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14. ABSTRACT The United States Air Force School of Aerospace Medicine, Consultative Services Division conducted an acoustical evaluation of the Combat Arms firing range, building 1894, at Malmstrom AFB, Montana. The purpose of this assessment was to classify the measured noise exposure as continuous or impulse, explain how the classification pertains to Air Force Occupational Safety and Health (AFOSH) Standard 48-20, <i>Occupational Noise and Hearing Conservation Program</i> , and provide recommendations for mitigating exposure. The noise in the firing range is characterized as continuous noise because the average noise decay time for each of the weapon types assessed was greater than 1 second due to reverberation. According to AFOSH Standard 48-20, unprotected exposure above 115 dBA is not allowed. The consultative letter recommends installing sound absorbing material to reduce the reverberant field.					
15. SUBJECT TERMS Impulse noise, impact noise, continuous noise, decay time, CATM, firing range, hearing, acoustics, noise, firearms, L_{eq}					
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DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

23 January 2015

MEMORANDUM FOR 341 MDOS/SGOJ
ATTN: MAJ BRIAN CLARKE
7300 NORTH PERIMETER ROAD
MALMSTROM AFB, MT 59402

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2014-0003, Acoustical Evaluation of
Combat Arms Firing Range, Malmstrom AFB, Montana

1. INTRODUCTION:

a. *Purpose:* From 16-20 June 2014, the United States Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), at the request of AFGSC/SGPB and 341 MDOS/SGOJ, conducted an acoustical evaluation of the Combat Arms firing range, building 1894, at Malmstrom AFB, Montana. The purpose of this assessment was to classify the measured noise exposure as continuous or impulse, explain how the classification pertains to Air Force Occupational Safety and Health (AFOSH) Standard 48-20, *Occupational Noise and Hearing Conservation Program*, and provide recommendations for mitigating exposure to hazardous noise. The process of assessing impulse noise at a firing range is a very complex task requiring specialized equipment. USAFSAM/OEC is the only AF Bioenvironmental Engineering resource with both the skilled personnel and equipment to accomplish these risk management/mitigation surveys.

b. *Survey Personnel:* Two Bioenvironmental Engineering Technicians, USAFSAM/OEC

c. *Personnel Contacted:*

- (1) Bioenvironmental Engineer, 341 MDOS/SGOJ
- (2) Bioenvironmental Engineering Technician, 341 MDOS/SGOJ
- (3) NCOIC, Combat Arms, 341 SSPTS/S4C
- (4) Combat Arms Instructor, 341 SSPTS/S4C

d. *Equipment:*

- (1) B&K PULSE Analyzer, Type 3052-A-030, SN: 3052-105153
- (2) B&K Microphone, Type 4128C 2530, SN: 2856097, 2856098
- (3) B&K Head and Torso Simulator (HATS), Model 4128C, S/N: 2425802
- (4) Quest Calibrator, Model # QC-20, SN QF8050050

2. BACKGROUND:

a. The Malmstrom AFB Combat Arms firing range is partially enclosed, with 17 total firing positions. Each firing position has a metal door that is opened when that specific point is used for live-fire training. The walls and ceiling inside the building are covered with a hard building material (drywall, painted plywood), while the floor is a smooth-poured concrete. A number of plywood-covered, steel safety baffles hang from the ceiling, down range of the firing line. These baffles are designed to deflect stray bullets and prevent them from leaving the range. The floor down range of the firing line is also smooth-poured concrete.

b. The firing range has two distinct painted floor lines for reference. The first point of reference is the yellow safety line. Students must stand behind this line while not actively firing a weapon. The second point of reference is the red firing line, which is 8 feet forward (down range) of the yellow safety line. The red line is where each student actively fires a weapon at a down range target. During live-fire weapons training classes, instructors are positioned along the yellow line to ensure the range is safe and to assist students when needed. During this assessment, Combat Arms instructors were observed wearing dual hearing protection (Moldex Camo ear plugs, which have a noise reduction rating of 33 dBA, and Peltor PowerComm headsets with a noise reduction rating of 24 dBA).

c. CATM uses this firing range facility to train and qualify base personnel on M4, M9, and M870 weapons firing. On average, CATM conducts firing 4 days per month on the M9 pistol, 2-3 days per month on the M4 rifle, and 2 days per month on the M870 shotgun. The average class for each weapon type is 17 students.

d. According to AFOSH Standard 48-20, “the maximum level of **continuous noise** that is allowed to reach the ear shall not exceed 115 dBA and the maximum level of **impulse noise** that is allowed to reach the ear shall not exceed 140 dB peak sound pressure level (SPL).” AFOSH Standard 48-20 defines impulse noise as: “The pressure-time history of a single burst includes a rapid rise to a peak pressure followed by a somewhat lower decay of the pressure envelope to ambient pressure. A series of impulses may last longer than 1 second.”

e. A noise reverberant field is created when the noise energy from a fired weapon is reflected off the ceiling, walls, and floor surfaces, thereby increasing noise levels for a longer duration. Additionally, the steel safety baffles located down range of the firing line are closely spaced and have the potential to reflect acoustical energy, thereby increasing the duration of noise levels.

3. METHODOLOGY:

a. *Sample Procedures:* USAFSAM/OEC collected three distinct sets of data simultaneously during each weapon type course of fire. USAFSAM/OEC used the first set of data, the SPL time-history, to calculate the average noise decay time for each of the weapon types. The second and third sets of data were the equivalent continuous noise levels (L_{eq}) at-ear unprotected and at-ear protected, respectively. The unprotected at-ear L_{eq} data represent the average noise level instructors would be exposed to if they were not wearing hearing protection. The protected at-ear L_{eq} data are the noise levels the instructors would be exposed to when correctly using the ear

plugs (Moldex Camo ear plugs) and communication headsets (Peltor PowerComm). Due to computer system performance limitations, the unprotected and protected L_{eq} data were collected in 30 second increments during the course of live-fire and averaged for each weapon type.

(1) USAFSAM/OEC measured the SPL time-histories corresponding to individual M4, M9, and M870 weapon firings with two 1/8-inch microphones. We placed each microphone 5 feet above ground level along the yellow safety line. USAFSAM/OEC used the data from these microphones to calculate and report the average decay time, as well as the peak SPLs for each weapon system presented in Table 1.

(2) USAFSAM/OEC used the same microphones to collect the SPL time-histories to collect the average unprotected noise level values presented in Table 2.

(3) The survey team collected the protected L_{eq} data using a HATS. The HATS is a mannequin with a 1/2-inch microphone embedded behind the earpiece. During this assessment USAFSAM/OEC fitted the HATS with the same hearing protection devices the Combat Arms instructors wear and placed it 5 feet above ground level along the yellow safety line to simulate an instructor at the yellow safety line while students were actively firing the weapons.

b. *SPL Time-Histories:* Time-histories are SPLs measured over a duration of approximately 10 seconds. This duration provides sufficient time to characterize the decay of the acoustical energy from ammunition discharge to background levels. We used these time-histories to compute acoustical decay characteristics. The linear SPL decay rate, in decibels per second, is computed by selecting the linear decay phase of each time-history and performing a sound level versus time analysis through it. Decay times are calculated from 150 dB down to 80 dB. The slope of this curve is the decay rate.

c. *Data Collection:* SPL time-history and L_{eq} data sets were collected from three different weapon types representing the spectrum of exposure scenarios typical at this firing range. Figure 1 shows the layout of the firing range as well as where the microphones were for each phase of data collection.

(1) For the first weapon type, 10 students each fired 90 rounds of ammunition from an M9 pistol.

(2) For the second weapon type, 8 personnel each fired 10 rounds from an M870 shotgun.

(3) We collected only SPL time-history data for the third weapon type, M4, because a formal training course was not scheduled during the period of this assessment. SPL time-histories were recorded from 8 personnel firing 30 rounds each from an M4 rifle.

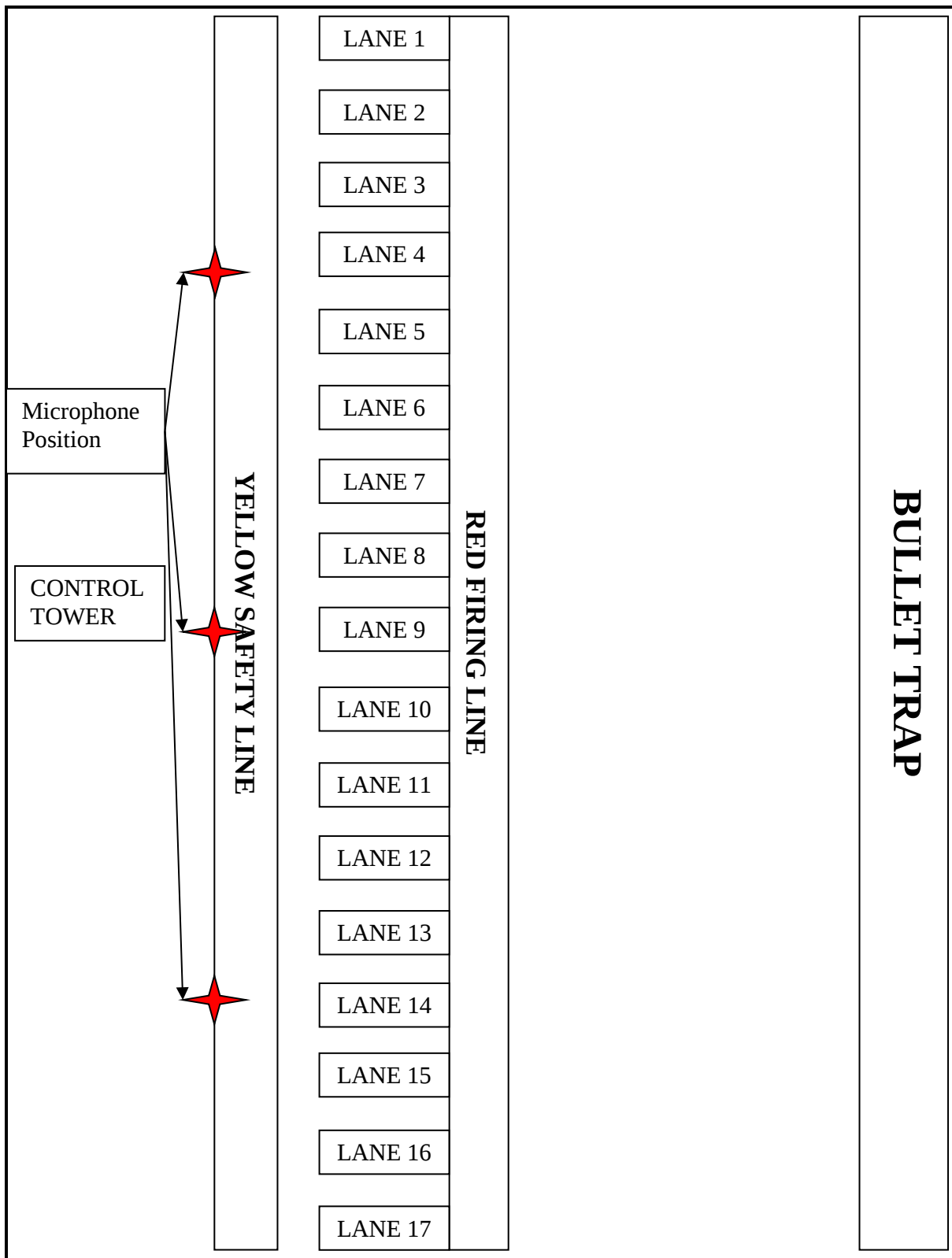


Figure 1. Malmstrom AFB Combat Arms Firing Range Layout and Microphone Positions

4. RESULTS:

a. Under the conditions of this assessment, the average noise decay time for each of the weapon types was greater than 1 second. As a result, we are classifying this noise as continuous. Also, peak SPLs for each weapon type were greater than 115 dB. According to AFOSH Standard 48-20, Table 3, there is no allowed exposure time for continuous noise above 115 dBA.

b. The average decay time and noise characterization of the three different types of weapons are in Table 1.

Table 1. Noise Characterization by Weapon Type

Weapon Type	Average Decay Time (s)	Noise Characterization	Measured Peak Sound Pressure Level (dB)	Permissible Unprotected Continuous Noise Level (dB)	Exceeds Continuous Noise Std. (Yes/No)
M9	1.6	Continuous	148	115	Yes
M4	1.6	Continuous	154	115	Yes
M870	1.8	Continuous	150	115	Yes

c. Table 2 summarizes the average unprotected and protected L_{eq} for the Combat Arms instructors for the M9 and M870. L_{eq} data for an M4 training course are not available because there was no active training course during the period of the assessment.

Table 2. Unprotected and Protected Noise Level Averages and Allowable Exposure Times

Weapon System/Class Type	Measured Average Unprotected Noise Level, L_{eq} (dB)	Allowable Unprotected Exposure Time (min)	Measured Average Protected Noise Level, L_{eq} (dB)	8-hour Permissible Protected Exposure Level (dBA)	Maximum Allowable Protected Exposure Time (min)
M9	111	1.2	66	85	Zero*
M870	111	1.2	66	85	N/A

*Exceeds peak exposure standards (Table 3)

d. Table 3 summarizes peak protected SPLs for the M9 and M870.

Table 3. Peak Protected SPLs

Weapon System/Class Type	Measured Peak SPL Protected (dB)	Permissible Unprotected Continuous Noise Level (dB)	Exceeds Continuous Noise Std. (Yes/No)
M9	118	115	Yes
M870	103	115	No

5. CONCLUSION:

a. The noise in the firing range is characterized as continuous noise because the average noise decay time, shown in Table 1, for each of the weapon types assessed was greater than 1 second. According to AFOSH Standard 48-20, unprotected exposure above 115 dBA is not allowed.

b. The current hearing protection devices (Moldex Camo ear plugs and Peltor PowerComm headsets) do not provide Combat Arms instructors adequate protection from hazardous noise during M9 pistol classes (Table 3). They are exposed to peak SPLs greater than 115 dB during M9 pistol training. Repeated exposures to peak levels greater than 115 dBA could potentially cause hearing damage.

c. We can reasonably expect that data for the M4 rifle will be very similar to the M9 pistol since peak SPLs are 6 dB higher (Table 1), each student fires more rounds of ammunition for qualification (AFMAN 36-2227, Volume 1), and class sizes are the same.

6. RECOMMENDATIONS:

a. Install sound absorbing material to reduce the reverberant field. This will reduce the noise level, better protect instructors and students from hazardous noise exposure, and improve speech intelligibility. Cover the following with acoustical absorption material: the firing area's first overhead baffle, the ceiling and side walls from the red line back to the rear wall, as well as the rear wall. Quilted fiberglass, or other fiberglass panels wrapped in a manner allowing easy cleaning, is one option. There are also more fixed installation materials available, such as products offered by Pyrok or Troy Acoustics.

(1) The goal of this recommendation is to change the noise classification from continuous to impulse noise by reducing the noise decay time to less than 1 second, as well as reducing peak SPLs below 140 dB, in accordance with AFOSH Standard 48-20, para 2.11.3.1.

(2) Previous studies have shown that proper installation of sound absorbing material(s) has changed the characterization of noise in Combat Arms firing ranges from continuous to impulse.

b. Since exposure to M9 SPLs constitutes an uncontrolled hazard, consider assigning a risk assessment code in accordance with AFI 91-202.

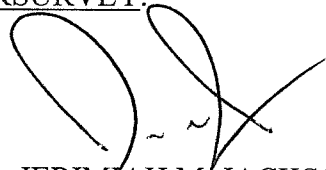
c. During all live-firing courses at the firing range, Combat Arms instructors should continue to wear dual hearing protection. The ear plugs must have a noise reduction rating of at least 33 dBA and the ear muffs/communication headsets must have a noise reduction rating of at least 24 dBA. We highly recommend that students wear the available dual hearing protection the range offers, to the maximum extent possible, with the understanding that certain portions of the course require students to wear a helmet or other protective gear that will not accommodate the use of ear muffs.

d. Based on the information collected during this assessment, Combat Arms instructors should be placed on the Hearing Conservation Program and be considered for close scrutiny (frequent) audiograms as defined in AFOSH Standard 48-20. Frequent audiograms will allow the Hearing Program Conservation Manager to identify any signs and symptoms of noise-induced hearing loss at an early stage to prevent progression. The frequency of the audiograms will need to be determined locally by the Occupational and Environmental Health Working Group. To reduce the frequency or eliminate the need for close scrutiny audiograms, engineering controls must reduce noise decay time to less than 1 second.

e. Combat Arms instructors should provide just-in-time training to students on the proper use of hearing protection devices as part of classroom instruction because there may be students who are required to qualify but are not enrolled in the Hearing Conservation Program and do not receive this training. NIOSH has a short video on proper insertion of foam ear plugs available for download at <http://www.cdc.gov/niosh/mining/products/movies/rphhi.wmv>.

f. Request a USAFSAM follow-up noise assessment when acoustical treatment of the range is complete.

7. If you have any further questions regarding this report, please contact TSgt Jerimiah Jackson at DSN 798-3312 or jerimiah.jackson@us.af.mil. Please direct any questions or comments regarding Industrial Hygiene Consultative support to Maj Marc Sylvander at DSN 798-3855 or marc.sylvander@us.af.mil. To improve our services, please complete the critique located at <https://www.surveymonkey.com/s/OECUSTOMERSURVEY>.

A handwritten signature in black ink, appearing to read 'Jerimiah M. Jackson', with a stylized flourish at the end.

JERIMIAH M. JACKSON, TSgt, USAF
Industrial Hygiene Consultant