Navy Environmental Health Center
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INDOOR FIRING RANGES INDUSTRIAL HYGIENE TECHNICAL GUIDE

NAVY ENVIRONMENTAL HEALTH CENTER

BUREAU OF MEDICINE AND SURGERY

INDOOR FIRING RANGES INDUSTRIAL HYGIENE TECHNICAL GUIDE

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Reviewed and approved by:

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1.0 Introduction

1.1 Purpose - This reference guide is intended to provide general information regarding indoor firing ranges (small arms ranges) to assist in recognizing, evaluating and controlling safety and health hazards. The contents are drawn from Federal regulations, Navy instructions, and other technical documents.

1.2 Use - This guide should be useful to range operators, industrial hygienists, safety professionals and technicians in performing range evaluations, understanding conditions that require additional expertise and developing operation and maintenance procedures.

1.2.1 This guide provides the following:

1.2.1.1 General hazard information,

1.2.1.2 General design and operation aspects,

1.2.1.3 Systems and equipment of industrial hygiene concern,

1.2.1.4 General discussion of ventilation design and evaluation,

1.2.1.5 Work practices and recommendations for controlling exposure to hazards and safe operation,

1.2.1.6 Other sources of information.

1.3 Technical assistance

1.3.1 For questions regarding this guide, users may contact Mr. John Bishop, CIH, Navy Environmental Health Center, Industrial Hygiene Directorate, (757) 953-0752, DSN 377-0752, e-mail bishopj@nehc.med.navy.mil.

1.3.2 For engineering support, contact the Naval Facilities Engineering Command, Technical Centers of Expertise, Mr. Randy Jackson, P.E. at (757) 322-4316.

2.0 Hazards

2.1 Components of ammunition

2.1.1 The projectile or bullet is usually made of a dense material such as lead and may be covered or jacketed with a copper-zinc alloy. Some special purpose bullets may be made from metals other than lead. The bullet may be non-jacketed (totally exposed lead bullet) or totally or partially jacketed. Even in totally jacketed bullets, the base of the bullet may have exposed lead.

2.1.2 The casing contains the propellant and the primer. The casing is usually brass and most ranges will recover them for recycling. The propellant is the main charge and provides the expanding gas that propels the bullet. It is usually a mixture of nitrocellulose and nitroglycerin. The propellant is ignited by the primer which is an explosive. Common formulations of primers contain sensitive metallic salts and metallic nitrate compounds that serve as an oxidizer (fulminates of lead, including lead staphynate, and sometimes lead peroxide).

2.2 The firing/shooting process

2.2.1 When struck by the firing pin, the primer explodes, igniting the propellant. The burning propellant can generate pressures of 18,000 to 20,000 pounds per square inch (psi) and may reach a temperature of 2000 degrees Fahrenheit. The expanding gas propels the bullet down the barrel.

2.2.2 The bore (inside diameter of the barrel) is scored with spiral groves called rifling. These grooves cause the bullet to spin as it is traveling down the barrel. A spinning bullet is more stable and resists tumbling as it travels through the air towards the target.

2.2.3 The velocity achieved is directly related to the amount of propellant in the charge. Pistol bullets accelerate to nearly the speed of sound. High powered pistol and rifle bullets reach speeds above the speed of sound.

2.3 Bullet impact

2.3.1 In an indoor range, the projectile will eventually require its energy to be absorbed. Bullets usually impact onto or into some type of bullet trap (see Section 3). On impact, the bullet may fragment in many directions. This is known as "backsplatter." Factors in the generation of backsplatter are the angle at which the projectile impacts the trap, the smoothness of the impacted surface and the impact velocity. The greater the energy of a bullet, the more likely the fragments will continue on their original path and not bounce back. Lower energy bullets (e.g., subsonic ammunition) produce the most pronounced backsplatter.

2.3.2 Backsplatter fragments projected back towards the shooter are called a ricochet. Ricochets should be rare in a properly designed range. Ricochets may also be caused by the type of target used. Hard targets such as bowling pins and metal targets (poppers) can increase the likelihood of ricochet. Improper ammunition used on the range may dent the bullet stop, increasing the chance of ricochet. Bullet strikes on structural components (target retrieval systems, electrical fixtures, etc.) can cause ricochets. Plate and pit traps in need of cleaning (many bullets in the trap) can increase ricochet.

2.3.3 Bullets that miss the target and trap can penetrate floors or ceilings of improperly designed or constructed ranges, thus posing a severe danger to surrounding areas.

2.4 Lead

2.4.1 Sources

2.4.1.1 Lead primers (fulminates) [lead staphynate or lead peroxide]

2.4.1.2 Projectiles (bullet)

2.4.1.3 Bullet stop (trap)

2.4.2 Exposure factors

2.4.2.1 During firing, hot gases from the propellant can vaporize lead in the bullet. Even with "full jacketed" bullets, lead may be vaporized if the base of the bullet is not jacketed. Rifling or misalignment of the barrel, cylinder, clips, or magazines may chip lead from the bullet.

2.4.2.2 As the bullet leaves the barrel, the hot expanding gases from the propellant and the primer will leave the muzzle in all directions (sideways). The expanding gases and the pressure shock can cause disturbances in the air around the breathing zone of the shooter. If ventilation is present, it may be difficult to capture and control all of the contaminants produced. With effective ventilation, lead particles are carried down range (toward the trap). Because of their density and the effect of gravity, lead particles will settle out of the air quickly, coating the surfaces immediately down range from the shooter with fine lead dust.

2.4.2.3 Lead particles (dust) may be inhaled by the shooters and range personnel during firing, maintenance and cleaning of the range. Lead dust will not penetrate the skin. However, contamination on hands, arms or the face may allow ingestion of lead during eating, drinking, smoking or applying of cosmetics if the skin is not adequately cleaned.

2.4.3 Exposure and Health considerations. Substance information regarding occupational exposure to lead and a summary of the key provisions of the Occupational Safety and Health Administration (OSHA) regulations are provided in 29 CFR 1910.1025.

2.4.4 Exposure limits. Exposure limits are set by OSHA and adopted by the Navy in OPNAVINST 5100.23 Series.

2.4.4.1 Permissible Exposure Limit (PEL). The PEL for an 8-hour time-weighted average (TWA) exposure to airborne lead is 50 micrograms per cubic meter ($\mu g/m^3$) of air. For employee exposure of more than 8 hours in a workday, the PEL shall be determined by the following formula.

$$\text{PEL } (\mu g/m^3) = \frac{400}{\text{No. Hours Worked Per Day}}$$

2.4.4.2 Action Level (AL). The AL for an 8-hour TWA exposure to airborne lead is 30 $\mu g/m^3$ (without regard to respirator use). Exposure to airborne lead at or above the AL, for more than 30 days per year, triggers biological monitoring and medical surveillance requirements.

2.4.5 Dust lead levels. There are no directly applicable established limits for occupational surface contamination (mass of lead per surface area). However, in a compliance instruction (CPL 2-2.58) for lead in the construction industry, OSHA has provided a level of acceptable lead loading (surface dust levels) for non-lead work areas (clean areas outside lead work areas, such as lunchrooms) of 200 μg/square foot (2152 μg/square meter or 21.52 μg/100 square centimeters). While not legally applicable, this serves as a useful guideline.

2.5 Other stressors.

2.5.1 Ammunition may contain other metals, such as barium and antimony.

2.5.2 The ignition of primers and propellants during firing can produce other toxic compounds. Ventilation systems that adequately control lead should also control exposures to any other toxic compounds generated. Other compounds that may be generated during firing:

2.5.2.1 Carbon monoxide. Carbon monoxide reduces the ability of blood to carry oxygen. Symptoms of over exposure include headache and nausea.

2.5.2.2 Oxides of nitrogen. Nitrogen oxides are irritating to the eyes and the respiratory system.

2.5.2.3 Organic compounds and unburned propellant. Other organic compounds may be generated. Of special concern is the unburned propellant that may accumulate down-range over a long period of time. This may create a fire hazard if the range is not cleaned properly and regularly. Unburned propellant may accumulate in porous surfaces or in crevices (concrete joints).

2.5.3 Noise. The discharge of weapons creates hazardous impulse noise levels. In a firing range, the impulse noise may act differently when it reflects off of hard surfaces. Repeated exposure to impulse noise greater than 140 decibels (dB) can cause significant hearing loss. The Navy permissible exposure limits (NPEL) and requirements for noise are presented in OPNAVINST 5100.23 Series, Chapter 18:

2.5.3.1 Greater than 84 decibels on the A-weighted scale (dB(A)) for frequencies of 20 to 16,000 Hertz (Hz)) for an 8-hour time-weighted average (TWA).

2.5.3.2 When TWA exposures are greater than 84 dB(A), activities shall include personnel in the Navy's Hearing Conservation Program.

2.5.3.3 For impact or impulse noise, the NPEL is 140 dB (peak) sound pressure level.

2.5.3.4 Noise reduction. Noise reduction in the range and outside the range require two different design considerations. Absorptive type acoustical surfacing can reduce the noise within the range. However, noise reduction within the range has trade-offs in the increased porosity of surfaces that can become contaminated with fine lead particles and the increased difficulty in cleaning such surfaces. Acoustical treatment behind the firing line is acceptable if it can be easily cleaned. Reflective surfaces in a range will reverberate noise during firing, extending the decay rate of the noise. Long decay rates (> 1 second) will require the industrial hygienist to treat the noise not only as impulse (peak pressure considerations) but as continuous noise also.

2.5.4 Eye hazards. Ricochets can be a significant eye hazard in indoor ranges. Poorly maintained traps or misdirected shots can cause fragments to be thrown back toward the firing line.

3.0 Design. The proper design of an indoor range provides a facility that meets the purpose of conducting weapons training in a safe manner. Several documents are available to assist in the design of indoor firing ranges and are listed in the Bibliography section. The following are several design recommendations with cited references:

3.1 Length of range. Usually 50 to 100 feet from the firing line to the furthest target line. The standard length of new ranges is 84 feet 4 inches (CEHND 1110-18, Draft UFC 4-160-01).

3.2 Firing lanes should be 5 feet wide (CEHND 1110-18) with a minimum of 4 feet wide (NGR 385-15, Draft UFC 4-160-01). The height should be 10 feet, but may need to be higher depending on the bullet stop design (CEHND 1110-18).

3.3 The structure design and construction must accommodate the weapons (ammunition) used and must prevent bullets from penetrating and exiting the walls. Recommended materials and construction are discussed in CEHND 1110-18 and MIL-HDBK 1027/3 (soon to be retired and replaced with Draft UFC 4-160-01). From a health and safety perspective, the following interior surface criteria should be met:

3.3.1 Surfaces should be as smooth as possible with no protruding edges.

3.3.2 Smooth dense floor surface, easily cleanable, with no floor joints that can provide an impact edge. Carpets should be prohibited, as they collect lead dust and are difficult to clean.

3.3.3 Baffles must be installed to protect light fixtures, pipes or ceiling from misdirected shots. Baffles should be at 30 degree angles to the ceiling and constructed of steel plate based on the ammunition used. Baffles within 40 - 50 feet of the shooting line should be covered with splatter protection (material and thickness depends on weapon/ammunition used). See CEHND 1110-1-18 (Draft UFC 4-160-01).

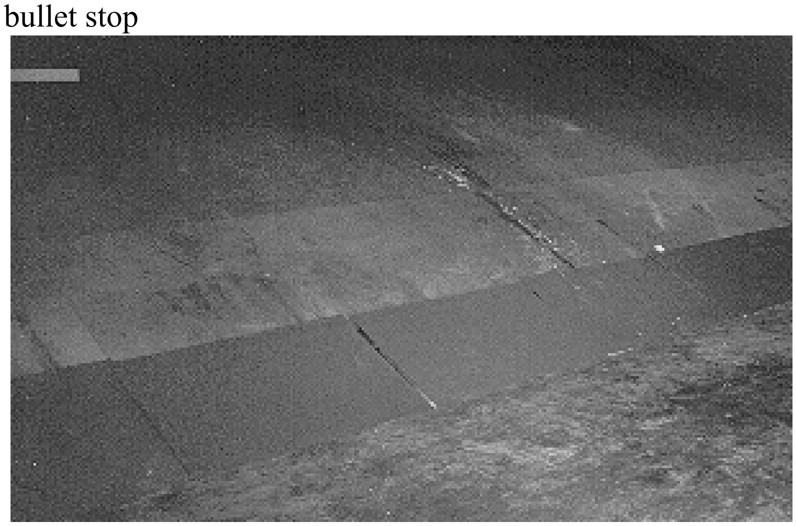
3.4 Bullet stops (traps). The purpose of the bullet stop is to absorb the energy of the bullet and to prevent the projectile or fragments escaping. There are several types of stops used in indoor ranges:

3.4.1 Plate and pit (Figure 1). The bullet stop consists of a plate of steel installed at a 45 degree angle. The thickness and hardness of the steel depend on the ammunition used (CEHND 1110-1-18). After striking the plate, the bullets are directed into a sand pit. There must be at least 6 - 8 inches of sand depth in the pit. These traps are not recommended since they require a high level of maintenance. They must be cleaned by removing the bullets from the sand - a messy operation with high lead exposure potentials. Lack of cleaning may cause ricochet hazards if bullets entering the sand pit strike other bullets.

Figure 1 - A Plate and Pit Bullet Stop

3.4.2 Escalator bullet stop (Figure 2). The escalator bullet stop has sloping steel surfaces to guide the bullet into a location where the projectile's energy can dissipate safely. The bullet travels up the surface of the plate to either a "swirl" area or deceleration chamber. Due to friction or multiple impacts, the bullet loses energy, then falls into a tray for later collection.

Figure 2 - Escalator bullet stop



3.4.3 Venetian blind. Several impact plates are angled at approximately 35 degrees to direct the bullets downward into a deceleration chamber. The plates are set such that they have the appearance of a venetian blind. The leading edges are sharpened in order to split bullets that strike right on the edge. Maintenance is required to keep the edges sharp for proper operation.

3.4.4 Snail type. The snail bullet stop is basically a large scroll where the bullet enters and looses energy through friction as it spins around the scroll. A water bath may be present to remove fragments.

3.4.5 Rubber lamella. This bullet stop is made of strips of rubber in multiple rows suspended from the ceiling. A steel safety plate is installed behind. The bullet energy is absorbed in the rubber and the projectile remains mainly intact.

3.4.6 Granular rubber. A steel based chamber opened towards the firing line is filled with granular pieces of rubber. This acts like a berm to receive the fired projectiles. The bullets remain intact, which reduces lead fragments, dust and backsplatter. The bullets migrate down through the granulated rubber and can be removed from cleanout access points under the steel chamber. The granular rubber bullet traps can either be reclined or installed vertically with a rubber membrane to hold the rubber.

3.5 The selection and installation of bullet traps must be based on the facility, construction materials, space, and most importantly the weapons and ammunition used. Trap design, construction and materials may restrict the types of weapons and ammunition which may be used safely within the facility.

3.6 Regular maintenance must be performed on the bullet traps to prevent ricochets or penetration and to reduce the chance of fired bullets impacting collected bullets. Follow the cleaning procedures provided by the manufacturer for commercially installed traps.

3.7 Target retrieval systems are recommended to prevent shooters or range personnel from entering the area downrange of the firing line. This will reduce the chance of accidental shooting mishaps and tracking of lead contaminated dust to other areas of the range or to personal clothing. Target holders must not present a flat surface perpendicular to the line of fire. Angled iron with the point facing the firing line is recommended to prevent ricochets.

3.7.1 The target should be retrieved by hand crank or a motorized mechanism.

3.7.2 The target height must be adjustable if firing will be conducted in prone, sitting, kneeling or standing positions.

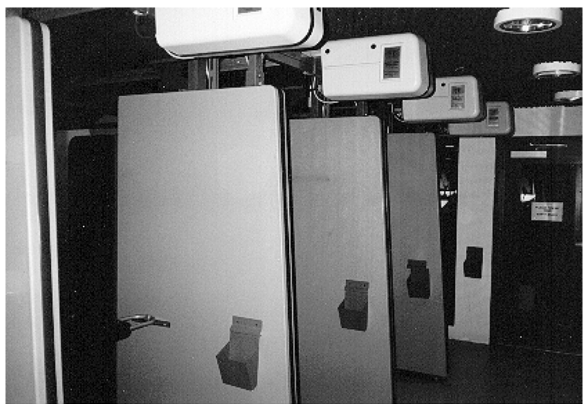
3.7.3 The target should have a locking mechanism to keep the target from moving during firing.

3.7.4 Targets (based on lane positions) should not be positioned in line with seams or welds in the bullet stop.

3.7.5 Automatic turning target mechanisms are available with programming provisions for target exposure.

3.8 Shooting booths or partitions (Figure 3) may be installed between the firing positions to reduce the possibility of misdirected fire. The booths should be fixed to the floor and at least 6 feet high. They should not extend more than 6 inches down range from the firing line or extend more than 18 inches back (behind) the firing line to ensure unrestricted viewing by the range master or instructor. Although arm rests are common, partitioning off the lower portion of the booth is undesirable as it obstructs air flow.

Figure 3 - Shooting Booths



3.9 Rubber mats may be used for prone or kneeling firing positions. They should have tapered edges (to avoid tripping) and should be easily cleaned. Mats should be stored out of the way when not in use.

3.10 Lighting. Lighting design should provide uniform intensity and be free of glare without shadows.

3.10.1 Lighting behind the firing line should not interfere with the shooter's view down range. The lighting should be intense enough to avoid enlargement of the pupil, which reduces the shooter's visual acuity.

3.10.2 Down range lighting should be at least 85 – 100 foot-candles measured 4 feet above floor at target face and baffled (no direct lighting to the firing line and protected from misdirected shots) (Draft UFC 4-160-01).

3.10.3 Other lighting includes emergency lights for egress, "Range in Use" signs at the entrance and exit lights. Lighting behind the bullet trap should be at least 30 foot-candles during maintenance or cleaning.

3.11 Alarms. The range may be equipped with alarms either on the firing line (notification that a shooter has crossed the line) or for the ventilation (signaling that the ventilation is not operating or electrical interlocks with the lighting that will not activate unless the ventilation is on and functioning properly).

4.0 Mechanical. Mechanical aspects of an indoor range include ventilation, heating and air cleaning systems.

4.1 Ventilation Systems. Ventilation in a range controls exposure to lead and other contaminants. The supply and exhaust air system design is crucial to proper operation. To ensure proper operation, interlocks should be installed that require both the supply and exhaust fans to be running.

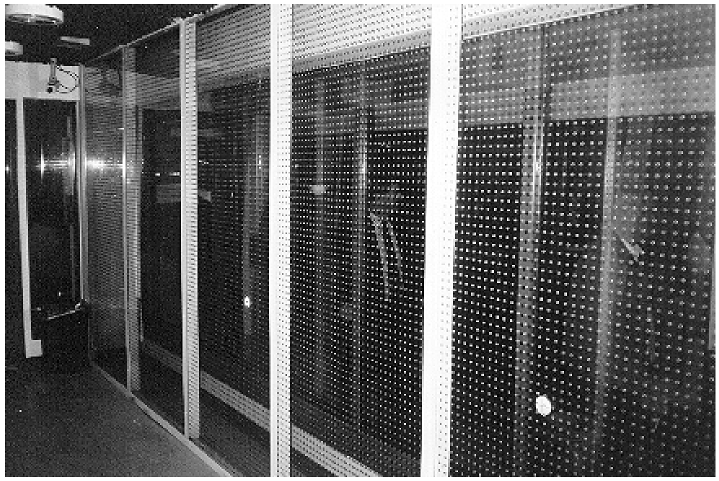
4.1.1 Exhaust. The exhaust system removes contaminated air from the range. The exhaust flow rate determines the velocity of the air down the range but does not affect the air flow pattern at the firing line. Exhausting 3 - 7 percent more air than is supplied will maintain a slight negative pressure in the range. Ranges should be maintained under negative pressure of -0.04 $\pm$ 0.02 inches water gauge. Because of the large volume of air being exhausted, energy recovery systems should be considered. Fans should be single speed and not multiple speed. Indicators (static or velocity pressure) for monitoring flow are a good idea to demonstrate proper operation of the exhaust system.

4.1.2 Supply air. The exhausted air flow must be made up by outside air. The distribution of the supply air is critical in determining the effectiveness of the ventilation system. Supply air systems are designed to distribute air evenly across the width of the firing range. If not evenly distributed, air flow at the firing line will be turbulent, causing lead and other contaminants to be carried back into the shooter's breathing zone. Supply air should be introduced as far up range as possible.

4.2 Air distribution. The distribution of supply air should provide uniform, diffuse, non-turbulent air flow towards the firing line and a near laminar flow down range.

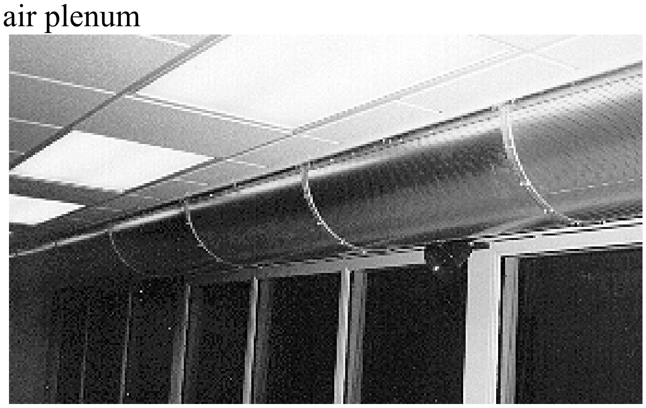
4.2.1 Perforated wall. A perforated rear wall (Figure 4) will provide uniform air distribution. A minimum of 15 feet distance is needed from the wall to the firing line. The system should maintain laminar flow of 50 - 75 feet per minute over the cross sectional area at the firing line. The minimum should be 50 feet per minute with a preference of 75 feet per minute. The system should provide 100% outside air. The perforated wall (sometimes known as an "air wall") should be designed to act as a plenum with approximately 6 - 10 percent free open area. This should evenly distribute the required flow at a pressure drop of 0.25 inches water gauge. The perforations should be sized to provide no more than 2000 feet per minute velocity through the holes, with a recommended velocity between 400 - 600 feet per minute. Hole diameters from 0.25 to 1 inch have been used effectively, with recommended diameters between 0.375 and 1 inch (3/8" - 1"). The perforated wall should extend the entire width and height of the range to distribute the supply air evenly. The plenum wall can be constructed of perforated hardboard, metal or clear plastic sheeting (polycarbonate/acrylic, etc.). Doors within the plenum are undesirable. Internal framing may interfere with air distribution.

Figure 4 - A perforated rear wall



4.2.2 Radial plenum (Figure 5). The radial plenum is a supply air system that has perforated metal half-round sections that are located in the upper back corner of the range. This radial plenum runs the entire width of the range. This system has been shown to be acceptable. The system should still maintain laminar flow of 50 - 75 feet per minute over the cross sectional area at the firing line, with a minimum of 50 feet per minute and a preference of 75 feet per minute. The system should provide 100% outside air.

Figure 5 - Radial supply air plenum



4.2.3 Dampers/diffusers. Many ranges have supply air distribution systems using dampers or diffusers. These are least desirable since they produce jets of air that can produce turbulence at the firing line. If diffusers are present, they should be located on the back wall behind the shooters. Diffusers should be sized to produce no more than 400 feet per minute maximum velocity.

4.3 Air flow. Air flow across the firing line should be approximately 75 feet per minute with a minimum acceptable flow of 50 feet per minute. Air flow down range should be maintained at a minimum of 30 feet per minute and should be evenly distributed. The air should be exhausted at or behind the bullet stop. Some ranges are designed to have multiple exhaust points down range. The important feature is to maintain the laminar flow and desired velocities at the firing line. When a floor to ceiling and wall to wall supply distribution system is used, there should be no obstructions to the air flow between the plenum and the shooting station. Exhausting the air past the bullet stop assists in controlling exposures during down range maintenance and cleanup.

4.4 Intake and discharge of air.

4.4.1 Powered make-up air systems are desirable. Supply air should be 100 percent outside air. Air intake should be located to avoid recirculation of the exhausted air. Supply air may be heated. Depending on the outside air temperature and the size of the range (the needed volumetric flow), heating may not be cost effective. Range heating may be supplied by spot heaters at the firing line. Note that fans on spot heaters can disrupt air flows at the firing line. Gas fueled open fired heaters (no heat exchanger) can be installed in the supply air system. They must be properly designed and maintained to reduce the possibility of high carbon monoxide levels within the range.

4.4.2 The exhaust discharge must be separated from the supply air intake. If the range is part of a larger building or adjacent to other buildings, the range exhaust should not be located where cross contamination can occur. Note prevailing wind patterns or building projections that may cause turbulence or eddy currents which can affect ventilation effectiveness.

4.4.3 Filtration of the exhausted air may be required by local requirements. Provisions for increasing fan size to handle increased static pressures must be considered if exhaust filtration is retrofitted. A pressure drop (magnehelic/incline manometer) gauge across the filter is recommended to indicate when filter changes are required.

5.0 Evaluation. From a safety and health perspective, it is necessary to determine if an indoor range is operating properly. There are a few important steps that can be taken to properly evaluate an indoor range. The range must be evaluated from two perspectives--the physical/mechanical and the operational. The first includes the facility design, construction and the mechanical systems used in the facility. The second focuses on how the range is operated (the interaction of the occupants, weapons and ammunition with the facility).

5.1 Physical and operational assessment. Conduct a walk-through assessment of the facility and look for the desired design traits discussed in section 3. Note how the facility is maintained and operated. Gather information on the range's construction, layout, maintenance, listed weapon(s) used in the range, training content, expected number of shooters, frequency of use and typical expended rounds used. This information will be needed to conduct the operational risk assessment and to classify the range (see Appendix A).

5.2 Ventilation assessment. A properly designed and operating ventilation system is necessary to control exposures to shooters/instructors.

5.2.1 Smoke test. Using either a smoke tube or smoke candle, observe airflow currents and patterns throughout the range. This should identify disturbances and direction of airflow. Unnecessary personnel should not be present in the range or near the supply air plenum during the assessment. Prior to activating the tube or candle, ensure that the ventilation system is on and operating. If a smoke candle is used, a coffee can with some type of a handle fabricated (pliers) should be used to handle the candle. At the firing line, smoke test each firing station (booth). Test from the floor to about 6 foot level. Observe the smoke pattern. The smoke should move down range and demonstrate laminar flow. Document unusual smoke patterns or where smoke swirls and returns to the shooter's position. Eddies or swirls near the floor, or other obstructions are a concern and should be noted. If turbulence is observed, air velocities may be high in that area. Note that air velocity measurements conducted later in this area may not truly indicate the direction of the flow (turbulence and eddies may have flow directions other than down range but will be reflected only as a measured value). Conduct additional smoke measurements down range to ensure adequate air velocities and patterns are maintained down range towards the bullet stop. Note that many ranges were designed to have multiple exhaust points down range that will affect the smoke patterns.

5.2.2 Measure the cross sectional area for the range and calculate the necessary volumetric air flow. Measure the ceiling height and width of the range at the firing line.

5.2.3 Measure the ventilation. At the firing line, place the probe (or a grid meter if available) so that it is perpendicular to the floor at the firing line. Make sure no unnecessary personnel are present or near the supply air plenum during the assessment. Take three measurements at the same level in three locations from the floor: approximately 1 foot (prone level firing); approximately 3 feet (kneeling position); and approximately 5 feet (standing position). This will result in 9 readings for each firing position (or three grid meter readings). Average the 9 (or 3) readings and apply to the design criteria (50 - 75 feet per minute, with preference for 75 feet per minute). Optional measurements may be conducted down range at the 1, 3 and 5 foot high levels to ensure adequate air velocities are maintained (30 - 50 feet per minute). This can be conducted at 15 to 20 foot intervals. Again note that many ranges were designed to have multiple exhaust points down range.

5.2.4 Static pressure measurements. Since it is desirable to have the range under negative pressure related to other occupied spaces, static pressure measurements should be conducted in one of two ways. A manometer or magnahelic gauge can be used to check the pressure in relation to areas outside the range. A hose can be placed outside the door (careful not to crimp) with at least 6 inches of the hose outside the door. The result can be compared to the desired criterion level (-0.04 ± 0.02 inches water gauge). Another way to ensure range negative pressure is to use the smoke tube at all entrances or openings into the range (doors may need to be "cracked" a little to demonstrate. Smoke should enter into the range from outside areas. Excessive negative pressure will make doors difficult to open (or to keep closed) and can be a safety hazard (slamming doors [- 0.05 - 0.10 inches water gauge]). Excessive negative pressure also indicates insufficient supply air for the amount being exhausted.

5.3 Air sampling. Air sampling in the personal breathing zone of shooters and range instructors is imperative in assessing exposures. Follow the procedures presented in the NEHC Industrial Hygiene Field Operations Manual (IHFOM) and the sampling and analysis requirements of the Industrial Hygiene Sampling Guide for Consolidated Industrial Hygiene Laboratories. In order to properly assess health risks and classify the range, the following information should be recorded in addition to the required data presented in the IHFOM: The type of training being conducted; frequency of training; number of shooters; shooter placement (lane number); weapon type(s); caliber and manufacturer of the ammunition; jacketed or non-jacketed bullets; number of rounds expended; other activity that would contribute to exposure. Compare the air sampling results to permissible exposure limits or the administrative control table for the range being used (see Appendix A). Based on the exposure results and the facility or operational requirements, classify the range per OPNAVINST 5100.23 Series, Section 6 and Appendix A of this guide.

5.4 Range cleaning. Floors and horizontal surfaces should be cleaned on a regular basis. Cleaning frequency depends on how heavily the range is used. Floor and horizontal surfaces such as booth shelves or target retrieval systems may need daily cleaning if heavily used. Otherwise, cleaning should be performed once or twice a week. Cleaning can be conducted either with a vacuum equipped with a high efficiency particulate air (HEPA) filter or wet methods. Consideration for an explosion-proof HEPA vacuum is necessary due to the possibility of buildup of unburned powder. The vacuum should be dedicated for the lead dust cleanup. Individuals performing cleaning operations should be properly trained and not try to hurry the process. Dry sweeping or the use of compressed air to "blow down" the range should be prohibited. The cleanup of spent shell casings ("brass") should not use brooms (a wooden "casino rake" can be useful). The ventilation system should be on during cleanup operations. Appendix D provides guidance for indoor range cleaning.

5.5 Hygiene. Specific practices should be in place to prevent the ingestion of lead or the contamination of other areas by range personnel/shooters.

5.5.1 Personnel and shooters should know what areas of the range they are allowed access to and in what spaces clothing or skin may become contaminated. Shooters should not be allowed past the firing line. Disposable shoe coverings should be available for individuals who may have to walk down the range. Sticky walk-on mats should be available at the exit door to remove dust from shoes of individuals exiting the range.

5.5.2 The use or consumption of food, beverages, tobacco, gum or cosmetics should be prohibited in the range. Lead dust on hands can easily contaminate such items.

5.5.3 Shooters should wash hands and face thoroughly before consuming food, beverages, etc. For operations where contamination is likely, personnel should vacuum off their clothing with a HEPA vacuum before exiting the range. Vacuuming should reduce the spread of lead dust contamination to other areas of the building or to personal vehicles or quarters.

5.5.4 Washroom facilities should be provided with hot and cold water and soap or a powdered skin cleanser. A change room must be provided with showers (if feasible) if personnel are exposed above the permissible exposure limit. If a break (lunch) room is available, it should have smooth, easily cleanable surfaces. It must be cleaned often enough to maintain surface dust loading less than 200 $\mu g/ft^2$ (OSHA CPL 2-2.58). An active range should not be used as a storage or office area.

5.5.5 Proper protective clothing must be maintained and available for personnel who perform range maintenance or cleaning where contamination is likely.

5.5.6 To limit contamination of objects, bags and clothing, only the weapon to be fired and the necessary ammunition should be carried into the range. Coat racks or lockers external to the range are recommended.

5.5.7 Range support and cleaning equipment should be easily accessible but in a separate storage closet.

5.6 Surface contamination assessments. To determine contamination levels of lead dust or to determine the effectiveness of cleanup, surface wipe sampling is performed. Follow the procedure in Appendix B or consult the laboratory for specific instructions. Once deposited, leaded dust is difficult to clean effectively. Cleaning is the process of removing visible debris and dust particles too small to be seen by the naked eye. Wipe samples for settled leaded dust can be collected from floors, interior contact areas, and other reasonably smooth surfaces.

6.0 Control measures.

6.1 Substitution with less hazardous materials is the most desirable means to control lead exposure. Reduced lead or "lead-free" ammunition has been developed. If allowed by the cognizant training activity, these "lead-free" alternatives should be considered for use. Lead exposures can be reduced by using jacketed rounds. Non-lead bullets are being developed that provide similar ballistic properties. Non-lead primers are also being developed using diazo-dinitro phenol (Dynol).

6.2 Ventilation systems used in ranges can be effective in controlling lead exposures. Existing systems may be inadequate. Some systems may be retrofitted to improve their performance, however, ventilation system modifications require engineering analysis by professionals experienced in indoor firing range ventilation design. For engineering support, contact the Naval Facilities Engineering Command, Technical Center of Expertise, Mr. Bill Gibbings at (757) 322-4205. Because any modification of a system can affect the operation of other parts of the system, a thorough evaluation of the system as a whole is necessary. "Self-help" modifications rarely improve the control of exposures.

6.3 Maintenance. No system, regardless of design, can be effective over time without proper maintenance. The evaluation of the ventilation system and recommended modifications should take into consideration the availability of qualified personnel committed to proper maintenance.

6.4 Administrative. Administrative controls or range operational policies, although least desirable, can be used to reduce exposures. This can take the form of limiting exposure time (limiting range use). This should be part of the range's standard operating procedure and included into the range classification and operational recommendations per OPNAVINST

5100.23 Series and Appendix A. Other lead exposures resulting from hobbies, off-duty shooting and other work duties such as soldering can contribute to the individual's total lead exposure and should be considered in the maximum allowable exposure time.

7.0 Acceptance Testing

7.1 Background – Sections 3 and 5 presented general elements for conducting a basic industrial hygiene characterization with consideration for obtaining the necessary information (including monitoring) to assess health risks following the requirements of Chapter 8 of OPNAVINST 5100.23 Series. These evaluations assess hazards based on the operation, tasks and work practices taking place in the operating range. Major changes in a range due to changes in operation, general life cycle maintenance or by major modifications as recommended by the NAVFAC Technical Center of Expertise, would require an industrial hygiene reevaluation. After major contracted modifications, it may be desirable to conduct an initial evaluation to demonstrate the effectiveness of the facility at the maximum operational (designed) capability to document the completion of the work and to have a baseline industrial hygiene assessment for the range’s operational SOP.

7.2 A generic industrial hygiene acceptance test for small arms indoor ranges is provided in Appendix F.

Appendices

Appendix A

Health Considerations for Routine Range Use/Cleanup: Generic Standard Operating Procedure for Training Type Indoor Small Arms Ranges

Section 1 General

Note: Contents of this standard operating procedure (SOP) include only the considerations to reduce personal exposure during routine range use and cleanup, and to reduce the chances of spreading contamination or taking toxic contaminants home at the end of the work day. This SOP does not include other requirements that are necessary per OPNAVINST 5100.23 Series and OPNAVINST 3591.1C as determined by local evaluations. Applicable portions of this SOP may be used in a range's overall operating SOP. [The determination for use and content of the bracketed items are based on local industrial hygiene evaluations].

Note: The Commanding Officer (Safety Office) of the activity owning the indoor range facility has oversight responsibility to ensure safe operation. These use and cleaning requirements will help ensure the safety and health of Navy personnel.

1.1 References:

Navy Instructions
OPNAVINST 5100.23 Series, "Navy Occupational Safety and Health Program Manual"
OPNAVINST 3591.1C, "Small Arms Training and Qualification"

Navy Technical Manuals
Industrial Hygiene Field Operations Manual (IHFOM) - NEHC, Latest Revision

Military Handbooks
MIL-HDBK-1027/3B, "Range Facilities and Miscellaneous Training Facilities Other than Buildings" To be replaced by Draft UFC 4-160-01, 15 March 2002 "Design and Maintenance of Small Arms Ranges."
Code of Federal Regulations
29 CFR 1910.1025, Lead (General Industry)
29 CFR 1926.62, Lead (Construction)

1.2 Definitions

1.2.1 Action Level - Employee exposure, without regard to use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air, time weighted averaged over an 8- hour period (30 $\mu g/m^3$ 8-hr TWA).

1.2.2 Area Sampling - Sampling of lead concentrations within the lead control area and inside the physical boundaries. It is representative of the airborne lead concentrations but is not collected in the breathing zone of personnel.

1.2.3 High Efficiency Particulate Air (HEPA) Filter Equipment - Vacuuming equipment with a HEPA filter system capable of collecting and retaining lead-contaminated particulate. A high efficiency particulate (HEPA) filter has been certified as at least 99.97 percent efficient for 0.3 micron or larger size particles.

1.2.4 Industrial Hygiene Range Classifications:

1.2.4.1 "Unlimited" classification - Based on industrial hygiene and use evaluations, an indoor range classification of "Unlimited" permits authorized firing for military and civilians.

1.2.4.2 "Limited" classification - A "Limited" classification permits use under specified controlled conditions.

1.2.4.3 "Restricted" classification - A "Restricted" classification indicates the range is not authorized for use under any conditions. It will not be used for any other purpose (i.e., storage, office space, classrooms or dining facilities) without first being decontaminated.

1.2.5 Permissible Exposure Limit (PEL) - Fifty (50) micrograms per cubic meter of air as an 8- hour time weighted average (50 $\mu g/m^3$ 8-hr TWA) as specified in OPNAVINST 5100.23 Series and 29 CFR 1910.1025.

1.2.6 Personal Sampling - Sampling of airborne lead concentrations within the breathing zone of an employee to determine the 8-hour time weighted average concentration in accordance with the IHFOM (NEHC) and OPNAVINST 5100.23 Series. Samples shall be representative of the employees' work tasks. Breathing zone shall be considered an area within a hemisphere, forward of the shoulders, with a radius of six to nine inches and centered at the nose or mouth of an employee.

1.3 Basis for exposure/cleaning determinations:

1.3.1 Maximum effort will be made to reduce the airborne lead levels below the action level of 30 micrograms per cubic meter (30 $\mu g/m^3$) per OPNAVINST 5100.23 Series.

1.3.2 Lead exposures for personnel are determined by a sampling strategy that employs breathing zone samples. Once an airborne lead concentration is determined, the maximum allowable hours of exposure for each category of range user can be established (see Attachment (1) of Appendix A). Other potential lead exposures, including other training/duty firing, may contribute to an individual's overall exposure and should be considered in establishing maximum allowable exposure time or personal protective equipment recommendations.

1.3.3 The following factors are critical to proper range evaluation:

1.3.3.1 - Sample during periods of maximum use.

1.3.3.2 - Sample during the use of higher-caliber ammunition if more than one type of ammunition is used.

1.3.3.3 - Follow the sampling procedures in the IHFOM (NEHC).

1.4 Operational considerations to reduce exposures:

1.4.1 Range Classification - Indoor ranges should be classified as "unlimited," "limited," or "restricted" based on industrial hygiene evaluations. An industrial hygienist may classify indoor ranges as limited with permits for use under controlled conditions. Exposure limits for intermittent atmospheric lead exposure must be used for limited operation of the indoor range (see MIL-HDBK-1027/3B (To be replaced by UFC 4-160-01) and Attachment (1)).

1.4.1.1 Based on local industrial hygiene (IH) evaluations required by OPNAVINST 5100.23 Series, the range is classified [unlimited] [limited] for the listed weapon(s) based on the following scenario, including the number of shooters and expended rounds. Example Range Classification:

[Limited Range Classification - 38 cal or 9 mm - 8 shooters - Hand Gun Qualification Course - Total 50 rounds/person]

1.4.2 Shooters shall never move forward of the firing (red) line during firing.

1.4.3 Shooter’s hygiene

1.4.3.1 Eating, drinking or smoking are prohibited in an active firing range.

1.4.3.2 All shooters shall wash hands after turning in weapons. [If no washing facilities are available, shooters must use wet wipes to clean hands prior to exiting range.]

Section 2 Products

2.1 Chemicals

2.1.1 Ensure applicable Material Safety Data Sheets are available for all chemicals used in range cleanup work.

Section 3 Execution

Note: Cleaning indoor ranges routinely as outlined or specified below should be the norm and is presumed to be sufficient to protect human health and the environment.

3.1 Equipment and Engineering Controls:

3.1.1 HEPA filter vacuuming is the only vacuum method authorized for range cleaning. All generated waste must be disposed of as hazardous material. If a HEPA vacuum cleaner cannot be obtained, wet mopping may be used. Dry sweeping is prohibited. Use of compressed air is prohibited.

3.1.2 The range ventilation system must remain on at all times during cleaning. The ventilation system must be evaluated per the requirements of Chapter 21 of OPNAVINST 5100.23 Series. Filter replacement shall be based on the following schedule or when static pressures exceed recommended levels [insert recommended level in inches water gauge ("wg)].

~ Pre-filters [for example, monthly]
~Secondary filters [for example, quarterly]
~HEPA filters [for example, annually]

3.2 Protection - Annual Cleaning

3.2.1 Operational ranges must have a complete and comprehensive cleaning annually. Special training, equipment and [medical surveillance] are required for personnel assigned range cleaning responsibilities.

Note: Depending on bullet stop and other use or configuration factors, comprehensive cleaning may be required at frequencies other than annual.

3.2.2 All rooms and surfaces should be cleaned using the HEPA vacuum cleaning process or wet mopping methods, except for those that were found not to have lead hazards and were properly separated from shooting areas. If exterior cleanup work was conducted or if debris was stored or dropped outside during cleaning, sidewalks, driveways, and other exterior surfaces should be vacuumed. Vacuuming should begin on the ceilings, end on the floors and be sequenced to avoid passing through areas already cleaned.

3.2.3 Respiratory protection and personal protective equipment requirements will be determined during the industrial hygiene assessment of the range. Respirator use will depend on exposure levels. If exposures are above the permissible exposure limit, the minimum respiratory protection is a half-mask HEPA cartridge (N, R or P-100) respirator. See OPNAVINST 5100.23 Series for respirator program requirements.

3.2.4 Full body protection is [not] required during range cleaning. [Disposable or cloth coveralls are authorized for use with booties or shoes dedicated for the job. After use, non-disposable coveralls must be sealed in bags with the appropriate labeling required by OPNAVINST 5100.23 Series and 29 CFR 1910.1025. Contracted laundry services must be informed of the lead contamination.]

3.2.5 [All openings of the protective clothing should be closed by taping.]

3.2.6 [Gloves are required to preclude skin contact. Glove type selection is dependent on level of mechanical protection (hand cleaning of metal surfaces that may have burrs would require leather).]

3.2.7 Annual medical surveillance is required for all employees who are or may be exposed to lead in excess of the action level for more than 30 days a year or as required by OPNAVINST 5100.23 Series.

3.2.8 Train each employee performing lead cleaning work or disposal operations prior to the time of initial job assignment and annually thereafter, in accordance with OPNAVINST 5100.23 Series, and State and local regulations where appropriate.

3.3 Protection - Routine Cleaning

3.3.1 Routine range cleaning shall be conducted after every [insert #] training evolution(s). [Daily cleaning using wet wipes shall be conducted on all horizontal surfaces in each used shooting station.]

3.3.2 Clean using HEPA vacuums or wet mopping methods sequenced to avoid passing through areas already cleaned. For example, start at the firing line area and end at the bullet stop. [Routine cleaning may end just at the firing line if access past the line is prohibited and strictly enforced by instructors]. [Cleaning is restricted to floor or horizontal surfaces only]. Note that brass cleanup may require access past the firing line.

3.3.3 Respiratory protection and personal protective equipment requirements will be determined during the industrial hygiene assessment of the range. Respirator use will depend on exposure levels. If exposures are above the permissible exposure limit, the minimum respiratory protection is a half-mask HEPA cartridge (N, R or P-100) respirator. See OPNAVINST 5100.23 Series for respirator program requirements.

3.3.4 Full body protection is [not] required during range cleaning. [Disposable or cloth coveralls are authorized for use with booties or shoes dedicated for the job. After use, non-disposable coveralls must be sealed in bags with the appropriate labeling required by OPNAVINST 5100.23 Series and 29 CFR 1910.1025. Contracted laundry services must be informed of the lead contamination.]

3.3.5 [All openings of the protective clothing should be closed by taping.]

3.3.6 [Gloves are required to preclude skin contact. Glove type selection is dependent on level of mechanical protection (hand cleaning of metal surfaces that may have burrs would require leather).]

3.3.7 Full annual medical surveillance shall be made available to all employees who are or may be exposed to lead in excess of the action level for more than 30 days a year or as required by OPNAVINST 5100.23 Series.

3.3.8 Train each employee performing lead cleaning work or disposal operations prior to the time of initial job assignment and annually thereafter, in accordance with OPNAVINST 5100.23 Series, and State and local regulations where appropriate.

3.4 Decontamination

3.4.1 Remove contaminated protective equipment and wash hands and face prior to lunch or breaks and at the end of the work shift.

3.4.2 Decontamination is necessary to ensure that worker's families, other workers, and surrounding areas do not become contaminated. Work clothing, work shoes, and tools should not be placed in a worker's automobile unless they have been laundered, cleaned or placed in sealed bags.

3.4.3 Proper decontamination of equipment, tools, and materials prior to their removal from lead clean up areas should be implemented (e.g., wet wipe before removal). All vacuums and tools used should have a thorough HEPA vacuuming followed by wet wiping using baby wipes, sponges or rags wet with detergent solutions.

3.4.4 End of shift/job worker exiting procedures - (assuming change room or shower not contiguous to range).

3.4.4.1 - Prior to leaving work area, vacuum any loose dust from coveralls. Stay within the boundaries of the "dirty" side.

3.4.4.2 - Remove shoe covers if they were used or wipe off boots with damp rag (or baby wipe). Discard shoe cover/rag in waste bin. Remove boots and place in a plastic bag (or a designated storage bin).

3.4.4.3 - Remove gloves. Remove coveralls rolling the inside of the coveralls out.

3.4.4.4 - Wipe down respirator with a wet rag (or baby wipe) and remove respirator until further cleaning can be performed. Place respirator in a plastic bag.

3.4.4.5 - Put on a clean pair of coveralls, wash face and hands and travel to shower.

3.4.5 After cleaning is complete, replace consumable/disposable supplies, such as sponges and rags. Soiled items should be treated as contaminated debris.

Attachment (1)
Allowable Exposure Limits for Lead - Intermittent Exposures

Per MIL-HDBK 1027/3B (To be replaced by UFC 4-160-01), design criteria for indoor firing ranges should be based on 30 - 40 ug/m^3 airborne lead exposure. Per 29 CFR 1910.1025, worker protection from lead and the requirements for training, personal protection, engineering controls and medical surveillance are based on exposure as an 8-hour time-weighted average (TWA).

Administrative controls (i.e., limiting the time personnel are in the range actively firing) may be based on the measured exposure. From a regulatory perspective, non-firing (unsampled) periods are assumed to be zero lead exposure unless the worker is performing some activity to cause potential exposure (this should be part of the sampled period). To limit personnel exposure below the action level of 30 ug/m^3, limitations on firing operations may be computed or may be selected using the table that follows.

Exposure Based -

$$30\ \mu g/m^3 \text{ criterion} = \frac{\text{(measured exposure concentration) x (acceptable time)}}{\text{8 hours}}$$

Example - if the measured exposure during firing was 0.15 mg/m^3 (150 $\mu g/m^3$);

$$30\ \mu g/m^3 \text{ criterion} = \frac{(150\ ug/m^3) \text{ x (acceptable time)}}{\text{8 hours}}$$

Acceptable time = 1.6 hours

1.6 hours at 150 $\mu g/m^3$ will expose the worker to less than 30 $\mu g/m^3$ TWA for the entire work day (including the firing period).

Lead exposure limits

Taken from Table 3 of MIL-HDBK-1027/3B (To be replaced by UFC 4-160-01)

Personnel Exposure limits for Intermittent Atmospheric Lead Exposures		
Airborne lead concentration (mg/m^3)	Maximum hours of allowable exposure per day	
	Firing 30 or more days per year	Firing less than 30 days per year
0.0 – 0.03	8	8
0.03 – 0.04	6	8
0.04 – 0.05	4.5	8
0.05 – 0.06	4	6.5
0.06 – 0.08	3	5
0.08 – 0.10	2.25	4
0.10 – 0.15	1.50	2.5
0.15 – 0.20	1	2
0.10 – 0.30	0.75	1.25
0.30 – 0.40	0.50	1
0.40 – 0.50	0.50	0.75
0.50 – 0.75	0.25	0.50
0.75 – 1.00	0.25	0.25
1.00	0	0

Appendix B

Wipe Sampling for Settled Lead-Contaminated Dust

Wipe samples for settled lead dust can be collected from floors (both carpeted and uncarpeted), interior and sash/sill contact areas, and other reasonably smooth surfaces. Wherever possible, hard surfaces should be sampled. Wipe media should be sufficiently durable so that it is not easily torn, but can be easily digested in the laboratory. Recovery rates of between 80-120% of the true value should be obtained for all media used for wipe sampling. Blank media should contain no more than 25 μg/wipe. **Contact the laboratory for specific instructions**.

Wipe Sampling Materials and Supplies

1. Type of disposable wipe: Any wipe material that meets the following criteria may be used:
* Contains low background lead levels (less than 5 μg/wipe)
* Is a single thickness
* Is durable and does not tear easily (do not use Whatman™ filters)
* Does not contain aloe
* Can be digested in the laboratory
* Has been shown to yield 80-120% recovery rates from samples spiked with leaded dust (not lead in solution)
* Must remain moist during the wipe sampling process (wipes containing alcohol may be used as long as they do not dry out)

Individually-packaged "Dust Sampling Wipes" Part #484 from Palintest (1-800-835-9629) are acceptable to CIHL laboratory based on digestion recoveries. The wipe listed above has proven to be sufficiently durable under field use and to have acceptable recovery rates.

2. Non-sterile non-powdered disposable gloves. Disposable gloves are required to prevent cross-sample contamination from hands.

3. Non-sterile polyethylene centrifuge tubes (50 ml size) or equivalent hard-shell container that can be rinsed quantitatively in the laboratory (contact the CIHL).

4. Dust sample collection forms (IHFOM).

5. Camera & Film to document exact locations (Optional)

6. Template - Options:
* Masking tape. Masking tape is used on-site to define the area to be wiped. Masking tape is

required when wiping window sills and window wells in order to avoid contact with window jambs and channel edges. Masking tape on floors is used to outline the exact area to be wiped.

* Hard, smooth, reusable templates made of laminated paper, metal, or plastic. Note: Templates should be cleaned between each use to avoid transfer of contamination. Disposable templates are also permitted so long as they are not used for more than a single surface. Templates must be larger than 0.1 ft^2, but smaller than 2 ft^2. Templates for floors are typically 1 ft^2. Templates are usually not used for windows due to the variability in size and shape (use masking tape instead).

7. Container labels or permanent marker.

8. Trash bag or other receptacle (do not use pockets or trash containers at the range).

9. Rack, bag, or box to carry tubes (optional)

10. Measuring tape

11. Disposable shoe coverings (optional)

Single Surface Wipe Sampling Procedure

1. Outline Wipe Area:

a. Floors or horizontal surfaces: Identify the area to be wiped. Do not walk on or touch the surface to be sampled (the wipe area). Apply adhesive tape to perimeter of the wipe area to form a square or rectangle of about one square foot. Exact measurement is not required at this time. The tape should be positioned in a straight line and corners should be nominally perpendicular. When putting down any template, do not touch the interior wipe area.

b. Window sills and other rectangular surfaces: Identify the area to be wiped. Do not touch the wipe area. Apply two strips of adhesive tape across the sill to define a wipe area at least 0.1 square foot in size (approx. 4 inches x 4 inches). When using tape, be sure to wipe the entire sampling area. It is permissible to touch the tape with the wipe, but not the surface beyond the tape.

2. Inspect the wipes to determine if they are moist. If they have dried out, do not use them.

3. Prepare centrifuge tubes: Partially unscrew the cap on the centrifuge tube to be sure that it can be opened. Do not use plastic baggies to transport or temporarily hold wipe samples. The laboratory cannot recover and measure lead left on the interior surface of the bag.

4. Gloves: Don a disposable glove on one hand. Use a new glove for each sample collected. If two hands are necessary to handle the sample, use two new gloves, one for each hand. It is not necessary to wipe the gloved hand before sampling.

5. Initial placement of wipe: Place the wipe at one corner of the surface to be wiped with wipe fully opened and flat on the surface. <u>First wipe pass</u> - (side-to-side): With the fingers together, grasp the wipe between the thumb and the palm. Press down firmly, but not excessively with both the palm and fingers (do not use the heel of the hand). Do not touch the surface with the thumb. If the wipe area is a square, proceed to wipe side-to-side with as many "S"-like motions as are necessary to completely cover the entire wipe area. (See step #6 for non- square areas.) Exerting excessive pressure on the wipe will cause it to curl. Exerting too little pressure will result in poor collection of dust. Do not use only the fingertips to hold down the wipe, because there will not be complete contact with the surface and some dust may be missed. Attempt to remove all visible dust from the wipe area. <u>Second wipe pass</u> - (top-to-bottom): Fold the wipe in half with the contaminated side facing inward. (The wipe can be straightened out by laying it on the wipe area, contaminated side up, and folding it over.) Once folded, place in the top corner of the wipe area and press down firmly with the palm and fingers. Repeat wiping the area with "S"-like motions, but on the second pass, move in a top-to-bottom direction. Attempt to remove all visible dust. Do not touch the contaminated side of the wipe with the hand or fingers. Do not shake the wipe in an attempt to straighten it out, since dust may be lost during shaking.

6. Rectangular areas (e.g., window sills): If the surface is a rectangle (such as a window sill), two side-to-side passes must be made over half of this surface, the second pass with the wipe folded so that the contaminated side faces inward. For a window sill, do not attempt to wipe the irregular edges presented by the contour of the window channel. Avoid touching other portions of the window with the wipe. If there are paint chips or gross debris in the window sill, attempt to include as much of it as possible on the wipe. If all of the material cannot be picked up with one wipe, field personnel may use a second wipe at their discretion and insert it in the same container. Consult with the analytical laboratory to determine if they can perform analysis of two wipes as a single sample. When performing single-surface sampling, do not use more than two single surface wipes for each container. If heavily dust-laden, a smaller area should be wiped. It is not necessary to wipe the entire rectangular areas, but do not wipe less than 0.10 ft^2 (approx 4" x 4").

7. Packaging the Wipe: After wiping, fold the wipe with the contaminated side facing inward again, and insert aseptically (without touching anything else) into the centrifuge tube or other hard-shelled container. If gross debris is present, such as paint chips from a window well, make every attempt to include as much of the debris as possible in the wipe.

8. Labeling the Centrifuge tube: Seal the tube and label with the appropriate identifier. Record the laboratory submittal sample number on the field sampling form.

9. Area Measurement - After sampling, measure the surface area wiped to the nearest eighth of an inch using a tape measure or a ruler. The size of the area wiped must be at least 0.10 ft^2 in order to obtain an adequate limit of quantification (25 µg/wipe is the typical detection limit with flame atomic absorption (AA) spectrophotometry. No more than 2 square feet should be wiped with the same wipe or the wipe may fall apart. Record specific measurements for each area wiped on the field sampling form.

10. Form Completion - Fill out the appropriate field sampling forms completely. Collect and maintain any field notes regarding type of wipe used, lot number, collection protocol, etc.

11. Trash Disposal - After sampling, remove the masking tape and throw it away in a trash bag. Remove the glove. Put all contaminated gloves and sampling debris used for the sampling period into a trash bag. Remove the trash bag when leaving the structure.

Composite Wipe Sampling - Composite sampling limits the information gained from specific surfaces. However, whenever composite sampling is contemplated, consult with the analytical laboratory to determine if the laboratory is capable of analyzing composite samples. When conducting composite wipe sampling, the procedure stated above should be used with the following modifications: When outlining the wipe areas, set up all of the areas to be wiped before sampling. The size of these areas should be roughly equivalent, so that one room is not over-sampled. After preparing the centrifuge tube, put on the glove(s) and complete the wiping procedures for all subsamples. A separate wipe must be used for each area sampled. After wiping each area, carefully insert the wipe sample into the same centrifuge tube (no more than 4 wipes per tube). Once all subsamples are in the tube, label the tube. Record a separate measurement for each area that is subsampled on the field collection form. Finally, complete trash disposal, making sure that no masking tape is left behind. Risk assessors and inspector technicians do not have to remove their gloves between subsample wipes for the same composite sample as long as their gloved hands do not touch an area outside of the wipe areas. If a glove is contaminated, the glove should be immediately replaced with a clean glove. In addition to these procedural modifications, the following rules for compositing should be observed:

- Separate composite samples are required from carpeted and hard surfaces (*e.g.*, a single composite sample should not be collected from both carpeted and bare floors).
- Separate composite samples are required from each different component sampled (*e.g.*, a composite sample should not be collected from both floors and window sills).

Blank Preparation - After sampling the final space of the day, but before decontamination, field blank samples should be obtained. Analysis of the field blank samples determines if the sample media is contaminated. Each field blank should be labeled with a unique identifier similar to the others so that the laboratory does not know which sample is the blank (i.e., the laboratory should be "blind" to the blank sample). Blank wipes are collected by removing a wipe from the container with a new glove, shaking the wipe open, refolding as in the actual sampling procedure, and then inserting it into the centrifuge tube without touching any surface or other object. One blank wipe is collected for each structure/space sampled or, if more than one structure/space is sampled per day, one blank for every 50 field samples, whichever is less. Also, submit one blank for every lot used. Record the lot number.

Decontamination - After sampling, wash hands thoroughly with plenty of soap and water, preferably before leaving the facility. A bathroom in the facility may be used for this purpose, with the operator's permission. If there is no running water in the facility, use wet wipes to clean the hands. During sampling, inspectors must not eat, drink, smoke, chew gum, apply cosmetics, or otherwise cause hand to mouth contact.

Quality Assurance/Quality Control - If more than 50 μg total lead/wipe is detected in a blank sample, the samples should be collected again since the media has become contaminated. Blank correction of wipe samples is not recommended. Re-sampling should be done with wipes from a different lot number.

Appendix C

Lead Compliance Plan

Written Compliance Plan and Competent Person(s) - For every job, OSHA requires employers to prepare a written compliance plan that specifically describes how the standard will be implemented and includes regular and frequent inspections of the job site by a competent person. The written compliance plan, in conjunction with frequent work area inspections by a competent person, should ensure the prevention of dangerous, unhealthy, or unsafe conditions.

A. Written Compliance Plan - An example of a written compliance plan is included in this Appendix. Prior to the start of every job in which employee exposure will potentially exceed the OSHA PEL, employers must develop and implement a written compliance plan. Providing respirators does *not* preclude the need for a written plan. The written plan should be an organized strategy for protecting workers and should account for potential exposure problems, control alternatives, and a schedule for inspection of the job by the competent person(s). At a minimum, the written plans should include:

1. A description of equipment and materials, controls, crew size, job responsibilities, and operations and maintenance procedures for each activity in which lead is emitted.
2. A description of specific control methods (e.g., abatement process selection, wet methods). For engineering controls, include supporting engineering plans and studies used to select methods.
3. Technology considered in meeting the PEL.
4. Air monitoring data documenting sources of lead emissions.
5. A detailed implementation schedule for the compliance plan, including the schedule for inspections by a competent person.
6. A description of the lead work practice program that will be used to control worker exposures. This includes the use of protective work clothing and equipment, hygiene facilities and practices, and housekeeping practices.
7. A description of arrangements made among contractors on multi-contractor worksites to inform affected employees (including by-standers) of potential lead exposures, and to clarify responsibilities with regard to control of those exposures.

For those lead jobs that proceed over an extended period, OSHA requires that the written compliance plan be updated at least every 6 months. The plan must be available at the worksite for representatives of OSHA, and at the request of any affected employee or employee representative.

B. Competent Person(s) - As defined by OSHA, a competent person is one who is capable of identifying existing and predictable hazards at the work site, and who has the authority to ensure prompt corrective measures are taken to eliminate them. The employer must use a competent person (or persons) to ensure that the worker protection program is effective. The definition of a competent person and the requirement for regular and frequent inspections of job sites, materials, and equipment by a competent person are identical to those already required by OSHA's general safety and health provisions for construction work (29 CFR 1926.32 and 29 CFR 1926.20). In the context of a lead job, the competent person should have knowledge of the lead exposures for each construction/cleanup method in use; the potential hazards from lead and other substances or physical agents in the work site; and the appropriate engineering controls, work practices, and personal protective equipment.

Suggested Competent Person (CP) Responsibilities:

1. Certify that training meets all federal, State, and local requirements.
2. Review and approve Lead Removal Plan for conformance to the applicable referenced standards.
3. Continuously inspect removal work for conformance with the approved plan.
4. Perform air and wipe sampling.
5. Ensure work is performed in strict accordance with contract specifications at all times.
6. Control work to prevent hazardous exposures to personnel and to the environment at all times.
7. Certify the conditions of the work as specified elsewhere in the contract.

Example of a

Lead Compliance Plan

Date: 01/01/2002

[The determination for use and content of the bracketed items are based on local evaluations or requirements]. This example represents work either to convert a range to non-range use or for major modification to replace main range components. If properly cleaned, construction work for installation of new components should not be considered a lead job. This plan has been developed to comply with the OSHA Construction Lead Standard, 29 CFR 1926.62.

1. Location of Project:

This job will take place at the indoor small arms range (SAR) located in Building XXX on Naval Activity XXXX, Anywhere, Virginia. Lead is released from the projectiles (bullets) and other lead compounds in the ammunition while using the range. The surfaces of the range, bullet stop, and pit contain lead as a dust or bulk fragments and represent a hazard to workers who may disturb it during component removal, lead hazard control or renovation activities.

2. Brief Description of Job:

The job will involve the removal of the [bullet stop, sand in the pit and bullet fragments, and the supply and exhaust ventilation equipment and ducts] [firing line partitions]. The removal and clean up activities are expected to generate leaded dust.

3. Schedule:

Work will proceed according to the following schedule:

Initial Setup of Lead Control Area -

Day ( ) - A temporary area, structure or containment, equipped with HEPA local exhaust, will be fabricated to prevent the spread of lead dust or debris. Critical barriers and physical boundaries are employed to isolate the lead control area and to prevent migration of lead contamination. The area will be physically roped or partitioned off around the lead control area to prevent unauthorized entry of personnel. These barriers ensure that airborne concentrations of lead will not reach 30 micrograms per cubic meter of air outside of the lead control area. Plastic sheeting will be placed on exterior ground surfaces under/ around accesses during component removal.

Bullet Stop Removal -

Day ( ) - Begin manual removal [by disassembly/torch cutting]. [Insert the actual process of disassembly and removal]. All components will be wetted with water mist prior to removal to minimize dust generation. Sections will be wrapped in 6 mil plastic prior to removal from the containment. Daily cleanup: wet sweeping, HEPA vacuuming.

Ventilation System Removal -

Day ( ) - Initial setup, including placement of plastic sheeting on openings to non work areas and non-movable appliances, and fixtures. All surfaces will be thoroughly wetted with water mist prior to disassembly. Disassembly will be through [insert the actual process of disassembly and removal, i.e., shearing or by fastener removal]. Removed items will be wrapped in 6 mil plastic prior to removal from the containment. Daily cleanup: wet sweeping followed by HEPA vacuuming and mopping with detergent solution.

Firing Range Partition Removal -

Day ( ) - Disassembly will be through [insert the actual process of disassembly and removal, i.e., shearing or by fastener removal]. Removed items will be wrapped in 6 mil plastic prior to removal from the containment. Daily cleanup: wet sweeping followed by HEPA vacuuming and mopping with detergent solution.

Range Cleanup -

Day ( ) - All surfaces will be vacuumed with a HEPA vacuum, followed by wet washing with special cleaning agents and rinsing, followed by a final pass with the HEPA vacuum. Surfaces include ceilings, walls, floors, doors, heating, ventilation, and air conditioning (HVAC) equipment (heating diffusers, radiators, pipes, vents), fixtures of any kind (lights, built-in cabinets, and appliances. All rooms and surfaces will be included in the HEPA vacuum process except those that were found not to have lead hazards and that were properly separated from work areas before the process began. Vacuuming will begin on the ceilings and end on the floors, sequenced to avoid passing through areas already cleaned, with the entryway cleaned last. All vacuumed surfaces will be thoroughly and completely washed with a lead-specific cleaning agent (or equivalent) and rinsed with clean water (energized electrical systems will not be washed). Select a detergent that does not damage existing surface finishes. Mix according to the manufacturer's instructions. Five gallons of the mixture should be used to clean no more than 1,000 square feet. Used cleaning mixture is potentially hazardous waste. Wash water should be filtered and then disposed [per local requirements]. After the preliminary final cleaning effort is completed, the certified supervisor will visually evaluate the entire work area to ensure that all work has been completed and all visible dust and debris have been removed. All treated surfaces will be painted or otherwise sealed.

Effectiveness of final cleanup will be determined through surface wipe sampling. Surface dust sample will be conducted on the following surfaces at locations chosen by the Competent Person:

Example Clearance Surface Lead Dust Sampling

# of Samples	Location
2	One in area of exhaust fan inlet and one in area of fan outlet
3	Range floor
3	Horizontal surfaces other than the floor (i.e., counters, sills)
3	Bullet trap area
3	Vertical surfaces such as walls, frames
3	Horizontal surfaces exterior to range at entrances

Note: Field blanks are required. Additional site-specific samples may be necessary as needed.

***4. Equipment and Materials**:*

HEPA vacuums, [trisodium phosphate] detergent, protective clothing, cotton work gloves, electric power saws, hammers, wrecking bars, pry bars, screwdrivers, plastic sheeting, and other hand tools as needed. The cleaning job will also include [sealing of all interior surfaces] [interior walls and floors] [with floor sealer].

The job is expected to start on July 11, 2002 and end on July 18, 2002. This compliance plan will take effect [specify date]. The competent person will conduct worksite visual inspections on a daily basis.

5. Crew:

The initial setup of the containment area will be completed by a crew of four workers. Crew assignments are:

R. Smith, lead
T. Jones
L. Topp
J. Gonzales.

The bullet stop and firing line partitions removal will be completed by

T. Jones
L. Topp
J. Gonzales
T. Gore (heavy equipment operator).

The ventilation system removal will be conducted by

T. Gore
H. Perkins.

Cleanup will be performed by

R. Smith, lead
T. Jones
L. Topp, and
J. Gonzales.

6. Competent Person:

Mr. Harold Simpson, a licensed lead abatement supervisor, will be on site at all times and will act as the competent person for occupational health and safety issues. Mr. Simpson's lead supervisor license number is: XMZ 678, expiration date --/--/----. Mr. Simpson will conduct daily inspections of the work areas to ensure that control measures, work practices, personal protective equipment, and hygiene facilities are used as prescribed in this document.

7. Control Measures:

During bullet stop, ventilation removal, [and firing line partition removal], components will be wetted with water mist to reduce airborne dust generation during removal activities. During removal, all scraping, sawing or prying activity will be done on wet surfaces. All debris will be wetted down before handling. Building components coated with lead will be wrapped in plastic sheeting after removal to reduce contamination of workers' hands and clothing during handling and disposal. Wet methods (mopping) and HEPA vacuums will be used during cleaning to minimize worker exposures to lead. To reduce generation of leaded dust in the work areas, debris, chips and dust will be vacuumed on at least a daily basis with HEPA vacuums. Final cleaning will be accomplished by three successive cleanings in this order: HEPA vacuuming; wet mopping with [trisodium phosphate] detergent solution; and HEPA vacuuming. The use of HEPA vacuums and wet cleaning methods will minimize worker lead exposures.

8. Technology Considered in Meeting the Permissible Exposure Limit:

The only specialized equipment that will be used for this project are HEPA vacuum cleaners and portable pressure tanks for water misting of surfaces. [HEPA exhaust fans will be used to reduce lead releases outside the containment area.]

9. Respirators:

All individuals in the work area will be provided with a [half-mask, air-purifying respirator equipped with HEPA cartridges] [a powered air-purifying respirator][air supplied respirators]. Respirators will be provided in the context of a complete respiratory protection program; the written respirator program is attached. Respirators will be required during bullet stop removal, ventilation system removal, [firing line partitions] surface preparation, any sawing or use of power tools, manual scraping, cleaning activities, and final cleanup. Respirator use during other activities, including initial setup (such as laying down plastic for containment), and surface sealing after surface preparation is [is not] required, *unless* other workers nearby (same interior space or outside wall) are performing activities for which respirators are required.

10. Protective Clothing:

Disposable protective clothing will be worn at all times inside the work area. Protective clothing will be made of breathable fabric to reduce the potential for worker heat stress. If visibly contaminated with dust or chips, protective clothing will be vacuumed before it is removed.

11. Hygiene Facilities:

Hand washing facilities will be used to decontaminate workers. The facilities will be located in [a portable trailer that will be parked in the driveway] [the adjacent rest room facilities slated for the lead workers only]. [The trailer will contain two sinks, a fresh water tank, hot water heater, wastewater collection tank, and easily cleanable floors and benches]. Labeled plastic bins with covers will be used to separate disposable protective clothing from street clothing. Hot water, soap, and towels will be provided. Hands and face will be washed before all breaks and at the end of the day. Wastewater will be collected, pretreated on site with filtration, and disposed of in
accordance with prior arrangements made with the Anywhere Municipal Wastewater Treatment Facility. The [trailer] [facility] will be cleaned with a HEPA vacuum and wet washed twice each week.

12. Air Monitoring Data:

Air sampling will [not] be performed on this job, since typical exposures have [not] been established for these work crews [(see attached report from previous jobs prepared by XYZ Industrial Hygiene, Inc.).] Based on [these][expected] results, the major exposures to lead will occur during [bullet stop, ventilation system and firing line partitions removal,] although significant exposures may also occur during cleanup. [In previous work conducted by the same contractor and work crew on similar ranges in the same city, using the same methods, *maximum* personal exposures measured for various activities were: bullet trap and ventilation system removal, 0.0XX mg/m^3; cleaning, 0.0XX mg/m^3; final cleaning, 0.0XX mg/m^3; and initial setup, 0.0XX mg/m^3. The environmental conditions in the range previously abated closely resemble the current location. These maximum exposures are expected to represent worst-case exposures because they did not include breaks or setup time. It is expected that 8-hour, time-weighted average exposures on this job will be lower than these figures.] Worker respiratory protection requirements will be based on the maximum exposures to allow for unexpected variations. The initial monitoring shall determine the requirements for further monitoring and the need to fully implement the control and protective requirements of this plan.

13. Medical Surveillance Program:

A medical surveillance program is already in place for this work crew. It is supervised by Dr. William Jones, a board-certified occupational health physician with Occupational Health Clinic, Inc. (phone: 800-555-1111). Worker blood lead levels are measured initially before the onset of work, each month for the first 6 months of employment, and every 6 months thereafter. Blood lead levels for current employees who will be assigned to this job are X - Y ug/dL, based on the May report (see attached). Worker blood lead increases of 10 ug/dL or more will trigger an investigation of protective equipment and work practices. All workers on this project are informed of their blood lead levels as soon as results are received.

14. Training:

All workers have been trained using the EPA Worker Training Curriculum. The training was conducted by Joe Smith, a certified industrial hygienist with XYZ Industrial Hygiene, Inc., and H. Simpson, the competent person, on March 3B5, 1999. Workers trained on March 3B5 include:

R. Smith
T. Jones
L. Topp
J. Gonzales
T. Gore
H. Perkins

Plan completed by:
________________________________ (name)

________________________________ (signature)________________________________ (date)

Appendix D

Indoor Firing Range Cleaning Guidance

1. Introduction - This document describes procedures to be employed in cleaning a range for non-lead use. All lead hazard control activities can produce dangerous quantities of leaded dust. Unless this dust is properly removed, a facility will be more hazardous after the work is completed than it was originally. Once deposited, leaded dust is difficult to remove effectively. Whenever possible, ongoing and daily cleaning of leaded dust during lead hazard control projects is recommended. Ongoing and daily cleaning is also necessary to minimize worker exposures. Cleaning is the process of removing visible debris and dust particles too small to be seen by the naked eye. Removal of lead hazards in a space will not make the space safe unless excessive levels of leaded dust are also removed. This is true regardless of whether the dust was present before or generated by the lead hazard control process itself. Improper cleaning can increase the cost of a project considerably because additional cleaning and clearance sampling will be necessary. A visibly clean surface may contain high and unacceptable levels of dust particles and require special cleaning procedures. However, cleaning and clearance can be achieved routinely if care and diligence are exercised.

2. Difficulties in Cleaning - While cleaning is an integral and essential component of any lead hazard control activity, it is also the most likely part of the activity to fail. Several common reasons for this failure include worker inexperience, high dust-producing methods, and deadlines.

3. Performance Standard - Although the cleaning methods described in this document are feasible and have been shown to be effective in meeting clearance standards, other methods may also be used if they are safe and effective. This performance-oriented approach should stimulate innovation, reduce cost, and ensure safe conditions for both occupants and workers.

4. Clearance Standard - 200 $\mu g/ft^2$ on interior floors and horizontal surfaces (NAVFAC Message 160647Z APR 98), 800 $\mu g/ft^2$ for exterior concrete (a HUD interim recommendation and serves as a useful guideline).

These levels are based on wipe sampling. Clearance testing determines whether the premises or area are clean enough to be reoccupied as a non-lead work area after the completion of a lead hazard control project. A cleaned area may not be reoccupied until compliance with clearance standards has been established. To prevent delays, final testing and final cleaning activities should be coordinated.

5. Worker Inexperience - To understand the level of cleanliness required to meet the established clearance standards for hazard control cleanup, new hazard control personnel often require a significant reorientation to cleaning. Many construction workers are used to cleaning up only dust that they can see, not the invisible dust particles that are also important to remove.

6. Equipment Needed for Cleaning - The following equipment is needed to conduct cleaning: high-efficiency particulate air (HEPA) vacuums and attachments (crevice tools), detergent, waterproof gloves, rags, sponges, mops, buckets, 6-mil plastic bags, debris containers, waste water containers, shovels, rakes, water-misting sprayers, and 6-mil polyethylene plastic sheeting (or equivalent).

7. Waste Disposal - Regulations governing hazardous and non-hazardous waste storage, transportation, and disposal affect both the daily and final cleaning procedures. The hazard control contractor and the disposal contractor should work together to establish formal written procedures, specifying selected containers, storage areas, and debris pickups, to ensure that all relevant regulations are met.

8. Containment - Because of the difficulty involved in the removal of fine dust, dust generated by hazard control work should be contained to the extent possible to the inside of work areas. Inadequately constructed or maintained containments or poor work practices will result in additional cleaning efforts, due to dust that has leaked out or been tracked out of the work area.

9. Precleaning Procedures - Precleaning (i.e., cleaning conducted before lead hazard control is begun) is necessary only in facilities that are heavily contaminated with debris/paint chips, etc. Precleaning involves removing large debris and paint chips, followed by HEPA vacuuming. These steps may be followed by removal of occupant furniture or carpeting (rugs or carpets or any porous item in the firing range is not recommended due to the difficulty in cleaning these items effectively), depending on the worksite preparation. Carpeting (if present) should always be misted before its removal to control the generation of hazardous dust. However, if necessary, owners or project management should be prepared to remove furniture before lead hazard control work begins.

10. Basic Cleaning Methods: Wet Wash and Vacuum Cleaning Techniques - Because leaded dust adheres tenaciously, especially to rough or porous materials like weathered or worn wood surfaces and masonry surfaces (particularly concrete), workers should be trained in cleaning methods. As a motivator, some contractors have awarded bonuses to workers who pass clearance the first time. The typical cleaning method uses a special vacuum cleaner equipped with a HEPA filter, followed by wet washing with special cleaning agents and rinsing, followed by a final pass with the HEPA vacuum. Although HEPA filtered vacuums and trisodium phosphate (TSP) cleaners have been considered the standard cleaning tools for lead hazard control projects, new research, discussed under the Alternatives Methods section in this document, suggests that other tools and products may also be effective in efficiently cleaning dust while providing adequate worker protection from airborne exposure risks. Some of these innovations may even be superior.

a. HEPA Vacuuming - HEPA vacuums differ from conventional vacuums in that they contain high-efficiency filters that are capable of trapping extremely small particles. These filters can remove particles of 0.3 microns or greater from air with 99.97 percent efficiency or greater. (A micron is 1 millionth of a meter, or about 0.00004 inches.) Some vacuums are equipped with an ultra-low penetration air (ULPA) filter that is capable of filtering out particles of 0.13 microns or greater at 99.9995 percent efficiency. However, ULPA filters are slightly more expensive and may be less available than HEPA filters. Vacuuming with conventional vacuum machines is unlikely to be effective because much of the fine dust will be exhausted back into the environment where it can settle on surfaces. Considerations for the proper use of a HEPA vacuum are listed below.

(1) Operating Instructions - There are a several manufacturers of HEPA vacuums. Although all HEPA vacuums operate on the same general principle, they may vary considerably with respect to specific procedures, such as how to change the filters. To ensure the proper use of equipment, carefully follow the manufacturer's operating instructions and, if possible, arrange training sessions with the manufacturer's representative. Although HEPA vacuums have the same suction capacity as ordinary vacuums that are comparably sized, their filters are more efficient. Improper cleaning or changing of HEPA filters may reduce the vacuum's suction capability.

(2) Special Attachments - Because the HEPA vacuum will be used to vacuum surfaces other than floors, operators should buy attachments and appropriate tool kits for use on different surfaces such as brushes of various sizes, crevice tools, and angular tools.

(3) Selecting Appropriate Size(s) - HEPA vacuums are available in several sizes, ranging from a small lunch bucket-sized unit to track-mounted systems. Two criteria for size selection are the size of the job and the type of electrical power available. Manufacturer recommendations should be followed.

(4) Wet-Dry HEPA Vacuums - Some hazard control contractors have found the wet-dry HEPA vacuums to be particularly effective in meeting clearance standards. These vacuums are equipped with a special shut-off float switch to protect the electrical motor from water contact.

(5) Prefilters - HEPA filters are usually used in conjunction with a prefilter or series of prefilters that trap the bulk of the dust in the exhaust airstream, particularly the larger particles. The HEPA filter traps most of the remaining small particles that have passed through the prefilter(s). All filters must be maintained and replaced or cleaned as specified in the manufacturer's instructions. Failure to do so may cause a reduction in suction power (thus reducing the vacuum's efficiency and effectiveness). Failure to change prefilters may damage the vacuum motor and will also shorten the service life of the HEPA filter, which is far more expensive than the prefilters.

(6) HEPA Vacuuming Procedures - Surfaces to be vacuumed include ceilings, walls, floors, doors, heating, ventilation, and air conditioning (HVAC) equipment (heating diffusers, radiators, pipes, vents), fixtures of any kind (light), built-in cabinets, and appliances. All rooms and surfaces should be included in the HEPA vacuum process, except for those that (1) were found not to have lead hazards and were properly separated from work areas before the process began, or (2) were never entered during the process. Sidewalks, driveways, and other exterior surfaces should be vacuumed if exterior hazard control work was conducted, or if debris was stored or dropped outside. Vacuuming should begin on the ceilings and end on the floors, sequenced to avoid passing through rooms already cleaned, with the entryway cleaned last.

(7) Emptying the HEPA Vacuum - Used filters and vacuumed debris are potentially hazardous waste and should be treated accordingly. Therefore, operators should use extreme caution when opening the HEPA vacuum for filter replacement or debris removal to avoid accidental release of accumulated dust into the environment. This may occur, for example, if the vacuum's seal has been broken and the vacuum's bag is disturbed. Operators should also wear a full set of protective clothing and equipment, including appropriate respirators, when performing this maintenance function, which should be done in the containment area or off-site.

b. Wet Detergent Wash - Several types of detergents have been used to remove leaded dust. Those with a high phosphate content (containing at least 5 percent trisodium phosphate, also known as TSP) have been found to be effective when used as part of the final cleaning process. TSP detergents are thought to work by coating the surface of dusts with phosphate or polyphosphate groups which reduces electrostatic interactions with other surfaces and thereby permits easier removal. Because of environmental concerns some states have restricted the use of TSP, and some manufacturers have eliminated phosphates from their household detergents. However, high TSP detergents can usually be found in hardware stores and may be permitted for limited use, such as lead hazard control. Other non-TSP cleaning agents developed specifically for removing leaded dust have also been found to be effective (possibly more effective than TSP) in limited trials by several investigators and may also be safer, since TSP is a skin and eye irritant.

* Manufacturer's Dilution Instructions - Users of cleaning agents for leaded dust removal should follow manufacturer's instructions for the proper use of a product, especially the recommended dilution ratio. Even diluted, trisodium phosphate is a skin irritant and users should wear waterproof gloves. Eye protection should also be worn, and portable eyewash facilities

should be located in or very near the work area. Consult manufacturer's directions for the use of other detergents.

* Appropriate Cleaning Equipment- Because a detergent may be used to clean leaded dust from a variety of surfaces, several types of application equipment are needed, including cleaning solution spray bottles, wringer buckets, mops, variously sized hand sponges, brushes, and rags. Using the proper equipment on each surface is essential to the quality of the wet-wash process.

(1) Proper Wet-Cleaning Procedures - At the conclusion of the active lead hazard control process and after the initial HEPA vacuuming, all vacuumed surfaces should be thoroughly and completely washed with a high-phosphate solution or other lead-specific cleaning agent (or equivalent) and rinsed. Select a detergent that does not damage existing surface finishes (TSP may damage some finishes). Work should proceed from ceilings to floors and be sequenced to avoid passing through rooms already cleaned.

(2) Changing Cleaning Mixture - Many manufacturers of cleaners will indicate the surface area that their cleaning mixture will cover. To avoid recontaminating an area by cleaning it with dirty water, users should follow manufacturer-specified surface area limits. However, regardless of manufacturers' recommendations, the cleaning mixture should be changed after its use for each room. As a rule of thumb, 5 gallons should be used to clean no more than 1,000 square feet. Used cleaning mixture is potentially hazardous waste; consult with your local water and sewage utility for directions on its proper disposal. Wash water should never be poured onto the ground. The wash water is usually filtered and then poured down a toilet (if the local water authority approves).

11. The HEPA/Wet Wash/HEPA Cycle Typical Procedures - The usual cleaning cycle that follows lead hazard control activities is called the HEPA vacuum/wet wash/HEPA cycle and is applied to an entire affected area as follows:

First, the area is HEPA vacuumed. Next, the area is washed down. After drying, the area is again HEPA vacuumed. The rationale for this three-pass system is as follows: The first HEPA vacuum removes as much dust and remaining debris as possible. The wet wash further dislodges dust from surfaces. The final HEPA cycle removes any remaining particles dislodged but not removed by the wet wash.

12. Single-Pass Wet Wash/HEPA Vacuum - Some lead hazard control contractors have found HEPA spray cleaner vacuums to be a cost-effective alternative to the three-pass system. Similar to home carpet-cleaning machines, these vacuums simultaneously deliver a solution to the surface and recover the dirty solution. Theoretically, this process combines two of the steps in the HEPA vacuum/wet wash/HEPA cycle into one step. While anecdotal evidence indicates that the spray cleaner wet wash/HEPA is effective for some uses, limitations have been noted in its use for ceilings, vertical surfaces, and hard to reach areas. This device may be used as long as clearance standards are met.

13. Sealing Floors - Before clearance, all floors without an intact, nonporous coating should be coated. Sealed surfaces are easier to clean and maintain over time than those that are not sealed. Wooden floors should be sealed with a clear polyurethane or epoxy coating. Concrete floors should be sealed with a concrete sealer or other type of epoxy coating. If these floors are already covered by an effective coat of sealant, it may be possible to skip this step. New surfaces should be cleaned with a cleaning solution that is appropriate for that type of surface.

14. Surface Painting or Sealing of Non-floor Surfaces - Surfaces, including walls, ceilings, and wood-work, should be coated with an appropriate primer and repainted. Surfaces enclosed with vinyl, aluminum coil stock, and other materials traditionally not repainted are exempt from the painting provision. Coating of walls may not be appropriate if lined with acoustic material to control noise.

15. Exterior Cleaning - Areas potentially affected by exterior lead hazard control should be protected via a containment system. Because weather can adversely affect the efficacy of exterior containment, the surface plastic of the containment system should be removed at the end of each workday. On a daily basis, as well as during final cleaning, the immediate area should be examined visually to ensure that no debris has escaped containment. Any such debris should be raked or vacuumed and placed in single 6- mil or double 4-mil plastic bags, which should then be sealed and stored along with other contaminated debris. HEPA vacuuming is appropriate for hard exterior surfaces, not for soil.

16. Worker Protection Measures - Studies indicate that during daily cleaning activities, especially while wet sweeping, workers may be exposed to high levels of airborne dust. Therefore, workers should wear protective clothing and equipment and appropriate respirators if required.

17. Maintaining Containment - The integrity of the plastic sheeting used in a lead hazard control project must be maintained. During their daily cleaning activities, workers should monitor the sheeting and immediately repair any holes or rips with 6-mil plastic and duct tape.

18. Decontamination of Workers, Supplies, and Equipment - Decontamination is necessary to ensure that worker's families, other workers, and subsequent properties do not become contaminated. Specific procedures for proper decontamination of equipment, tools, and materials prior to their removal from lead hazard control containment areas should be implemented. Work clothing, work shoes, and tools should not be placed in a worker's automobile unless they have been laundered or placed in sealed bags. All vacuums and tools that were used should be wiped down using sponges or rags and detergent solutions. Consumable/disposable supplies, such as mop heads, sponges, and rags, should be discarded after each space is completed. Soiled items should be treated as contaminated debris. Durable equipment, such as power and hand tools, generators, and vehicles should be cleaned prior to their removal from the site. The cleaning should consist of a thorough HEPA vacuuming followed by washing.

19. Preliminary Visual Examination - After the cleaning work is completed, the certified supervisor should visually evaluate the entire work area to ensure that all work has been completed and all visible dust and debris have been removed. While the preliminary examination may be performed by the lead hazard control supervisor, contractor, or owner as a preparatory step before the final clearance examination, it does not replace the independent visual assessment conducted during clearance. If the visual examination results are unsatisfactory, affected surfaces must be retreated and/or recleaned. Therefore, it is more cost effective to have the supervisor rather than the clearance examiner perform this initial examination.

20. Final Inspection - The final clearance evaluation should take place at least 1 hour after the final cleaning. Clearance has three purposes: 1) to ensure that the lead hazard control work is complete; 2) to detect the presence of leaded dust; and 3) to make sure that all treated surfaces have been repainted or otherwise sealed. Clearance is usually performed after the sealant is applied to the floor.

21. Advanced Screening - Advanced screening for clearance may be considered. Immediate on-site analysis of dust wipes may alert the contractor to continue cleaning prior to final clearance sampling.

22. Recleaning After Clearance Failure - If after passing the final visual examination, the space fails the clearance wipe dust tests, the HEPA/wet wash/HEPA cleaning cycle should be carefully and methodically repeated. Failure is an indication that the cleaning has not been successful. Recleaning should be conducted under the direct supervision of a certified supervisor. Care should be exercised during the recleaning of "failed" surfaces or components to avoid recontaminating "cleared" surfaces or components.

23. Cleaning Cost Considerations - An important consideration in determining lead hazard control strategies and methods is the cost and difficulty of required daily and final cleanup operations and the likelihood that one can meet dust-clearance standards. A general rule of thumb is that lead hazard control strategies that generate the most dust will have higher cleanup costs and higher initial clearance test-failure rates.

24. Initial Clearance Test Failure Rates - The likelihood of passing final dust-clearance tests is highly correlated with the chosen intervention strategy, methods, and care exercised by the contractor. Chemical removal and hand-scraping strategies generally experience higher failure rates than replacement and encapsulation/ enclosure strategies. However, clearance failure is not solely related to abatement method. The diligence and effectiveness of an abatement contractor's cleaning process has a major impact on the likelihood of the space to pass the final wipe test clearance.

25. Key Factors In Effective Cleaning - Effective cleaning will be aided by adequate sealing of surfaces with polyethylene sheeting prior to lead hazard control, proper daily cleaning practices, good worker training, and attention to detail. Where poor worksite preparation is employed, additional cleaning may be required to meet clearance.

26. Special Problems - Surfaces such as porous concrete, old porous hardwood floors, and areas such as corners of rooms and window troughs pose especially difficult cleaning challenges. Porous concrete and corners of rooms normally require additional vacuuming to achieve an acceptable level of cleanliness.

27. Alternative Methods - Alternatives to the recommended cleaning tools and practices discussed in this document are available, some with significant potential for increasing effectiveness and lowering costs. Other vacuums may be used if worker exposures do not increase, if compliance with clearance standards is achieved, and if a variance from OSHA regulation is obtained by the contractor or employer (if required). The OSHA lead standard requires the use of HEPA vacuum equipment (see 29 CFR 1926.62 (h)(4), which states, "where vacuuming methods are selected, the vacuums shall be equipped with HEPA filters."). Agitator heads on vacuums have been shown to significantly enhance vacuum effectiveness on carpets in cleaning fine dust without increasing airborne dust levels. Vacuums without agitator heads appear to perform relatively poorly on carpets.

Appendix E

BIBLIOGRAPHY

29 CFR 1910.1025, "Lead" (General Industry)

29 CFR 1926.62, "Lead" (Construction)

AFRC-ENV-CO (200), Lead Dust Accumulation within Indoor firing Ranges, Information Paper, 10 Jan 96

Anania, T.L. and J.A. Seta: "Lead Exposure and Design Considerations for Indoor Firing Ranges," HEW Publication No (NIOSH 76-130, December 1975

CEHND 110-1-18, "USACE Design Manual for Indoor Firing Range," June 1990, US Army Corps of Engineers

Crouch, K.G., T. Peng, and D.J. Murdock: Ventilation Control of Lead in Indoor Firing Ranges: Inlet Configuration and Booth and Fluctuating Flow Contributions. Am. Ind. Hyg. Assoc. J. 52(2):81-91 (1991)

MIL-HDBK-1027/3B, "Range Facilities and Miscellaneous Training Facilities Other than Buildings" To be replaced by Draft UFC 4-160-01, 15 March 2002 "Design and Maintenance of Small Arms Ranges."

NAVENVIRHLTHCEN Technical Manual, "Industrial Hygiene Field Operations Manual," latest revision

NGR 385-15 Department of the Army and Air Force - Evaluation and Maintenance of Indoor Firing Ranges

OPNAVINST 3574.1, Design, Construction, Maintenance, Inspection and Closure of Small Arms Ranges - Draft

OPNAVINST 3591.1C, "Small Arms Training and Qualification"

OPNAVINST 5100.23 Series, "Navy Occupational Safety and Health Program Manual"

OSHA Instruction CPL 2-2.58, December 13,1993, 29 CFR 1926.62, Lead Exposure In Construction; Interim Final Rule--Inspection and Compliance

Schaeffer D.J., R.A. Deem, and E.W. Novak: Indoor Firing Range Air Quality: Results of a Facility Design Survey. Am. Ind. Hyg. Assoc. J. 51(2):84-89 (1990)

Technical Memorandum, TM-2048-ENV, Lessons Learned for Ventilation Systems at Indoor Firing Ranges, Naval Facilities Engineering Service Center, Port Hueneme, CA

Appendix F
Industrial Hygiene Acceptance Test for Small Arms Indoor Range

1. **Initial Evaluation**. Major changes in a range due to changes in operation, general life cycle maintenance or by major modifications as recommended by the NAVFAC Technical Center of Expertise, would require an industrial hygiene reevaluation. After major modifications, it may be desirable to conduct an initial evaluation to demonstrate the effectiveness of the facility. From a safety and health perspective, it is necessary to determine if an indoor range is operating properly as designed. The range must be evaluated from two perspectives - the physical/mechanical and the operational. The first includes the facility design, construction and the mechanical systems used in the facility. The second focuses on how the range is operated (the interaction of the occupants, weapons and ammunition with the facility). The purpose of this acceptance test is to demonstrate the effectiveness of the facility to control exposures at the maximum operational capability (the maximum designed condition), not the normal operational tempo. It is nothing more than a descriptive expansion of an industrial hygiene range evaluation with suggested acceptance criteria developed with NAVFAC's Technical Center of Expertise and could be used as a basis for placing limits on the range's SOP. This test should only be used when a range has been modified or renovated through NAVFAC's Technical Center of Expertise with prior agreement on the test criteria prior to work by all affected parties. Bracketed [ ] items are selected or replaced by local use agreements.

2. **Physical and operational assessment**. Conduct a walk-through assessment of the facility and look for the desired design traits (refer to Sections 3 and 5 of the Technical Guide). Note how the facility is to be operated. Gather information on the layout, listed weapon(s) to be used in the range, training content, expected number of shooters, frequency of use and typical expended rounds used. This information will be needed to set up and conduct the air sampling exposure test.

3. **Ventilation assessment**. A properly designed and operating ventilation system is necessary to control exposures to shooters/instructors.

a. **Method:** Smoke test
Purpose: To visualize air movement patterns in the range and determine if these patterns meet design goals.
Procedure (Using either a smoke tube, smoke candle or fogger):

(1) Prior to activating the tube or candle, ensure that the ventilation system is on and stabilized.

(2) Unnecessary personnel should not be present in the range or near the supply air plenum during the assessment. Traffic through doors should be restricted to keep the ventilation stable and to limit stray air currents.

(3) If a smoke candle is used, a coffee can with some type of a handle fabricated (pliers) should be used.

(4) At the firing line, smoke test each firing station (booth). Test from the floor to about the 6 foot level. Observe the smoke pattern. The smoke should move down range and demonstrate laminar flow. Document unusual smoke patterns or where smoke swirls and returns to the shooter's position. If turbulence is observed, air velocities may be high in that area. Note that air velocity measurements conducted later in this area may not truly indicate the direction of the flow (turbulence and eddies may have flow directions other than down range but will be reflected only as a measured value).

(5) Conduct additional smoke measurements down range to ensure adequate air velocities and patterns are maintained down range towards the bullet stop.

Acceptance Criteria: Smoke should move down range uniformly. Eddies or swirls if present shall not demonstrate movement of smoke returning to the shooter's position.

b. **Method:** Air Velocity
Purpose: To determine if the ventilation system meets the designed airflow.
Procedure:

(1) Use a calibrated air velocity instrument to make measurements. Traffic through doors should be restricted to keep the ventilation stable and to limit stray air currents. The measurements should be conducted at the firing line (the line marked on the floor if present). Firing lines are not the same in all ranges. Some are positioned so the weapon must not pass the line and others, the line represents where the shooter places his toe (the weapon may pass the line). The velocity measurements should be very close whether or not the measurements are taken between the shooting stations or a few inches down range of the stations unless the partitions are very thick and perturb the airflow. This should be visible during the smoke test.

(2) Measurement –

a. Using a hot wire or vane type meter - At the firing line at each firing station, place the probe (or the meter) so that it is perpendicular to the floor at the firing line. Make sure no unnecessary personnel are present or near the supply air plenum during the assessment. Take three measurements at the same level in three locations from the floor: approximately 1 foot (prone level firing); approximately 3 feet (kneeling position); and approximately 5 feet (standing position). This will result in 9 readings for each firing position. Average the 9 readings.

b. Using a grid meter - At the firing line at each firing station, place the grid so that it is perpendicular to the floor at the firing line. Make sure no unnecessary personnel are present or near the supply air plenum during the assessment. In the center of each firing station, take a measurement at three locations from the floor: approximately 1 foot (prone level firing); approximately 3 feet (kneeling position); and approximately 5 feet (standing position). This will result in 3 readings for each firing position. Average the 3 readings.

Acceptance Criteria:
Firing Line – Compare the average at each shooting station to the design criteria [75 feet per minute +/- 10%]. Any individual reading less than 50 is unacceptable. [This should provide an overall range average at the firing line of approximately 75 feet per minute.]

c. **Method:** Static pressure measurements.
Purpose: To determine if the range is maintained at an acceptable negative pressure related to other occupied spaces while the ventilation system is operating.
Procedure: Use either -

(1) A manometer or magnahelic gauge can be used to check the pressure in relation to areas outside the range. A hose can be placed outside the door (careful not to crimp) with at least 6 inches of the hose outside the door or,

(2) Use a smoke tube at all entrances or openings into the range (doors may need to be "cracked" a little to demonstrate. Smoke should enter into the range from outside areas.

(Excessive negative pressure will make doors difficult to open (or to keep closed) and can be a safety hazard (slamming doors {- 0.05 to - 0.10 inches water gauge}). Excessive negative pressure also indicates insufficient supply air for the amount being exhausted.)

Acceptance Criteria: Either compare the measured result to the desired criterion level [-0.04 $\pm$ 0.02 inches water gauge], or smoke clearly enters into the range from outside areas.

4. **Air Sampling**. Air sampling in the personal breathing zone of shooters and range instructors is imperative in assessing exposure. Follow the procedures presented in the NEHC Industrial Hygiene Field Operations Manual (IHFOM) and the sampling and analysis requirements of the Industrial Hygiene Sampling Guide for Consolidated Industrial Hygiene Laboratories.

Method: Air sampling
Purpose: To determine if the ventilation system is adequate to protect personnel using the range.
Procedure:

(1) For the acceptance test, gather information regarding the expected use of the range including type of shooting, frequency of shooting, weapon type(s), caliber, jacketed or non-jacketed bullets, number of rounds expended, and any other activity that would contribute to exposure.

(2) To demonstrate the effectiveness of the facility at the maximum operational capabilities (the designed use), ensure all firing lanes are manned with shooters (provided the lanes are designed for shooting).

(3) Collect air samples in the personal breathing zone of [all][a significant number of people representing the entire range including] shooters, instructors, and the range operator (manager).

(4) Sample during worst-case weapon/ammunition use. The range operators should determine the weapon, ammunition and training scenario that would be considered worst case:

[For the XYZ Range at Naval Station Anywhere, this would be:

9 mm pistol qualification course using standard NATO jacketed round – Insert number of rounds

M-16 qualification course with standard NATO 5.56 mm round - Insert number of rounds]

(5) Sample for lead [and other metals if present] using a 0.8 μ MCEF filter at 3 liters per minute with minimum sample duration of 70 minutes or the duration of the firing evolution which ever is greatest. Follow the sampling procedures presented in the NEHC Industrial Hygiene Field Operations Manual (IHFOM).

[(6) If possible, sample separately two back-to-back training evolutions in each range (e.g., two separate 70 minute minimum sampling sessions). This will determine if a steady-state concentration has been reached in the range and will document that the ventilation can truly control exposures during the evaluation period.]

Acceptance Criteria: Compare the results of the air sample (not the 8 hour time weighted average) to the permissible exposure limit of [0.05 mg/m^3 (50 $\mu g/m^3$)]. [All results less than 50 $\mu g/m^3$ are acceptable.] [Exposure results greater than 50 $\mu g/m^3$ may be considered acceptable provided range standard operating procedures restrict firing evolutions in a manner that will provide an 8-hour time weighted average exposure less than the action level of 30 $\mu g/m^3$.]