Indoor Firing Range Ventilation System

In the design of a ventilation system for an indoor firing range, complete purging of the air is the prudent choice

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Over the past couple of years, indoor firing range design has evolved into a delicate science. Indoor ranges offer many advantages to law enforcement agencies such as protection from the elements and use of a controlled environment. However, these ranges present many health problems due to high lead exposure and improper ventilation.[1] Designers must consider the codes and regulations of many government agencies, particularly the Occupational Safety and Health Administration (OSHA). Because of the increased public awareness of lead poisoning and contamination, the mechanical engineer has to direct most of his attention to designing the ventilation system.

Designing the system

The primary purpose of the ventilation system is to prevent the build-up of noxious gases (CO_2, CO, NO) and exhaust the range of any particulates, such as lead.[2] Although lead comprises less than 10 percent of the total particulate generated, it is 100 times more toxic than any other element found in firing ranges. The primary source of the lead dust is from the bullet primer, which contains 25 to 30 milligrams of material, of which approximately 35 percent is lead styphnate and lead peroxide. Other sources of lead generation are from vaporization due to the heat of explosion and fragmentation of the projectile due to misalignment as it passes through the weapon after being fired. Airborne lead is also generated at the trap but is only a small percentage of the total and usually never reaches the shooter.

OSHA does not specifically have any regulations for ventilation of indoor firing ranges; however, the regulations for an indoor working environment apply. The lead exposure limit is 50 micrograms per cubic meter over an eight hour time-weighted average. The EPA lead exposure limit for air discharged into the atmosphere is 1.5 micrograms per cubic meter taken over a quarterly arithmetic average, which is based on 16 samples taken within a three-month period. Designers should be aware of these limits when considering different filter equipment.

Exhaust grilles at the apex of the bullet trap.

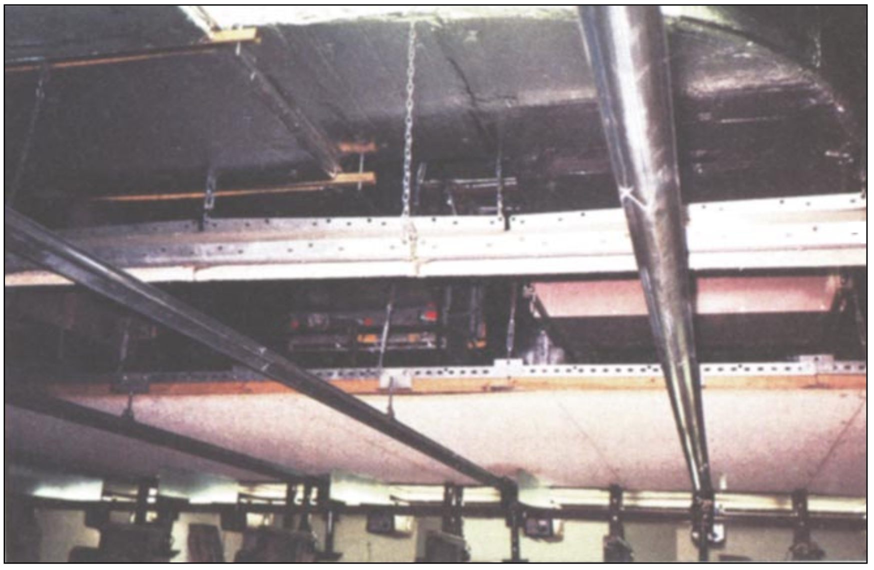
The National Institute for Occupational Safety and Health (NIOSH) is the investigative arm of OSHA. Over 17 years ago, NIOSH conducted a study of lead exposure in indoor firing ranges and released a publication titled "Lead Exposure and Design Con-

[1] *Superscript numerals refer to the references listed at the end of this article.*

siderations for Indoor Firing Ranges," which contained different design suggestions based on evaluations of existing ranges.[1,2] This report has mistakenly become gospel for some manufacturers. It is important for designers to realize that NIOSH is not a standards-making organization, although many companies would like you to believe this. NIOSH merely makes recommendations to OSHA. Much of what NIOSH recommends is, by its own admission, without scientific backing and based on incomplete data. Therefore, the mechanical engineer should carefully review this report when considering different filter equipment.

Exhaust vs. recirculate

The main design consideration is whether to exhaust 100 percent of the air or recirculate a percentage of it. A purging system is one that uses 100 percent outside air and exhausts all air to the environment. A recirculation system typically uses 75 percent of the air over again. The obvious cost savings in recirculating the air, especially during the cooling season, have to be carefully weighed against the health and safety considerations of the range users. After visiting many indoor ranges with various systems, I have concluded that purging the air is the safer choice. This opinion is based on the premise that expensive filter equipment used in recirculation does not always live up to advertised efficiencies. These safety risks, combined with the threats of being closed down by the government and future lawsuits, makes purging an attractive choice. It is difficult to justify recirculation simply to keep shooters more comfortable during the brief periods they spend on the firing line. However, a purging system necessarily means exceeding the statutes concerning energy conservation and does not guarantee clean air. There have been occurrences of excessive lead in range personnel when purging was used.



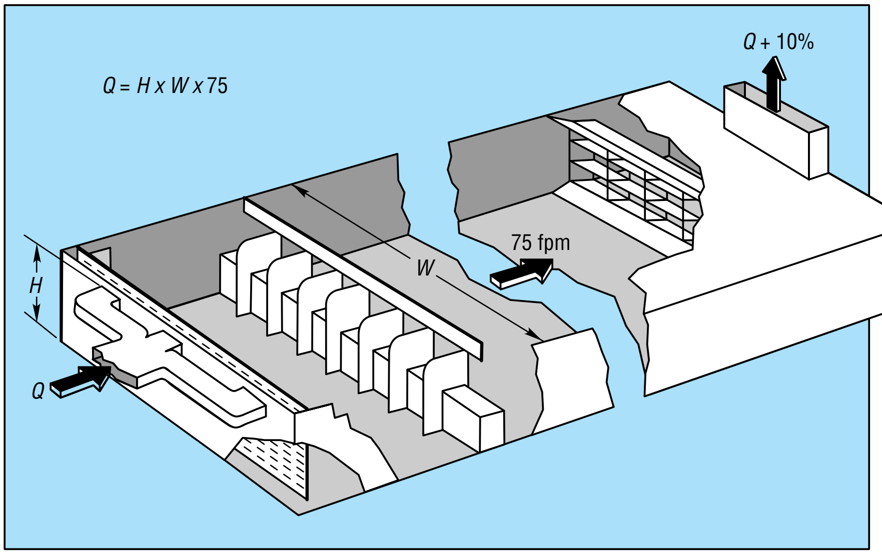
Ductwork for supply air in ceiling.

Electrostatic precipitators.

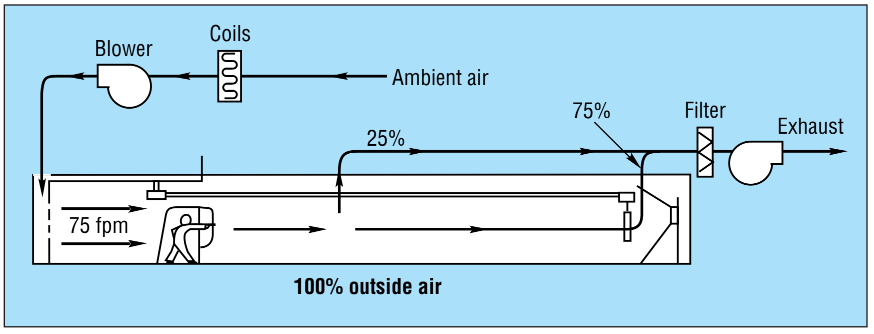
In either case, all exhaust and recirculation air must be heavily filtered. A specific maintenance schedule or contract should be set up to insure that filters will be taken care of on a periodic basis. An electrostatic precipitator is frequently used in filtering lead from the range. This type of high-voltage filter works by imparting a negative charge to the particles in the air stream, causing them to stick to the positively charged collector plates.[3] Vibrating or rapping the collector plates causes the particles to fall into a dust hopper. Most precipitators work with velocities up to 600 fpm. The advantages of this type of filter are that the pressure drop is negligible and collection efficiency is high and nearly uniform regardless of particle size. However, there are also many disadvantages. The cost of this filter is extremely high due to the high-voltage electrical equipment. The units are very heavy and take up much more space than conventional filter units. Precipitators tend to be sensitive to air changes that can affect efficiency. Also, under certain conditions, precipitators can generate considerable amounts of ozone. The biggest disadvantage, compared to other filters, is the maintenance. The collectors have to be taken out of the unit and cleaned periodically by trained personnel. Also, electrostatic precipitators frequently experience technical problems that result in lost efficiency of particle removal and costly repairs.

The high-efficiency particulate air (HEPA) filter is another popular type of filter used in firing ranges. The principle of collection is basically a microfiber paper that the air is passed through. This filter is 99.97 percent effective in removing 0.3 micron diameter particles. The federal government has established this size particle as the industry standard because it is the most difficult to remove from the air stream. Manufacturers should rate their filters based on dioctyl phthalate (DOP) testing performed in accordance with the Army Arsenal Instruction Manual 136-300-175 using cold DOP smoke particles.

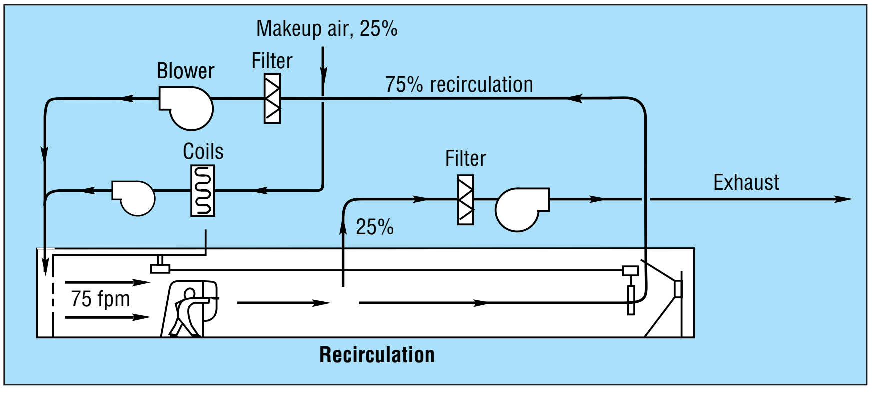
The advantage of the HEPA filter is its effectiveness in removing particles and its easy installation. The disadvantage is the high static pressure associated with this type of filter. The filter cannot be cleaned and must be replaced periodically, depending on the use of the range. This can be quite costly since the average HEPA filter can be up to 20 percent more expensive than a standard pleated flat filter. If designed properly by the manufacturer and the engineer, both HEPA filters and electrostatic precipitators can meet the standards set by the various government agencies.



1 Average amount of air required per shooting station.



2A In a 100 percent exhaust system, 25 percent of the air should be exhausted 15 ft downrange of the shooting station while the remaining 75 percent is exhausted at the apex of the bullet trap.



2B In a recirculation system, 75 percent of the air is returned from the bullet trap.

Recommendations

The American Conference of Governmental Industrial Hygienists (ACGIH) and other publications suggest that the optimum ventilation rate at the firing line should be 75 fpm with a minimum of 50 fpm.[2,4,5] This seems to be a good medium. If air velocity is increased, there may be too much turbulence in the breathing area of the shooter. If velocity is decreased, contaminants may not be moved out the shooter's breathing zone fast enough. Designers should note that an even distribution of the air across the range is important to establish a full sweep of air.

The average shooting station has a cross sectional area of 32 sq ft (8 ft height by 4 ft width). Using the suggested velocity, 75 fpm × 32 sq ft = 2400 cfm, which is the average amount of air required per shooting station (Fig. 1). This

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greatly increases the air required for the range as compared with conventional buildings. NIOSH recommends an air flow pattern originating 15 ft behind the shooter that will cause a horizontal air stream from floor to ceiling at the firing station.[1,2,6] The range should be kept at a slightly negative pressure to prevent the escape of contaminants to adjacent areas. To achieve this, the exhaust air should exceed the return air by about 10 percent. In keeping with decontamination, all surrounding office areas and the control room should be kept at a slightly positive pressure. Most publications suggest that 25 percent of the air be exhausted 15 ft downrange of the shooting stations while the remaining 75 percent is exhausted at the apex of the bullet trap as shown in Fig. 2A. In recirculation systems, 75 percent of the air should be returned from the bullet trap as shown in Fig. 2B. The controls for the supply and exhaust fan should be interlocked at their set speeds to avoid any error in turning on one system without the other. The ventilation system, especially exhaust outlets, should be totally isolated from any of the other systems in the building to prevent contamination.

An easy solution to the lead exposure problem is to change the type of ammunition used. When bullet primers are used that do not contain lead, the reduction in exposure was found to be a factor of 10.[7] Clean weapons used with copper-jacketed bullets also reduce lead hazards.[8] However, human error dictates that this ammunition may not be used at all times and should not be a consideration in the design of the ventilation system.

Conclusion

Shooting range ventilation warrants serious consideration by the engineer. Harmful gases and lead exposure present health hazards to range personnel that must be dealt with.

At this time, government regulation is inconclusive and without scientific backing. However, there are several design recommendations that can keep lead exposure to a minimum if implemented correctly. Mechanical engineers must make a careful analysis of their applications and choose between recirculating the air or using 100 percent outside air. Filtration plays a big role in the success of the range and must meet the standards of OSHA and the EPA. However, following some simple design considerations, it is still possible to plan an indoor firing range that will be safe for all to use. Ω

References

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