NAFA®
National Air Filtration Association

Guidelines

Recommended Practices for

Filtration for Firing Range

This NAFA Guideline has been provided, courtesy of:

Independent Filter Service
82 Northern Road,
Heidelberg West, 3081, Victoria
T: (03) 9458 3644
E: sales@independentfilter.com.au
www.independentfilter.com.au

INDEPENDENT FILTER SERVICE P/L

About this publication

Why NAFA Guidelines?
The National Air Filtration Association (NAFA) provides "Best Practice Guidelines" to help supplement existing information on the control and cleaning of air through proper filtration. Many organizations recommend "minimum" air cleaning levels. NAFA publishes best practice based on the experience and expertise of our membership along with information and research of the governmental, medical and scientific communities showing the short and long term impact particulate and molecular contaminants have on human health and productivity.

This Guideline provides advice on achieving the cleanest air possible based on the design limits of existing HVAC equipment and with consideration of the impact on energy and the environment. For a more complete explanation of principles and techniques found in this Guideline, go to the website www.nafahq.org and purchase the *NAFA Guide to Air Filtration*, 4th Edition.

Disclaimer
The information contained in this Guideline is intended for reference purposes only. NAFA has used its best efforts to assure the accuracy of information and industry practice. NAFA encourages the user to work with a NAFA Certified Air Filter Specialist (CAFS), to assure that these Guidelines address specific user equipment and facility needs.

Issues regarding health information may be superseded by new developments in the field of industrial hygiene. Users are therefore advised to regard these recommendations as general guidelines and to determine whether new information is available.

NAFA does not guarantee, certify or assure the performance of any products (other than those bearing the NAFA Certified Product label), components, or systems operated in accordance with NAFA Guidelines.

NAFA®

National Air Filtration Association
(NAFA)
22 N. Carroll St, Ste 300
Madison, WI 53703
(608) 310-7542
nafahq.org

Committee members and contributors

Committee Chair :
Phillip Masters, CAFS
R. P. Fedder Corporation

Joseph Benoit, CAFS
Filtration Group, Inc.

Stevan Brown, CAFS
TEX-AIR Filters/Air Relief Technologies

Carol Christensen, CAFS
The Filter Man, Ltd.

Kevin Delahunt, CAFS
B.G.E. Service & Supply Ltd.

Leonard Duello, CAFS
Ahlstrom Air Media

Alisa Edmunds, CAFS
Filtration Group, Inc.

Dave Hurd, CAFS
PlymoVent Canada Inc.

Rupert Langston, CAFS
Air Flow Technology, Inc.

Paula Levasseur, CAFS
Cameron Great Lakes, Inc.

William Matkins
Aeolus Corporation

Phil Maybee, CAFS
The Filter Man, Ltd.

Bill Palmer
AeroMed, Inc.

Bill Patterson, CAFS
Dave Downing & Associates

Thomas Riddell, CAFS
Air Filter Sales & Service

Table of Contents

Filtration for Firing Ranges

Purpose

This best recommended practice establishes air filtration guidelines for the removal of airborne contaminants for the protection of employees and participants in indoor firing ranges.

Scope

To identify air quality issues associated with indoor firing ranges. Also, to provide air filtration component selection, application, and maintenance guidelines for those involved in the design of indoor firing ranges.

Background

Exposure to lead and fumes from a firing range can present a potential health risk to shooters as well as the employees of a firing range. Protecting the health and welfare of occupants in a firing range, while minimizing the environmental contamination from lead exposures, is an important element in the operational procedures for a firing range. Filtration plays an integral role in reducing the risk of toxic exposure in indoor shooting facilities.

Potential health issues from firing ranges

The firing of bullets from firearms creates a significant quantity of pollutants that are potentially toxic to humans. The Occupational Health and Safety Administration (OSHA) has established a standard for lead exposure to employees, CR 1910.1025. The Permissible Exposure Limit (PEL) for workers is 50 micrograms per cubic meter of air of exposure averaged over an 8 hour period.

Lead adversely affects the body by poisoning the blood. Lead poisoning is caused by lead oxide dust which is generated from the friction of lead bullets ejecting from the barrels of the guns used in the range. Metallic lead dust is not the primary culprit as the actual metals are heavy enough that the body can process and clean it from the system. Several fumes, created by the firing process, are harmful when introduced through the respiratory system. Lead oxide is the white powdery substance that is oxidation of the lead itself and it is toxic by inhalation, absorption through the skin, or ingestion.

Early signs and symptoms of lead poisoning

Fatigue	Headaches	Uneasy Stomach
Sleeplessness	Nervousness	Poor Appetite
Metallic "Taste"	Irritability	Reproductive Problems

Each individual reacts differently to lead exposure. One of the most common pathways of lead poisoning occurs from hand to mouth ingestion sources. This is the reason it is not advisable to allow smoking or consumption of food and/or beverages in, or around the firing range.

Areas of potential lead concentration within the range

There are three key areas within an indoor firing range where lead is most concentrated and potentially high risk. These are the Shooters Station, the area approximately 15 feet down range from the shooters station, and the target area. Each of these areas has their own unique sets of circumstances that create potential risks. See Typical Firing Range Diagram on page 5.

Shooter's Station

This is the point of highest airborne concentration, due to the firing of the guns and the barrel discharge. Each shot fired releases a small quantity of harmful dusts and gases which should not be allowed into the breathing zones of the shooters or other occupants of the range.

Area 15 feet down range
This is the region that the EPA found greater than 90% of the "heavier dusts" settle from the air stream. This area becomes extremely contaminated from this waste dust and should not be entered without the proper protective gear, per OSHA guideline CFR 1910.134. The primary exposure risk is contact from this region.

Target Area
It is in the target area where the fragmentation of lead from bullets is highest. There are a few designs for capturing bullets in target areas. While each has advantages and disadvantages, the fragmentation of lead means the lead oxide develops at very rapid rates and is likely a hazard through contact and inhalation. This area should not be entered without OSHA regulated protective gear.

Ventilating an Indoor Firing Range

Types of firing ranges may dictate system and equipment design for optimum use within the standard range parameters, however ventilation is a critical part to the reduction of lead exposure. Once a system is built it should provide effective air movement toward the target area away from the shooters stations and the gallery areas of the facility. Additionally, a system must be maintained properly and kept free of obstructions that may alter or interfere with the ventilation patterns designed to control the airflow. It is critically important that the actual range ventilation be isolated from any of the other building HVAC systems to prevent any potential cross contamination of non-protected areas. Exhaust air should be established so that it does not re-entrain into the make-up air intakes.

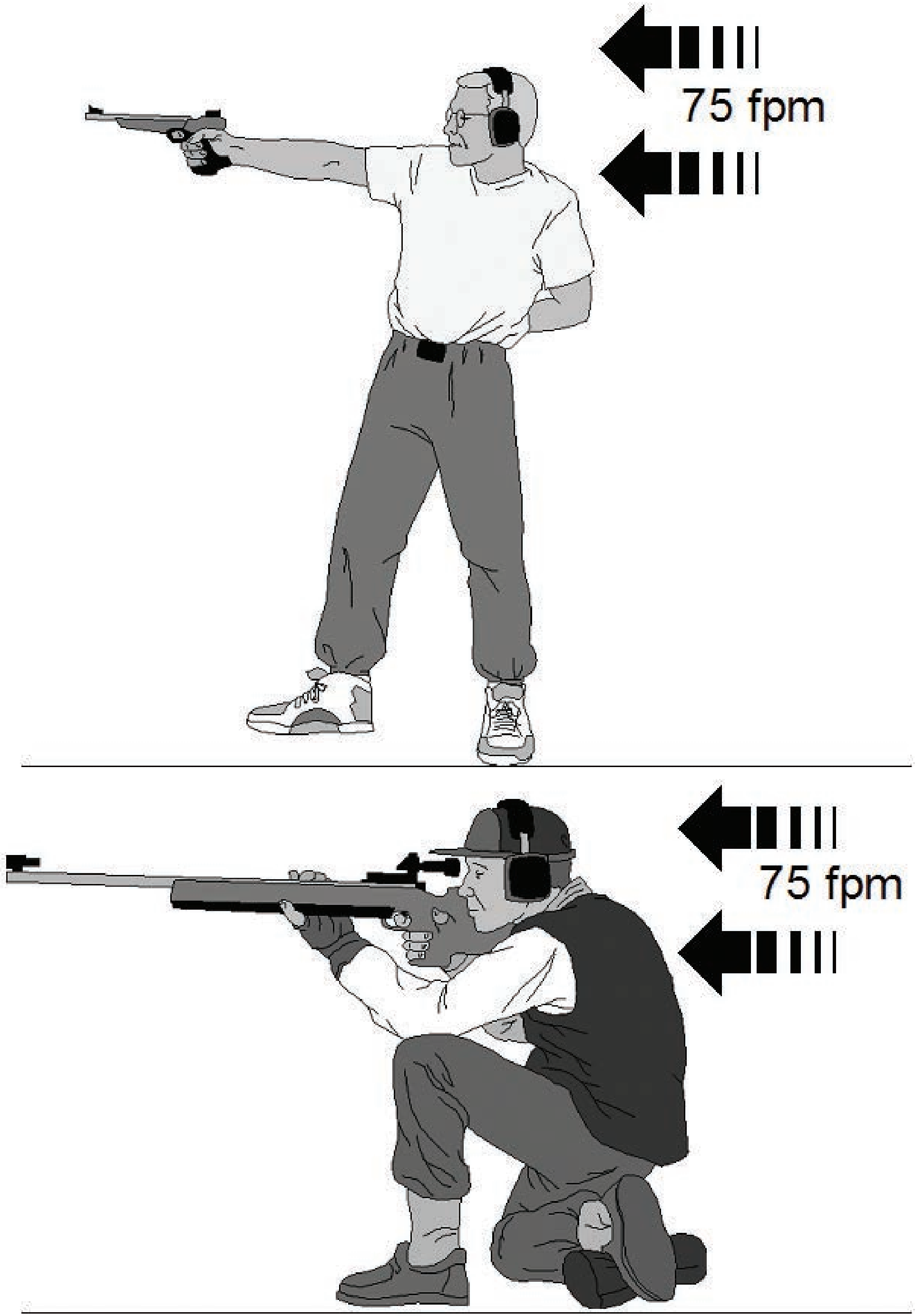
There are several designs used currently within firing ranges for ventilation control of the dust and fumes of the firearm discharging. The most common has been to supply air behind the shooter toward the target area in an attempt to create a "laminar flow" of air to wash the contaminants down range. Maintaining a design velocity between 50 to 100 feet per minute (fpm) is recommended. Higher airflows may create a circular flow of air starting downstream of the shooter, allowing contaminated air into the breathing zone. In addition higher velocities may create optical distortion of movement of the target itself. Another design being used by some government facilities introduces make-up air at each shooters station in small quantities to move the air down range.

While there are debates over the airflow rates, one clear agreed upon criteria is that the air should be visibly moving all smoke and fumes down range away from the shooters' stations and gallery. This is accomplished by creating a slightly negative pressure down the range. Air will seek the negative pressure release point. OSHA research has verified that the heaviest concentration of fallout dust in a range is an area roughly 15 feet down range from the shooter.

It is imperative that the breathing zones of the shooter stations be supplied clean air for the persons occupying the range. This means that any of the contaminants must be moved down range or filtered from the air if the air is re-circulated through the HVAC system.

Breathing Zone for Shooters

Most engineers use a system that will provide proper airflow across the brathing zone of range occupants, introduce sufficient levels of fresh outside air, maintain a negative range pressure differential with respect ot other areas of the building and remove offending contaminants through the use of air filtration. Air shall be introduced in a horizontal laminar pattern if possible.



The breathing zone is different for these two shooters. Most firing ranges are for pistol use and the shooter shoots primarily from a standing position. The breathing zone is typically 1 to 7 feet from the floor. If the firing range accommodates kneeling or prone positions, then the breathing zone for these positions are much closer to the floor (1 to 4 feet). Supply air should always be introduced behind the shooting positions. The system should be capable of accommodating all planned shooting positions.

System Designs

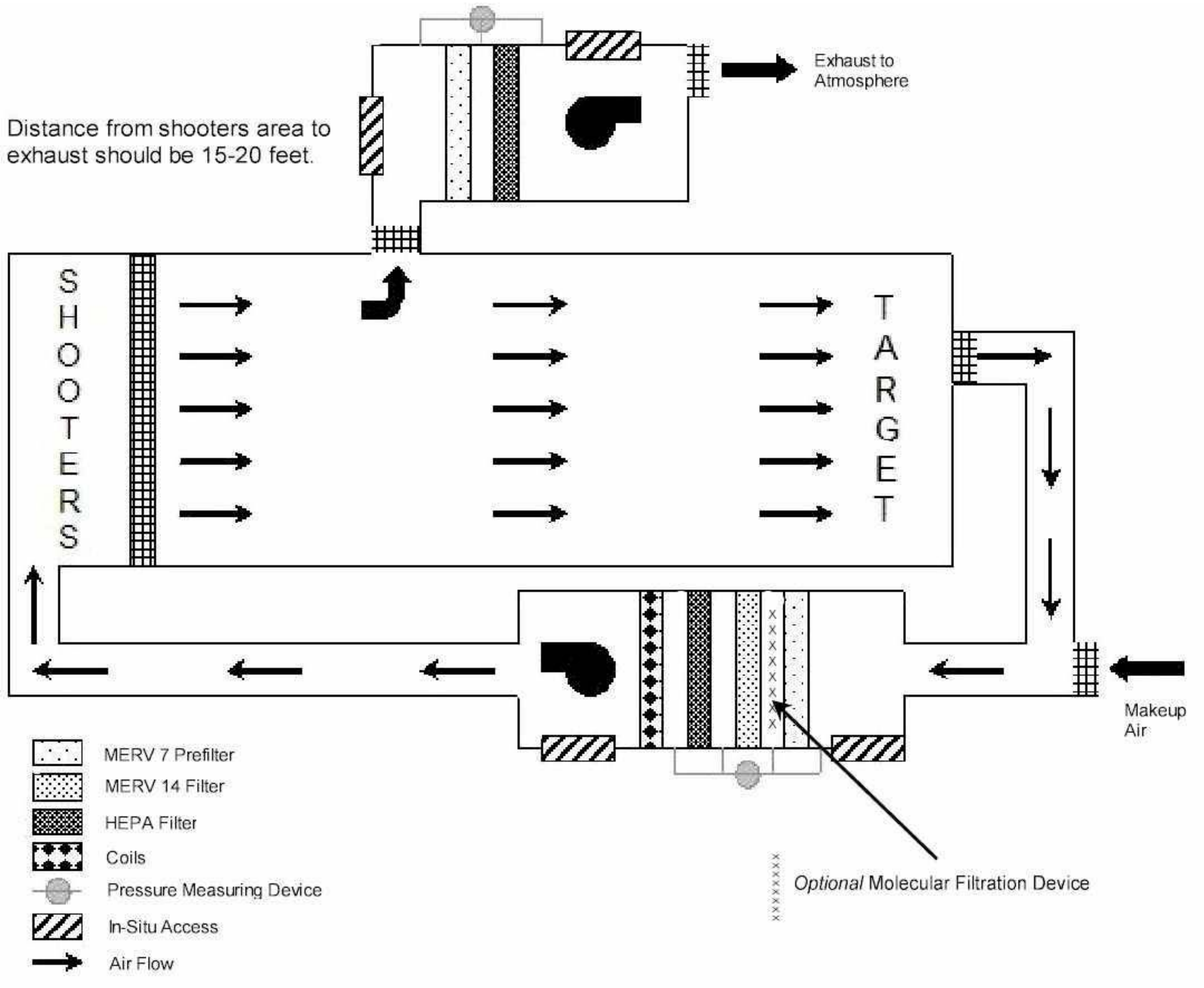
Single Pass System

One of the simplest of system designs is for air to make one pass through the range. This would use 100% outside air drawn into the area behind the shooters and pass through the range and exhaust out the opposite end. While this is simple in design, it is very costly due to the cooling or heating of 100% outside air.

Re-circulating System

This system allows for most of the contaminated air to be filtered and re-introduced into the space. Some exhaust to atmosphere is still necessary to maintain the negative pressure down range. This exhaust air must be filtered in accordance with the United States Environmental Protection Agency (EPA) requirements. A make-up air intake is required to maintain air balance in this design. Drawing in clean, outside air will also help provide the dilution required to maintain air quality. As a rule of thumb, the supply air should be 10% less than the exhaust air.

Typical Firing Range Diagram



Filtration Requirements

There are two concerns that should be dealt with when providing the filtration in a firing range. The first is that the make-up air must be filtered to protect the HVAC equipment from outside contaminants. The second is for the removal of the hazardous contaminants that are generated by the firearms when exhausting or re-circulating the air from within the facility.

Make-up air should be filtered with a Minimum Efficiency Reporting Value, (MERV) 14 filter in accordance with ASHRAE (American Society of Heating, Refrigeration and Air-conditioning Engineers) Standard 52.2. These should be sized to provide adequate efficiency and proper sealing mechanisms for installation in the HVAC system. The filter face velocities should be designed at 400 fpm with pressure drop indicators installed to help determine filter change-out points.

Exhaust or re-circulated air must be filtered at the point of removal with a minimum of 99.97% High Efficiency Particulate Air (HEPA) filter, per the Institute of Environmental Sciences and Technology (IEST) recommended practice for HEPA/ULPA filters (IEST RP-CC001). All HEPA filters should be accompanied by a letter of certification or a label documenting that each filter has met the test requirements. The airflows should be designed at the manufacturers recommended face velocity, usually 250 fpm. Pressure drop measuring devices should be installed on all HEPA filter sections for monitoring filter life cycles.

It is recommended that HEPA filters be pre-filtered with a minimum of MERV 14 filters to provide an extended life cycle of the HEPA filters. A MERV 7 pre-filter should also be considered to extend the life of the MERV 14 filter. Pressure drop measuring devices should be installed on all filter sections for filter maintenance.

Framing Systems

Framing systems shall be specifically designed and tested for HEPA filters, so as to eliminate leakage or penetration of air around the filter. A proper filter gasket consisting of closed cell foam rubber is critically important to eliminate air bypass. All housings and components should be leak free up to 6.0” water gage (w.g.).

Molecular Filtration

Traces of carbon monoxide, barium oxide, nitrogen dioxide, nitrogen textraoxide and oxides of sulfur may also be found in an indoor range. While the make-up air will provide dilution of the known gaseous contaminants created in the shooting range it is advisable to provide for molecular filtration whenever the air is being re-circulated. This filter section can be installed in the HVAC portion of the shooting range system. Makeup air ratio of 30% is recommended to prevent the buildup of oxides of nitrogen and carbon.

System Startup and Maintenance

NAFA Recommended Practice

The HEPA filters should be leak-tested, in-situ, using the cold dioctlyphthalate (DOP) (or accepted alternative aerosol) method prior to initial startup and after replacement. Testing must be done by a trained certifier. A certificate of this test shall be kept by the owner.

Filter Service Recommendations

Manufacturers’ recommendations for filter changing procedure will be followed when servicing air filters. Use of protective gear, such as gloves and dust masks, should be used when handling used filters removed from an HVAC system.

Filter Evaluation (gauges)
To ensure that filters are operating properly and that the maximum life of each stage is utilized, Magnehelic gauges should be used to determine the differential pressure drop across the filter bank. An optimum installation includes a filter gauge for each stage of filters. Multiple gauges allow immediate evaluation of an individual bank so corrective measures may be taken as soon as possible, i.e. a sudden drop in gauge reading may indicate a filter failure. A single gauge with gauge cocks designed to isolate each filter stage is also acceptable.

HVAC system velocities can vary widely based upon the designer (typically from 350 to 500 fpm). Filter manufacturers publish maximum recommended final pressure drop values to prevent degradation of the filter. In a firing range system an additional level of security is recommended. NAFA recommends changing the air filter when the initial pressure drop doubles, i.e. initial pressure drop is .35" w.g. x 2 = .70" final change-out.

Precautions and Employee Protection

Lead Oxide dust should never be handled with bare skin contact. The lead dust clean-up in the range should never be swept as a cleaning method, this will aerosolize the dusts. Employees changing filters should wear protective equipment including gloves, outer wear, mask and goggles. The OSHA (CFR 1910.134) guidelines or the respective states or regional guidelines should be followed for protective gear.

Filter Disposal

Used (non-hazardous) filters will be wrapped in two layers of (six) 6 mil poly and sealed with duct tape. Potentially hazardous or contaminated filters shall be disposed of in accordance with all local, state and federal regulations.

Glossary

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers. ASHRAE is an international organization that sets standards and guidelines for the heating, ventilating, air conditioning, and refrigeration industry.

CAFS: Certified Air Filter Specialist accreditation granted by NAFA to those who pass an exam on air filtration.

CFM: Cubic feet per minute; a volumetric measurement used to size fans and duct work.

Cold DOP Test Method: See *NAFA Guide to air Filtration.*

DOP: Dioctyl Phthalate is a chemical used to challenge HEPA filters. Factory testing involves heating DOP to produce a monodispersed particle challenge and distribution through a Laskin nozzle produces a polydispersed particle challenge.

EPA: Environmental Protection Agency; United States.

FPM: Feet per minute describes velocity of air. FPM is always positive and always measured in one direction.

HEPA: High Efficiency Particulate Air filter – describes a filter that achieves a minimum of 99.97% efficiency on 0.3 micrometer particles or similar challenge.

HVAC&R: Heating, Ventilating, Air Conditioning and Refrigeration.

IEST: Institute of Environmental Sciences and Technology.

In-situ: translated means "in position." This refers to measuring a filter installed in a system commonly using cold DOP for HEPA filters to test for leaks or using ambient air and a particle counter to perform ANSI/ASHRAE GP 26.

MERV: Minimum Efficiency Reporting Value refers to the lowest efficiency of a filter when tested in accordance with ANSI/ASHRAE Standard 52.2 2012.

NAFA®: registered acronym for the National Air Filtration Association, the trade association for air filter manufacturers and distributors, worldwide.

OSHA: Occupational Safety and Health Administration, the group that is charged with enforcement of health and safety legislation.

PEL: Permissible Exposure Limit; standard level of exposure levels set by government regulations.

Bibliography

Controlling Airborne Lead in Indoor Firing Ranges, Environmental Hygienist, July 1990.

Controlling Lead Exposures in the Workplace, the Lead Industries Association, Inc.

Firing Range Design, Cambridge Filter Corporation.

Firing Ranges, The Airborne Lead Dust Hazard Shooters Guide, and Firing Ranges, The Airborne Lead Dust Hazard, Employers Guide, Texas Department of Health.

Indoor Firing Range Indoor Air Cleaning Systems, American Air Filter.

Indoor Firing Range Ventilation System, Brian O'Rourke, HPAC, October, 1992

Lead Exposure and Design Considerations for Indoor Firing Ranges, NIOSH 75-130.

Lead Exposure at an Indoor Firing Range, United States Department of Commerce.

Lead Exposure at an Indoor Firing Range, T.L. Anania, J.B. Lucas, J.A. Seata, DHEW, National Institute of Occupational Safety and Health, Publications 74-100 and 76-130.

Lead on the Range, Boston University School of Public Health.

Indoor Pistol and Small Bore Rifle Range Ventilation, American Conference of Governmental Industrial Hygienists, 1978.

Indoor Shooting Range, Boyd Morgenthaler, P.E., David F. Shumway, P.E., ASHRAE Journal, December 2002.

Occupational Lead Poisoning, Kevin C. Staudinger, M.D. M.P.H, Victor S. Roth, M.D., M.P.H., American Family Physician, February 15, 1998.

Occupational Exposure to Lead: Final Standard, Federal Regulation 43 (220), US Occupational Safety & Health Administration, 1978.

On Target with Camfil Farr, Camfil Farr, 1997.

OSHA Lead Standard (29 CFR 1910.1025).

This NAFA Guideline has been provided, courtesy of:

Independent Filter Service
82 Northern Road,
Heidelberg West, 3081, Victoria
T: (03) 9458 3644
E: sales@independentfilter.com.au
www.independentfilter.com.au

INDEPENDENT
FILTER
SERVICE P/L

NAFA®
National Air
Filtration
Association

The source for expertise, education and standards in air filtration.

22 N. Carroll St, Ste 300, Madison, WI 53703
(608) 310-7542
nafahq.org