NAFA®
National Air Filtration Association

Guidelines

Recommended Practices for

Filtration for Firing Range

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*.

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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. To provide air filtration component selection, application, and maintenance guidelines for those involved in the design and operation of indoor firing ranges.

Background

Exposure to lead and fumes 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. Filtration plays an integral role in reducing the risk of toxic exposure in indoor firing ranges.

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 eight-hour period.

Early signs and symptoms of lead poisoning

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 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

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

the Shooting Station, the area approximately 15 feet down-range from the Shooting Station, and the Target Area. Each of these areas has its own unique set of circumstances that create potential risks. See Typical Firing Range Diagram on page 5.

Shooting 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 to enter the breathing zones of the shooters or other occupants of the range.

Area 15 feet down-range

This is the region where the United States Environmental Protection Agency (EPA) found greater than 90% of the "heavier dusts" settle from the airstream. This area becomes extremely contaminated from this waste dust and should not be entered by anyone without the proper protective gear. The primary exposure risk is contact from inside this region. Shooters are prohibited from entering this area. OSHA Respiratory Protection Standard (29 CFR 1910.134) should be reviewed by the owner, employee and contractor for recommended Personal Protective Equipment (PPE) in this area.

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 piece to the reduction of lead exposure. Once a system is built, it should provide effective air movement toward the Target Area away from the Shooting 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 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 it does not re- enter the make-up air intakes.

There are several designs used currently within firing ranges for ventilation control of the dust and fumes from the firearm discharging. The most common has been to supply air from behind the Shooting Station toward the target area in an attempt to create horizontal flow of air to push the contaminants down range without cross currents. Maintaining a design velocity between 50 and 100 feet per minute (fpm) is recommended. Higher airflows may create a turbulent flow of air starting downstream of the shooter, allowing contaminated air back into the breathing zone. In addition, higher velocities may create optical distortion of movement of the target itself.

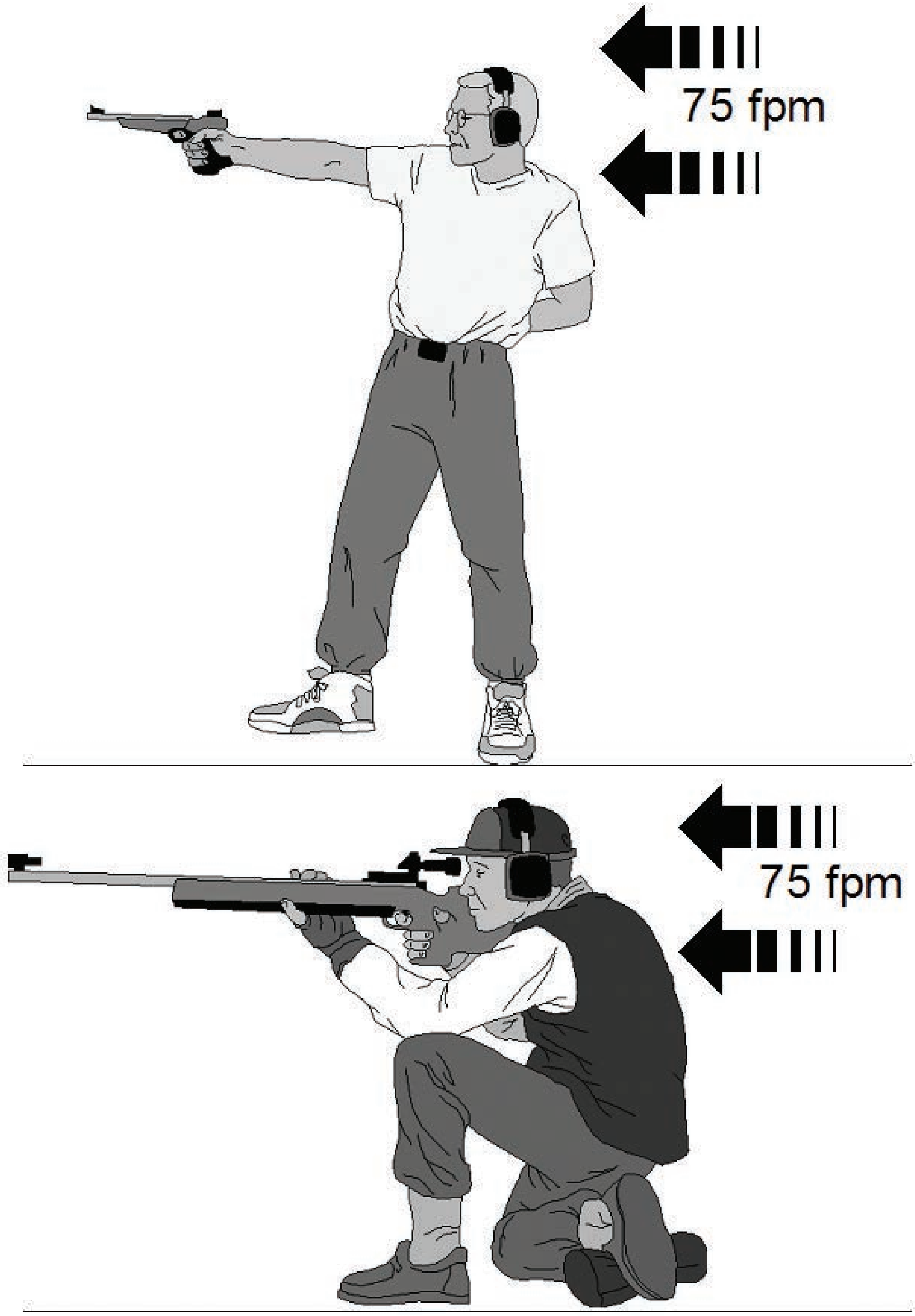
Another design being used by some government facilities introduces make-up air at each Shooting Station in small quantities to move the air down range.

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

It is imperative the breathing zones of the Shooting Stations be supplied clean air for the persons occupying the range.

This means 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 provides proper airflow across the breathing zone of range occupants, introduce sufficient levels of outside air, maintain a negative range pressure differential with respect to other areas of the building and remove offending contaminants through the use of air filtration. Air shall be introduced in a horizontal flow pattern in an effort to push the contaminates down range.



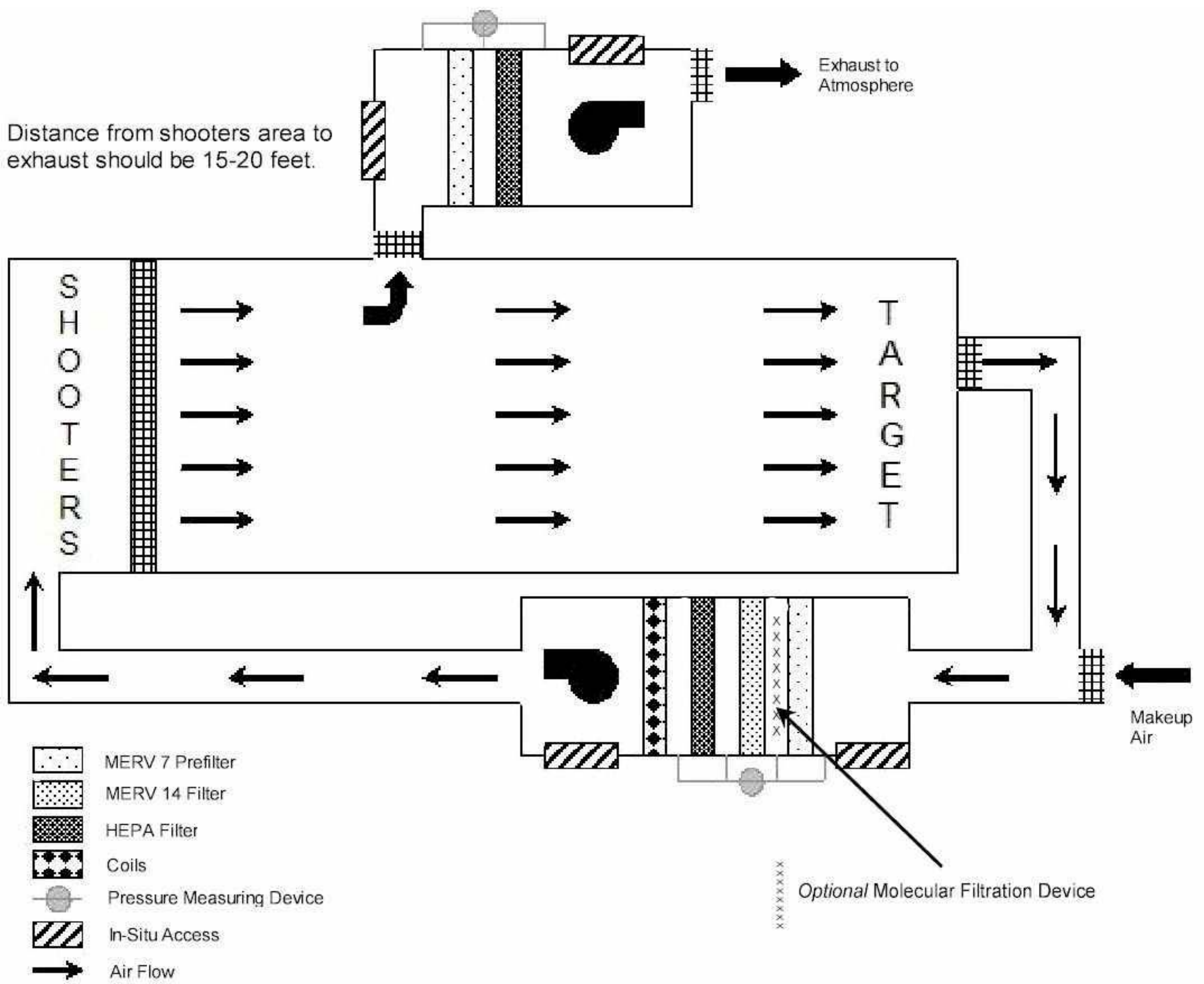
The breathing zone is different for these two positions. Most firing ranges are for pistol use and the shooter is primarily in a standing position. The breathing zone is typically 1 to 7 feet from the floor. If the firing range accommodates kneeling or prone positions, then the breathing zone is much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

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 Shooting Stations, passed through the range and exhausted out the opposite end. While this is simple in design, it is very costly due to the cooling or heating of 100% outside air.

Recirculating 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 cleaner, 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

Filtration in an indoor firing range should address the protection of HVAC equipment from outside contaminants and the removal of 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 final 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 should be filtered at the point of removal with a minimum of a 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 or EN1822:2009 H13 Rating). All HEPA filters should be accompanied by a letter of certification or a label documenting that each filter met the test requirements. The airflow should be designed at the manufacturer's 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. A MERV 8 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 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 gauge (w.g.).

Molecular Filtration

Traces of carbon monoxide, barium oxide, nitrogen dioxide, nitrogen tetroxide 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. Make-up 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 an ASHRAE accepted 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 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. It is recommended to establish a regular preventative maintenance cleaning schedule to all measuring instruments. This practice will help to avoid buildup of contamination and maintain accurate instrument readings.

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 protection 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. This recommendation would be for each filter section where applicable; PreFilter, Secondary, Final and HEPA.

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 as this will aerosolize the dusts. Employees changing filters should wear protective equipment including gloves, outer wear, safety goggles and approved respiratory protection. OSHA Respiratory Protection Standard (29 CFR 1910.134) should be reviewed for the appropriate device.

Filter Disposal

Used (non-hazardous) filters should be wrapped in two layers of (six) 6 mil poly and sealed with duct tape. Loaded filters will likely contain lead in sufficient quantity to classify the used filter as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) (40 CFR 260– 279). A Toxicity Characteristics Leaching Procedure (TCLP) test will determine whether the filter is a regulated hazardous waste under the RCRA regulation. If the filter does not meet the criteria of a hazardous waste, it can be disposed of as normal solid waste. If the filter does have sufficient lead to be considered a hazardous waste, there are two options: first is to recycle or reuse the filter, in which case it is not considered a waste (RCRA recycling exemption 40 CFR 261.4(a)(13)) and there are no hazardous waste handling procedures required, second if the filter is not recycled, and it fails the TCLP, then it must be transported and disposed of properly in accordance with Federal, State and local regulations.

Who Covers What and Where?

Agency	Mandate	What is covered
Environmental Protection Agency (EPA)	Protect human and environmental health.	Anything that is exhausted to the outdoor environment.
Occupational Safety and Health Administration (OSHA)	Assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.	Anything that reaches the respiratory zone and may expose employees or shooters.
National Institute for Occupational Safety and Health (NIOSH)	Conduct research and make recommendations for the prevention of work-related injury and illness.	Detailed design criteria for indoor shooting ranges.

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.

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: Heating, Ventilating and Air Conditioning.

IEST: Institute of Environmental Sciences and Technology.

In-situ: translated means "in position." This refers to measuring the performance of a filter installed in a system to test for leaks.

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.

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