At a glance…

Indoor Gun Range Ventilation and Filtration

Protecting workers and shooters from lead and gaseous pollutants at indoor firing ranges is not a new concern. With an estimated 18,000 indoor gun ranges in the United States – 3,000 of which are military – approximately 1.2M law enforcement officers and nearly 20M target shooters, it is more important than ever.

While many people may understand the dangers of potential lead poisoning at an indoor gun range, the filtration technology available today is notable and worthy of revisiting the issue. The contents herein provide information on lead exposure symptoms, sources of lead and acceptable levels, recirculating range air, the importance of filtration, changing filters, filter disposal, and filter recommendations.

The Dangers of Lead

The dangers of lead have been well-documented, and the most extreme cases can result in coma and death. It is important to be aware of symptoms, although note that not everyone displays the traditional symptoms of acute lead poisoning or chronic lead toxicity.

Acute lead poisoning:

- Cramping, abdominal pain and weakness
- Nausea, vomiting
- Black, tarry stools
- Headache, confusion, stupor
- Sudden decrease in amount of urine
- Jaundiced skin and eyes

Chronic lead toxicity:

- Brain and nervous system damage
- Blood damage (anemia, jaundice)
- Renal failure, high blood pressure, gouty deposits in kidneys
- Digestive tract irritability
- Decreased libido, abnormal sperm production, infertility, irregular menses, miscarriage
- Muscle and joint pain, particularly in shoulders and back
- Gout

If anyone at the range is exhibiting any of these symptoms, it is important to see a medical professional immediately. Lead poisoning is a very serious condition, and not everyone displays the symptoms. Case studies have found lead poisoning in law enforcement trainees, school rifle teams, police officers, and even in kids whose parents frequent or work at the range.

For the health of the employees and patrons, and for the long term financial health of the gun range, the range should take all precautions to protect everyone. Lawsuits alleging negligence are only part of the price a range might have to pay. Significant fines over $100,000 and range closures are very real possibilities.

Lastly, a range operator should provide employees with separate lockers for work and clean clothes, laundry service, showers, and proper OSHA (Occupational Safety and Health Administration) certified equipment for lead dust cleaning purposes.

Sources of Lead at the Range

The primary source of lead at the range is bullets and their dust and fragments. In spite of alternatives, lead's physical properties make it the preferred material used in ammunition. There are three areas of the range that present the greatest threat to lead exposure:

First is the shooting station, where people fire guns. This is the site of the highest airborne concentration of lead. The second area is 15 feet downrange, where the EPA has found more than 90% of heavy lead dust settlement. Lastly, the target area contains the spent bullets and their fragments created upon impact with the trap.

Before anyone walks downrange for any reason, it is recommended that one wear the appropriate OSHA regulated protective gear.

Acceptable Lead Levels

The idea of contracting lead poisoning by merely shooting a few rounds at a range might seem outlandish. However, it is not how often or how much one shoots; rather it is about the air quality of the range itself.

OSHA has established an action level (AL) and a permissible exposure level (PEL) for employees (29 CFR 1910.1025). The AL is 30 micrograms per cubic meter ($\mu g/m^3$) of air as an eight hour time weighted average. When lead levels reach $30\mu g/m^3$, actions must be taken to regularly monitor and further control the lead levels in the air to ensure compliance.

The PEL for employees is 50 $\mu g/m^3$ of air as an eight hour time weighted average. If lead is present at $50\mu g/m^3$, any prolonged exposure is considered dangerous. A developed action plan is required to improve the long term air quality of the range, which could face significant fines and even closure if it fails to comply. Additionally, employers must continue to provide pay and benefits to employees recovering from dangerous levels of lead in their blood.

That being said, some workers compensation insurance carriers will monitor range air for free.

Recirculating the Air at an Indoor Firing Range

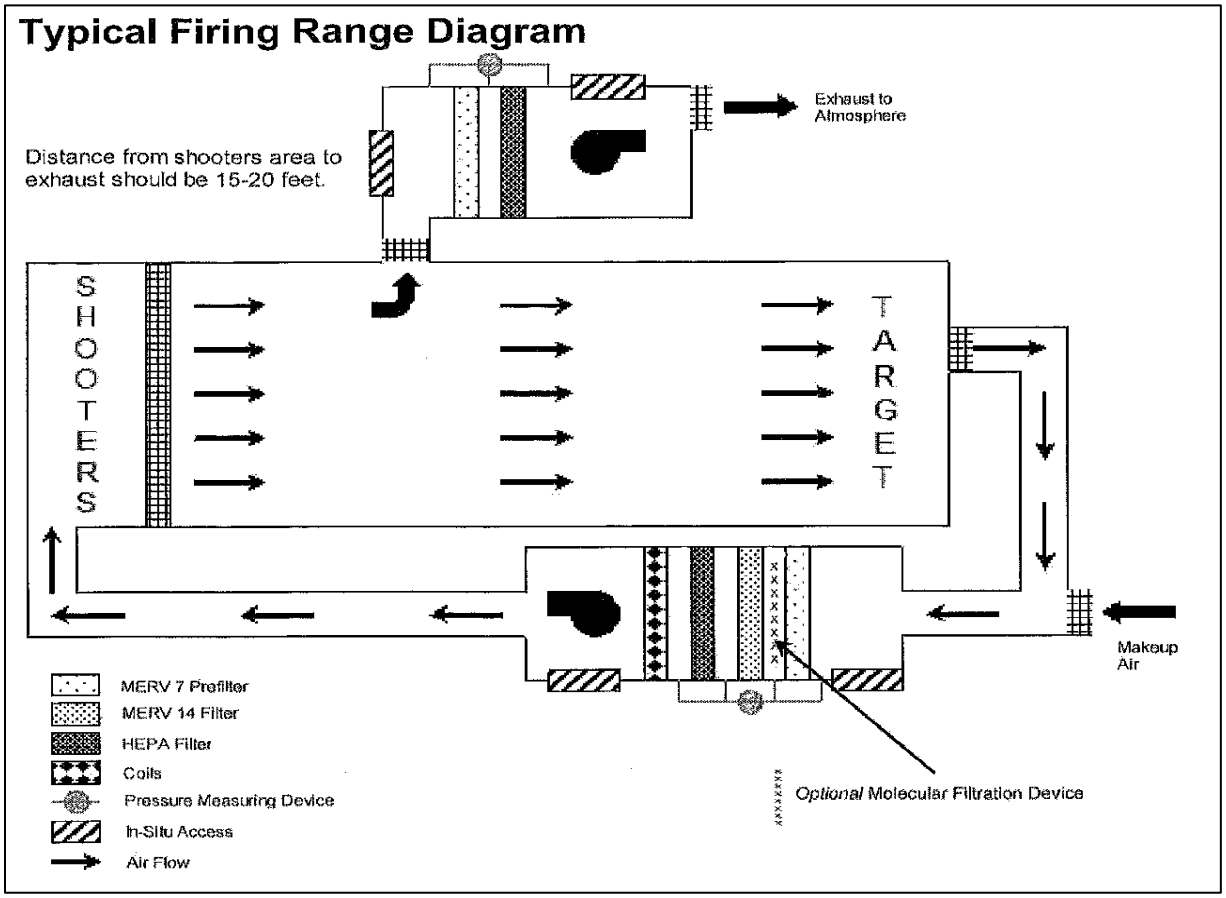
Filters can remove nearly all lead dust that passes through the HVAC system – depending on the type of filter, of course. Equally as important, however, is the ventilation system used at the range.

Some traditional ranges use the effective pass through or "once" through ventilation system – taking 100% of supply air from outside. As such, these systems require 100% of air to be heated or cooled to the desired temperature, drastically increasing the cost of energy for the range. While the pass through HVAC systems still need filters and maintenance, the dangers posed to employees and shooters are far less prominent than those of the diluted or recirculated ventilation systems.

Because recirculating ventilation systems for indoor firing ranges in most climates are significantly more energy efficient than alternatives, it is far cheaper to maintain and has become common practice. While proper ventilation and filtration is imperative in all HVAC systems, the recirculating system in an indoor firing range poses particular challenges and risks and a greater threat to danger. Having the right filters in place can easily solve any issues before they become a problem. This will be the focus moving forward. See Figure 1.1 on the next page for reference.

First and foremost, the air must be blowing from behind the shooting stations. Recommended rates of airflow vary from 50 to 100 feet per minute (fpm), but authorities unanimously agree that the air flow should be visibly blowing all smoke and particles down range away from the shooters. In order to accomplish this effectively, the distribution of airflow must be equivalent across the entire line of shooters, with no obstructions in its path. This even distribution of air is known as laminar airflow, and it eliminates turbulent areas where particles and dust might drift back towards the shooters' respiratory zone, otherwise called "backflow."

Figure 1.1:



In addition to the laminar airflow behind the shooting stations, negative air pressure down range helps move particles and lead dust away from the shooters. Air seeks a negative pressure release point, and by introducing newly supplied air as far up range as possible – behind the shooter – it effectively "pulls" the movement of air, and thus the particles, away from the shooter.

To help achieve this downrange negative pressure in a facility, an exhaust vent should be located approximately 15 feet downrange from the shooter. Not only does this exhaust some of the air supply, creating the negative pressure, but it extracts the largest lead particles because of its location as well. Because it does contain lead dust, all exhaust air must be filtered in accordance with the requirements of the United States Environmental Protection Agency.

Vents behind the target area will recirculate the non-exhausted air, combining it with supply air from outside. As a general rule, supply air should be 10% less than exhaust air to maintain the negative pressure in the range. Additionally, a supply air ratio of 30% is recommended to prevent buildup of toxic gases such as carbon monoxide.

The ventilation system is without question an important part of protecting employees and shooters. Equally important, however, are the series of filters used in the air handling unit (AHU).

The Importance of Filtration

Despite bringing in supply air from outside, filtration of both exhaust and recirculated air is absolutely imperative. The exhaust air, if not filtered properly, will release lead particles and toxins into the neighboring environment. The recirculated air needs to be filtered to both remove recirculating lead particles as well as prevent outside contaminants from supplied air from finding their way inside the HVAC system and range.

All exhaust and recirculated air *must* be filtered according to local, state, and federal law. Many states require 99.97% High Efficiency Particulate Air (HEPA) filters, but not all do. The Institute of Environmental Sciences and Technology (IEST) recommends HEPA for all points of removal (IEST RP-CC001).

If a range's HVAC system is not equipped for HEPA filters and HEPA is not required by law, there are 99%+ high efficiency filters that meet performance standards. Still, CLARCOR Air Filtration Products – like IEST and the NRA – recommends using HEPA filters.

HEPA and high efficiency filters are expensive and not intended to handle large particles, which will damage the fragile media and render the filter useless in removing lead dust. Because of this, it is recommended to place upstream at least one pre-filter for exhaust air and a prefilter and secondary filter for recirculated air. NAFA recommends a pre-filter with a minimum efficiency reporting value (MERV) of 7; CLARCOR Air recommends a MERV 8. Secondary filters should be at least a MERV 14. While pre-filters and secondary filters will need more frequent change-outs, the cost savings by replacing them instead of the significantly more expensive high efficiency filters is sizable.

Lastly, CLARCOR Air Filtration Products recommends gaskets on the filter sides and face to eliminate any potential bypass or leakage of lead dust.

When to Change Filters

Changing filters when needed is every bit as important as having the right filters in place. If filters are saturated with dust and particles, they cease to adequately provide the function of maintaining clean air. Additionally, the increase in resistance will increase energy costs.

The National Air Filtration Association (NAFA) and CLARCOR Air Filtration Products recommend – because of the dangers of lead at gun ranges – changing a filter when its initial pressure drop doubles. Measuring pressure drop can be done in different ways, the easiest being to install a differential pressure gauge with the HVAC system.

There is no standard amount of time to change out filters. While change-outs may become predictable based on time, this is not the recommended practice for a variety of reasons, including but not limited to filter damage, time of year, and how busy the range is. A differential pressure gauge is highly recommended for minimizing energy costs and maximizing safety.

For OSHA-regulated practices when handling lead, refer to OSHA Standards found here:

http://www.osha.gov/SLTC/lead/index.html

While a range can effectively service itself, many choose to hire a full service indoor gun range maintenance company to both change filters and clean the facility.

Proper Disposal of Filters

Because HEPA filters from indoor firing ranges contain dangerous quantities of lead particles, they are considered hazardous waste and must be handled and stored in accordance with regulations in the Resource Conservation and Recovery Act (RCRA).

For more information on proper disposal of the hazardous lead waste at a firing range, please contact the appropriate state agency found here:

www.epa.gov/osw/wyl/stateprograms.htm

Purolator™ Filter Solutions for Indoor Gun Ranges

CLARCOR Air's Purolator brand possesses an ample product line with cutting edge technology to fulfill any range's filter needs. Please see the chart on the next page for Purolator's range of applicable and recommended products for high efficiency, secondary, and pre-filters.

Thank You and Be Safe

For more information about CLARCOR Air Filtration Products, please contact a local distributor, visit www.clcair.com, or call us at 1-866-925-2247.

Purolator™ Filters for Indoor Gun Ranges with Recirculating Ventilation

HEPA and High Efficiency Filters

The most efficient, and thus expensive, filters in the ventilation system. All HEPA filters are tested individually to ensure that the quality matches or exceeds the necessary requirements, and each filter delivered includes a copy of its unique test results.

Purolator recommends the HEPA and high efficiency filters in the table to the right. More models are available upon request.

Name and Depth	Initial Pressure Drop	Efficiency Rating**
Ultra-Cell LR*(12”)	1.0	99%+
Ultra-Cell V (11.5”)	1.2	HEPA
Ultra-Cell 2000 (11.5”)	1.35	HEPA

*Efficiency ratings based on percentage removal of particles .3 microns or greater

**Ultra-Cell LR is a high efficiency filter but not HEPA certified; not applicable where HEPA is required by law

Secondary Filters

Imperative for prolonging the useful life of the HEPA filter, secondary filters at indoor gun ranges have an industry minimum recommendation of MERV 14.

The table to the right contains Purolator’s recommendations for secondary filters. More models are available upon request. Purolator specifically recommends the Dominator filter, made with proprietary E-pleat® technology; no other filter on the market for this application measures up to the Dominator’s low initial pressure drop and high efficiency, significantly reducing energy consumption and costs while outperforming its competitors. Available in 4” depth for tight spaces.

Name and Depth	Initial Pressure Drop	Efficiency Rating
Dominator (12” Box)	.28	MERV 15
SERVA-Cell VA (12”)	.37	MERV 14
Dominator LoadTech (4”)	.43	MERV 14
SERVA-Cell (12”)	.65	MERV 14

Pre-filters

Lastly, CLARCOR Air recommends a minimum MERV 8 pre-filter. With its selection of pre-filters, Purolator is the one-stop-shop for indoor firing ranges.

The most cost-effective solution for one system is not always the best option for others. Purolator recommends wire-back pleats in indoor gun ranges, but fully incinerable, self-supporting pleats are available upon request as well.

At the table to the right, Purolator recommends wire-back pleat pre-filters for an indoor gun range with recirculating ventilation.

Name and Depth	Initial Pressure Drop	Efficiency Rating
Defiant Mark 80-D (2”)	.19	MERV 8
Hi-E40 (2”)	.22	MERV 8
PAF 11 (2”)	.30	MERV 11
Puro-Green 13	.37	MERV 13

All performance data is based on the ASHRAE 52.2 Test Standard. Based on a test velocity of approximately 500 fpm for a 24x24 filter.

Sources and References:

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Self-Reported Gun Ownership in US is Highest Since 1993, Lydia Saad, Gallup, 2011

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Recommended Practice Guidelines: Firing Ranges, National Air Filtration Association, Training Education Certification

Workshop on Indoor Shooting Ranges: Responsible Care of Range Environment, World Forum on the Future of Sport Shooting Activity, 2005

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