred during the far-field measurements carried out at Camp Dodge. Ambient neighborhood noise such as traffic, airplanes, children playing, and a hacksaw cutting metal were typically louder than the gunshot noise. At one site the sound propagation conditions were so unstable that some muffled shots sounded louder than the unmuffled shots; this can only be the result of anomalous propagation conditions.

One measurement site was fortuitously located within the projectile shock alley. While noise event levels were too low to be measured, the human perceptions were interesting. The observers reported that the projectile shock noise and muzzle blast noise were clearly different in character, and that they were of roughly equal loudness for the unmuffled shots. The observers further reported that the projectile shock events seemed to be of similar loudness for the muffled and unmuffled shots, but that the muffler made the muzzle blast events nearly inaudible. This suggests that the muffler is very effective in reducing muzzle blast noise, which is the noise of greatest importance in almost all of the far field.

Measurements of muffler attenuation close to the gun, correctly interpreted and extrapolated, can give a good indication of the attenuation to be expected at large distances. To make this extrapolation requires knowledge of the spectra of the noise events. An impulse noise event such as gun noise has a fairly broadband spectrum; that is, the sound energy is spread over a fairly large range of frequencies. Furthermore, the muffler will more effectively absorb energy at some frequencies. The attenuation (the difference between sound level for unmuffled and muffled shots) might be expected to decrease somewhat with distance for the following reasons. The muffler could be expected to more effectively attenuate higher frequencies. Higher sound frequencies are also attenuated more than low frequencies during propagation through the atmosphere. Thus, some of the sound energy that is attenuated by a muffler would have been attenuated by the atmosphere after a long propagation distance.

ASEL spectra for both guns, for muffled and unmuffled shots, are presented in Figures 16 and 17. These data were measured at the 10-meter, 90° microphone. These graphs show that the mufflers produced relatively little attenuation at low frequencies, which is consistent with the acoustic properties and thickness of the tube liner material. These spectral data can be used to estimate the change in far field attenuation, by applying well-known values for atmospheric attenuation to each band ASEL and summing the results to obtain overall relative levels. Carrying out this calculation shows that the attenuation at 1 kilometer is little different than close-in, while at 3 kilometers the attenuation is reduced by about 5 dB. That is, if the muffler produced 20-dB attenuation at 10 meters from the gun, it could be expected to produce only about 15-dB attenuation at 3 kilometers (about 2 miles). Considering the amount of attenuation available and the fact that the noise level is almost always very low at distances beyond a mile or two, this is judged to not be a serious problem. The muffler gives adequate attenuation throughout most of the far field.

An interesting aspect of the spectral data is that they indicate that the muffled shots have larger energy at very low frequencies than do the unmuffled shots. This could be due to the mufflers resonating when excited by the gun blast. These results are consistent with auditory impressions during the testing; the mufflers seemed to add a hollow-sounding, rather low frequency boom to the noise of the shot. This is one reason that the muffler attenuation decreases at larger distance. Fortunately this is not a serious problem, as discussed above.

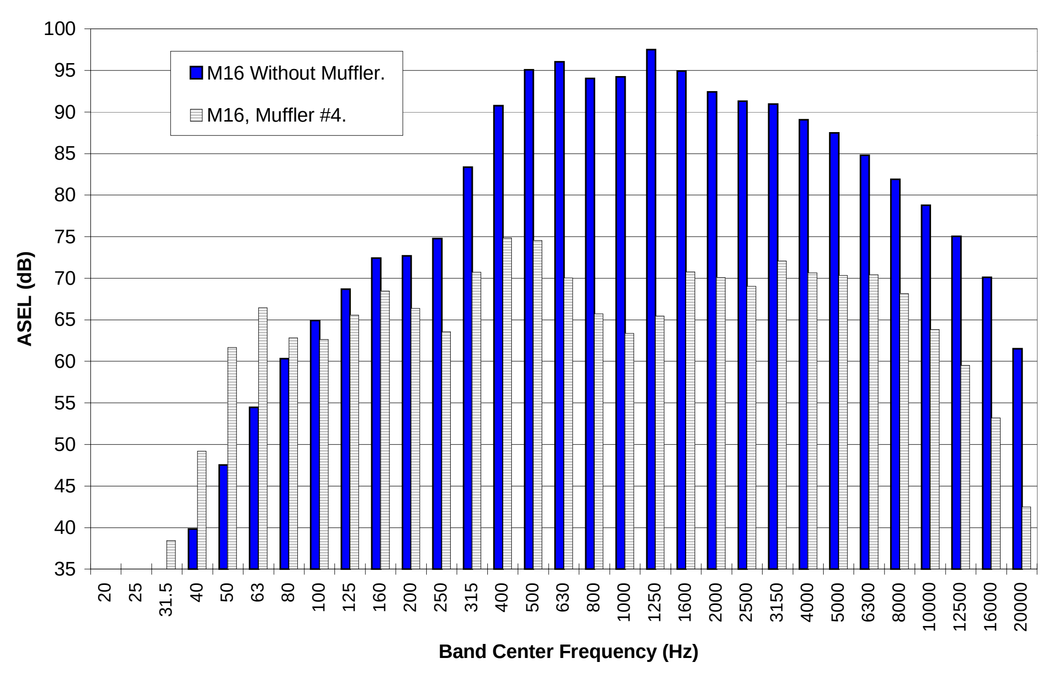

Figure 16. One-third octave band ASEL spectrum for M-16 (90 degrees, 10-meter).

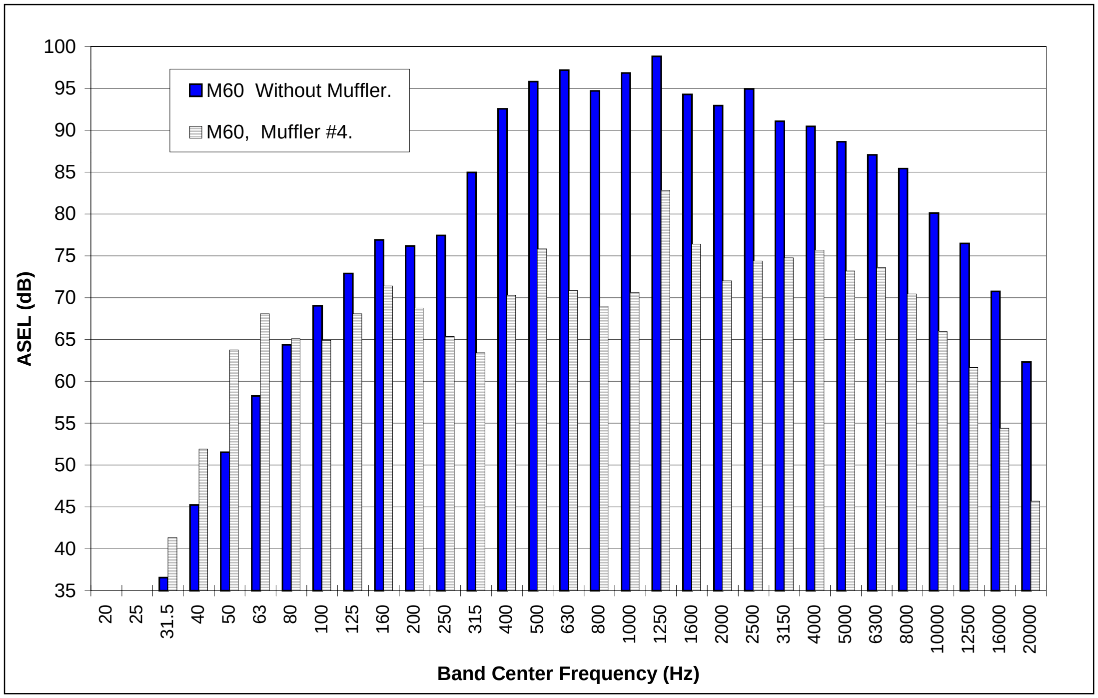

Figure 17. One-third octave band ASEL spectrum for M-60 (90 degrees, 10-meter).

6 Conclusions

Overall, muffler configurations 3 and 4 appear to offer the best combination of performance, cost, and ease of construction, though any of the configurations could be satisfactory. This conclusion is made pending long-term durability testing results. ASEL is a meaningful measure of small arms noise level for judging human annoyance response.

The data show that either of these muffler configurations will provide a reduction in ASEL noise level of 10 to 20 dB throughout most of the noise-sensitive region surrounding Camp Dodge. This is a significant reduction in noise level. To give perspective, a reduction of 10 decibels is perceived by humans as about half as loud. Smaller attenuation can be expected to the rear, which is of less importance because the noise level is much lower in this direction.

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Appendix A: Regulatory Background

a. Introduction. A characteristic of environmental noise is that it is not steady but varies in amplitude from one moment to the next. To account for these variations and to assess environmental noise in a uniform manner, the U.S. Environmental Protection Agency (EPA) (EPA 1974) endorsed the day-night level (DNL) as the acceptable noise evaluator. This evaluator is used by many Federal and state agencies, including the Department of Defense (DOD), Department of Housing and Urban Development (HUD), and the Federal Aviation Administration (FAA) as the standard for describing environmental noise impact.

b. The Noise Control Act of 1972.

(1) The Noise Control Act of 1972 (Public Law 92-574 1972) states "...that it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare" and that Federal agencies "(1) having jurisdiction over any property or facility, or (2) engaged in any activity resulting, or which may result, in the emission of noise, shall comply with Federal, State, interstate and local requirements..." [Section 4(b)].

(2) In Section 6 of the Act, the Administrator of the EPA is directed to establish noise emission standards for products and to prescribe regulations for such products.

(3) However, in Section 3, Congress excluded any military weapons or equipment that are designed for combat use from the definition of product.

c. The Office of the Judge Advocate General.

(1) The Office of The Judge Advocate General (U.S. Army 1989) states "In light of this, we think the correct Army policy with respect to the Noise Control Act is that all Army activities should endeavor to comply with all Federal, State and local requirements respecting the control of noise as stated in Section 4(b) of the Act, unless to do so would conflict with the Army's mission. The obligation to comply with State and local noise laws arises out of the Army's policy of cooperation on environmental matters generally."

(2) In accordance with Army Regulation (AR) 200-1 (1997), questions regarding the applicability of State and local laws and regulations should be referred to the command legal officer and through channels to the Office of the Judge Advocate General.

d. Army Regulation 200-1.

(1) Chapter 7 of AR 200-1 implements all Federal laws concerning environmental noise from Army activities through the ICUZ program. The ICUZ program defines three noise zones.

(a) Zone I - compatible.

(b) Zone II - normally incompatible.

(c) Zone III - incompatible.

(2) These compatibility zones are used for land use planning, to prevent conflicts with noise-sensitive land uses, such as residential housing and hospitals. Land uses such as commercial, industrial, and agricultural (except livestock), are compatible with most noise environments. A listing of land use compatibilities is contained the Federal Interagency Committee on Urban Noise report (FICUN 1980).

e. Military Noise Environments and Land Use Guidelines. Military noise environments and land use guidelines are discussed in Appendix B. A discussion of environmental noise descriptors is in Appendix C.

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Appendix B: Military Noise Environments and Land Use Guidelines

1. REFERENCES. Army Technical Manual (TM) 5-803-2, "Environmental Protection: Planning in the Noise Environment." (Headquarters, Department of the Army, 1978).

2. MILITARY NOISE ENVIRONMENTS. Military noise environments are generally characterized by three types of noise.

a. Transportation Noise. Transportation noise resulting from aircraft and vehicle activities is best described in terms of the A-weighted day-night level (ADNL). The A-weighting scale closely resembles the frequency response of human hearing and, therefore, provides a good indication of the impact of noise produced by transportation activities. The compatibility levels for ADNL were developed through social surveys conducted by many government and private organizations.

b. High Amplitude Impulsive Noise. High amplitude impulsive noise resulting from armor, artillery and demolition activities is described in terms of the C-weighted day-night level (CDNL). The C-weighting scale measures more of the low frequency components of this noise than the A-weighting does. These low frequency components can cause buildings and windows to rattle and shake. This is an important ingredient in a person's perception of the annoyance from blast activities. The compatibility levels for CDNL were developed through studies performed by the Federal Aviation Administration (FAA) and the U.S. Army Construction Engineering Research Laboratories (USACERL).

c. Small Arms Range Noise. Currently, the ADNL is used to evaluate the noise from small arms ranges. The A-weighting frequency network of the sound level meter deemphasizes the lower frequency portion of the noise spectrum to approximate the human ear's response to the noise. This gives best correlation between the noise from small arms ranges and the percent of the population highly annoyed.

3. LAND USE PLANNING GUIDELINES.

a. The land use planning guidelines use the different noise weighting scales as discussed above. This difference in weighting scales reflects the difference in the mechanisms underlying annoyance. Transportation noise annoys people because it is heard; impulsive noise annoys people because it shakes their homes.

b. The following table represents the current consensus. A detailed description of noise levels, weighting schemes, standards and guidelines can be found in Technical Manual 5-803-2 and Appendix C.

Land Use Planning Guidelines

Noise Zone	Population Highly Annoyed	Transportation ADNL	Impulsive CDNL	Small Arms ADNL
I	< 15	< 65 dBA	< 62 dBC	< 65 dBA
II	15 – 39	65 - 75 dBA	62 - 70 dBC	65 - 75 dBA
III	> 39	> 75 dBA	> 70 dBC	> 75 dBA

dBA = decibels, A-weighted
dBC = decibels, C-weighted
< = less than
> = greater than

Appendix C: Environmental Noise Evaluators

1. REFERENCES. References used in this Appendix are listed at the end.

2. INTRODUCTION. A characteristic of environmental noise is that it is not steady, but varies in amplitude from one moment to the next. To account for these variations in the sound pressure level with time, and to assess environmental noise in a consistent and practical manner, a statistical approach has been used to reduce the time-varying levels to single numbers. The currently accepted single-number evaluators are the equivalent sound level (LEQ) and the day-night level (DNL).

3. BACKGROUND.

a. Noise is defined as unwanted sound. Sound is the variation of air pressure about a mean (atmospheric) pressure. These changes in the atmospheric pressure [100,000 Pascals (14.7 pounds per square inch) (psi)] vary from approximately 0.0006 Pascals for a whisper at 2 meters to 1,000 Pascals for firing an M-16 rifle near the firer's ear. Because of this large range of sound pressure and the fact that the human ear responds more closely to a logarithmic scale rather than a linear scale, sound pressure level is defined as 20 times the common logarithm of the ratio of the sound pressure to the reference pressure (0.00002 Pascal). The sound pressure level is measured in decibels (dB). For example, if the sound pressure doubles from 0.2 to 0.4 Pascals, the level increases by 6 dB from 80 to 86 dB.

b. In environmental noise, the sound pressure level is usually measured using one of the frequency networks of the sound level meter. Since the human ear is more sensitive to sounds of 1,000 Hertz (Hz) and above than sounds of 125 Hz and below, it is appropriate to apply a weighting function to the noise spectrum that approximates the response of the human ear. The A-weighting frequency network of the sound level meter deemphasizes the lower frequency portion of the noise spectrum to approximate the human ear's response to the noise. This A-weighting frequency response is specified by American National Standards Institute (ANSI) standard S1.4-1983 (ANSI 1983). Thus, the

A-weighting of the frequency content of the noise signal has been found to have an excellent correlation with the human subjective judgment of annoyance of the noise. The sound pressure levels measured using the A-weighting network are expressed as dBA.

c. To assess the additional annoyance caused by low frequency vibration of structures, the C-weighting network is used to evaluate the impulsive noise from all weapons larger than small arms. This weighting is also specified by the standard. The sound pressure levels measured using the C-weighting network are expressed as dBC.

d. For small arms ranges, the linear weighting network is currently being used. The peak decibels sound level (dBP) is used to evaluate this noise. This weighting is also commonly used to measure the dBP from impulsive events. The linear weighting network weights the sound energy contained in all frequencies equally.

4. HISTORY.

a. Before the mid 1970's, every organization had its own set of preferred environmental noise evaluators. This resulted in a wide variety of evaluators. Since each evaluator was developed for a specific purpose, a noise environment measured with one evaluator could not be compared with an environment measured using another evaluator.

b. In carrying out its responsibilities under the Noise Control Act of 1972 (PL 92-574 1972), the EPA recommended the adoption of a single environmental noise evaluator, the LEQ and its 24-hour version, DNL. The Department of Defense, along with most other U.S. Government Agencies followed the EPA recommendation. The DNL is the most widely accepted descriptor for environmental noise (FAA 1990) because of the following characteristics:

(1) The DNL is a measurable quantity.

(2) The DNL is simple to understand and use by planners and the public who are not familiar with acoustics or acoustical theory.

(3) The DNL provides a simple method to compare the effectiveness of alternative scenarios.

(4) The DNL is a "figure of merit" for noise impacts which is based on communities' reactions to environmental noise.

(5) The DNL is the best measure of noise exposure to identify significant impacts on the quality of the human environment.

(6) By Federal interagency agreement, the DNL is the best descriptor of all noise sources for land use compatibility planning.

(7) The DNL is the only metric with a substantial body of scientific survey data on the reactions of people to noise.

c. In recommending the DNL, the EPA noted that most noise environments are characterized by repetitive behavior from day to day, with some variation imposed by differences between weekday and weekend activity, as well as seasonal variation. To account for these variations, an annual average is used.

d. Since annoyance is caused by long-term dissatisfaction with the noise environment, the annual average is an excellent predictor of the average community annoyance when there is not a large variation in the day to day or season to season DNL. The annual DNL is not a good predictor of noise complaints, since complaints represent the person's immediate dissatisfaction with the noise environment.

e. Currently, there are no guidelines for judging the land use compatibility for single noise events. Although much of the early work on annoyance was done on single events, each study was designed differently, and the results cannot be combined in a systematic fashion to form a statistically valid sample. Most of these studies were either done inside a laboratory or, if done outdoors, in controlled settings. Only recently has equipment become available that allows subjects to register their annoyance if single events are experienced during their routine activities. There is not enough of this information available to support setting standards on single events.

f. For impulsive noise, the Department of the Army uses the CDNL. The use of C-weighting is based on the findings of the National Academy of Sciences Committee on Hearing, Bioacoustics and Biomechanics Association (CHABA 1981). Studies have been performed by USACERL (Schomer and Neathammer 1984) to define the average annoyance as a function of the CDNL. The ANSI has endorsed this methodology for predicting the annoyance caused by impulsive noise (ANSI S12.4-1986).

g. Until recently the dBP was used to predict the annoyance caused by small arms range noise. In late 1996 the U.S. Army Small Arms Range Noise Assessment Model (SARNAM) was introduced. Developed by the USACERL with the assistance of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), this model produces noise contours using the ADNL. In conformance with ANSI Standard S12.9, a 12-dB adjustment for impulsiveness is added to the ASEL values used to calculate the ADNL.

5. LEQ/DNL.

a. The LEQ is defined as the equivalent steady state sound level that, in a stated period of time, would contain the same acoustic energy as the time-varying sound during the same period. The LEQ is an energy average. The energy average puts more emphasis on the higher sound pressure levels than the arithmetic average. The LEQ is usually computed for a 1-minute, 10-minute, 30-minute, 1-hour, 8-hour, or 24-hour segment of environmental noise.

b. To assess the added annoyance of the environmental noise during the nighttime hours (2200 - 0700 hours), the DNL is used. The DNL is the 24-hour LEQ, with a 10-dB penalty added to the nighttime levels.

c. By using the LEQ and DNL, the three important determinants of noise annoyance can be described by a single number. The three determinants are the intensity of the noise event, the duration of the noise event, and the number of times the noise event takes place.

d. The noise from jet aircraft operations on a military training route is unique in several respects. The combination of low altitudes and high air speeds results in noise signatures with high levels and short durations. This results in a very rapid onset that may produce a startle response. Also, the noise events are highly sporadic. To account for the rapid onset and sporadic events, the onset rate-adjusted monthly day-night level (DNRML) is used. The DNRML is a monthly DNL that is adjusted for the added annoyance caused by the rapid onset of the noise.

6. NOISE CONTOURS.

a. Noise contours are generated using the A- or CDNL. The contours are computed by averaging over the time period of interest, the acoustical energy from the operations of the set of noise sources of interest. The averaging period is usually a busy day, a training cycle, or a year. The contours, representing the boundaries between the noise zones, are constructed by connecting points of equal acoustical energy.

b. The noise contours for small arms ranges are generated using the ADNL with a 12-dB impulsive adjustment added or the A-weighted sound exposure level (SEL).

c. For example, the contours for an airfield are computed by averaging at many points the acoustical energy arriving at these points from aircraft operations. A 10-dB penalty is added to all nighttime operations. The contours for the airfield are constructed by connecting all points having a total acoustical energy equal to 65 dBA and connecting all points equal to 75 dBA.

REFERENCES

American National Standards Institute (ANSI), 1983, S1.4-1983, “American National Standard Specification for Sound Level Meters.”

ANSI, 1986, S12.4-1986, “American National Standard Method for Assessment of High-Energy Impulsive Sounds with Respect to Residential Communities.”

Committee on Hearing, Bioacoustics, and Biomechanics Association (CHABA), 1981, Working Group 84 Report, “Assessment of Community Response to High-Energy Impulsive Sounds.”

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Luz, 1982, “An improved procedure for evaluating the annoyance of small arms ranges,” presented at the 104th Meeting of the Acoustical Society of America, Orlando, Florida.

PL 92-574, 1972, Noise Control Act of 1972.

Schomer, Paul D. and Robert D. Neathammer, *Community Reaction to Impulse Noise: A 10-Year Research Summary,* USACERL Technical Report N-167, ADA141762 (USACERL 1984).

Appendix D: Complaint Management

1. REFERENCES.

a. Army Regulation, (AR) 200-1, “Environmental Protection and Enhancement.” (Headquarters, Department of the Army, 21 February 1997).

b. U.S. Army, 1980, USAEHA Technical Guide (TG) 044, “Suggested Procedures for Recording Noise Complaints at Army Installations.”

2. There are two key words to a successful complaint management program: integrity and sensitivity.

a. The program must have integrity so that when you tell the community something, the community will believe and trust you. Once you tell the community, they consider the information as your policy. If you tell the community that you will not detonate explosive charges before 0900 hours, then you must not detonate before 0900 hours. If it is necessary to change this policy, then you should explain to the community why you are changing the policy before the change takes place.

b. The program must be sensitive to the community’s concerns. You should listen to them and find out what is annoying them. There may be a simple solution to the problem, once you discover the cause. You should also be responsive to them by telling them, for example, why you must perform the operation. Remember, the public’s perception is their reality.

3. A successful noise complaint management procedure will help the installation avoiding community action against training activities. Like all portions of the Environmental Noise Management Program (ENMP), this procedure needs to be proactive. Its purposes are to reduce the potential of noise complaints by keeping the public informed about what is going to happen and to satisfy the complainants so that noise complaints do not escalate into political actions.

4. The potential of noise complaints can be reduced by providing the news media with press releases when other than normal operations are scheduled or

when normal operations are scheduled to resume after a period of inactivity. The press release should include a telephone number that the community can use to receive additional information or complain about the noise. The news media should be monitored to make sure the information is released to the community.

5. If the installation does not respond to complaints in a timely and polite fashion, the complainants often organize into citizen action groups. These groups will address the complaint to higher levels of command and government. When the situation becomes political, the installation's mission can be impaired by unnecessary operational restrictions and resources spent reacting to political pressures (local, state, and Congressional).

6. A noise complaint procedure is required by AR 200-1 to log and investigate all complaints. An effective procedure will enable the installation to maintain a good relationship with the surrounding communities. The minimum requirements of the complaint procedure are listed and discussed below.

a. <u>A log is maintained of all noise complaints</u>. The log should contain the complaint location, date, time, cause of complaint, and meteorological conditions (for example, wind speed and direction, temperature, cloud cover, precipitation). The complaint log would help in isolating habitual complainers, would show the effectiveness of predictions, and would identify the types and times of operations that are most offensive.

b. <u>Complaints are investigated without delay</u>. By investigating complaints immediately, it may be possible to delay the cause of the complaint until noise propagation conditions improve. This action will reduce the risk of additional complaints and will show the complainants that the Army is concerned about their health and welfare.

c. <u>The complainant is aware of the installation's mission and that every effort will be made to correct the problem, mission permitting</u>. Installation representatives should visit with the complainant. If feasible, this visit should occur during a time when the operation that caused the complaint is being performed. The representatives should explain the operation to the complainant, including why it is being performed at this time and installation. They should ask the complainant about how the noise environment today compares with the day of the complaint, and try to obtain some insight into why the complaint was generated. If feasible, the complainant should be invited to the installation to observe the operation.

d. Complaints are routed to the office responsible for the type of activity that resulted in the noise complaint. The Public Affairs Officer (PAO) will require a response for the purpose of providing information to the complainant. Sample complaint and followup forms are shown in the USAEHA TG (U.S. Army 1980). Besides being used to provide a response to the complainant, this information can also be used for planning future operations.

e. A copy of the complaint and response is provided to the Environmental Quality Control Committee (EQCC). The EQCC will provide technical assistance to the PAO and the activities generating the noise.

f. The noise-generating activity will complete a followup by identifying the cause of the noise and any action taken to correct the deficiency. A copy of the followup documentation will be provided to the EQCC. This followup information will be useful when planning future operations.