NAFA®
National Air
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Association

Guidelines

Recommended Practices for

Filtration for Welding Fumes

Cynthia Farmer | Dreamstime.com

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*, 5th Edition.

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Appendix One: Racetrack Air Circulation

Filtration for Welding Fumes

Purpose

This best practice establishes air filtration guidelines for the removal of particulate and gaseous contaminants from the immediate breathing zone of employees engaged in the process of welding. Filtration guidelines for general ventilation, when applicable, are also addressed.

Scope

This best practice provides selection criteria in ventilation methods and filter selection in recognition of recommended practices and procedures.

Background

Fumes are aerosols formed by the condensation of vapors of solid materials. Welding fumes are a combination of solid, liquid and molecular particles originating from welding consumables, primarily the oxides of the metals involved and any coating present on the base metal. Molecular contaminants produced during the welding process may also be produced by the effects of process radiation on the surrounding environment. Researchers have determined that while fume size differs with process variables, welding fumes and molecular gases produced by welding are consistently in the sub micrometer range.

This best practice guideline covers fume control exposure limits along with recommendations for source capture, along with three criteria methods of control for welding fumes:

A. Recommended Source Capture
B. Exhaust System Method
C. Filtration Method
D. Operation and Maintenance

Fume control and exposure limits - Cognizant Organizations

Based on the EPA's "Tools for Schools" program, "…all schools should have a minimum filtration efficiency of MERV 8 in all HVAC applications."

Filter Efficiency

The Occupational Safety & Health Administration does not currently regulate welding fumes. Welding fumes and compounds that form its component parts must not exceed certain concentrations in a workers breathing zone. These concentrations may be expressed in different ways.

- OSHA sets standards for exposure to various chemical contaminants best known as permissible exposure limits (PEL), which are based on a time weighted average (TWA). This limit is defined as the average value of exposure over the course of an eight hour work shift. It can be expressed in parts per million (ppm) or in mg/m3. Some PEL's designated by a ceiling limit (C) control the amount an individual may be exposed to at any one time. A complete list of the limits for compounds such as nickel, chromium, cobalt and manganese can be found at www.osha.gov and reference OSHA1910.1000. For the compounds shown above, the TWA is 5 mg/m3.
- ACGIH-The American Congress of Governmental Industrial Hygienist also lists values of allowable exposure with a threshold limit value (TLV). These are guidelines are based on 8 hours of exposure and they may or may not be the same recommended level as OSHA.
- NIOSH-National Institute of Occupational Safety and Health has established a recommended exposure limit (REL) for welding fumes (and total particulates) of the lowest feasible concentration. NIOSH considers welding fumes potential occupational carcinogens [NIOSH 1992].

When designing a system it is essential that the system can control these toxic compounds to recommended or required levels. Since these levels can change, NAFA recommends checking OSHA, State or local regulations for the most updated information.

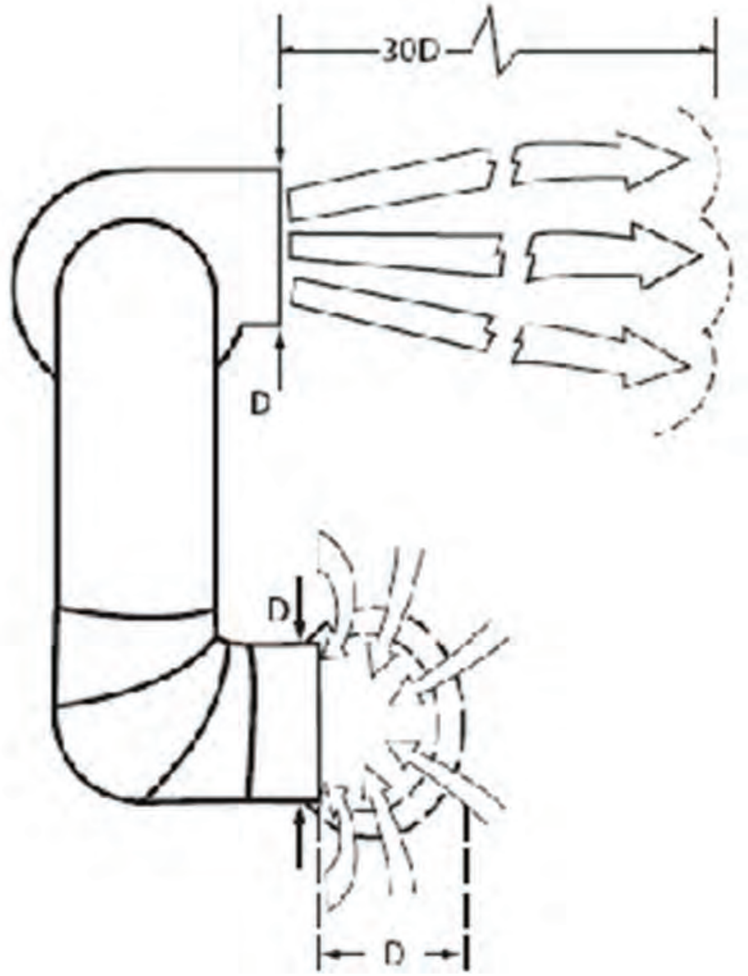
Welding Fume Control:

Exhaust System Method and Genral Air Cleaning Method

Air cleaning for welding operations can be achieved mainly through either exhaust systems or general air cleaning and each may or may not involve source capture.

Source Capture

The source capture method of removal is generally the best method of capture as it removes airborne contaminants at the point of generation, and more effectively removes them from the breathing zone of the operator. Stationary, mobile or portable source capture systems may consist of the following basic elements; capture hood, duct system, air filter, fan and exhaust ductwork. These elements must be specifically engineered for each application, but the distance between the capture hood and the point of fume generation should generally be no more than 1 times the duct diameter of the capture hood. (See Figure 1.)



Blowing
Approximately 10% of face velocity at 30 diameters from outlet.

Exhausting
Approximately 10% of face velocity at one diameter from outlet.

Figure 1: Standard mechanical formulas for determining effective air velocity and capture distance of air from or to a conduit.

Figure 2: Source capture method – downdraft welding bench. Courtesy Plymovent North America

Exhaust System Method

Exhaust systems involve the removal of air that contains welding fumes and molecular contaminants from a facility directly to the outdoor environment.[1] While seemingly inexpensive, this method can pollute the surrounding environment and may violate local or state regulations, can negatively affect the air balance in a building, and creates a need for conditioning (heating or cooling) all air that is brought into the facility to equal the air removed (makeup air). The energy cost of conditioned makeup air can make this method far more costly than either general air cleaning or source-capture air cleaning.

Exhaust systems may be a large exhaust fan pulling air away from the welding operation and out of the facility, a booth or canopy over the work designed to pull fumes upward, a welding table, specially designed to pull air across the welding work surface and exhaust it, or a source capture hose with hood specifically designed to be positioned at the welding spot to pull fumes and gases off of the work.

[1] American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) 1999 Handbook, Chapter 20

Air Cleaning Method - NAFA - Recommended Best Practice
Recirculated Exhaust Air: Exhaust air from a welding operation may be re-circulated in a work area under the following conditions:

A. The recirculation of air is in compliance with the regulatory authority or the authority having jurisdiction.

B. The exhaust air is cleaned by passing it through a highly efficient filter MERV 16 (HEPA filtration efficiency tested to MIL Std. 282 to achieve 99.97% on 0.3 micrometer particles of thermally generated DOP or suitable substitute challenge).

C. Gases that cannot be removed by molecular filtration do not exceed acceptable limits.

D. Components to be welded and materials used in the welding process are not prohibited.

General Air Cleaning Method

The general air cleaning method must create enough air changes per hour to overcome the amount of contaminant being generated. Depending on the type of welding being done, 10 to 25 or more air changes per hour may be required to maintain desired levels of contaminant removal. The advantages of this method over source capture methods include the elimination of a need for source capture hoods, ductwork, and the associated effect on the gas shielding and weld integrity. Conversely, a larger amount of air movement and air cleaners is required and this method does not directly remove the contaminant out of the welders breathing zone.

Filtration in the general air cleaning method should be multiple stages including molecular filtration, with the final stage of particle filtration being a MERV 15 filter to address a mean particle size of 0.4 microns. The General Air Cleaning Method normally uses air cleaners suspended from the ceiling or mounted on sidewalls and arranged in a "racetrack pattern" of air movement. (See Figure 3.) This method entrains the contaminant as they rise and blows them to an adjoining cleaner thus providing proper removal of particulate and molecular contaminants. Another method involves placing a large stationary capture hood directly over the welding operation to capture fumes as they rise from the work.

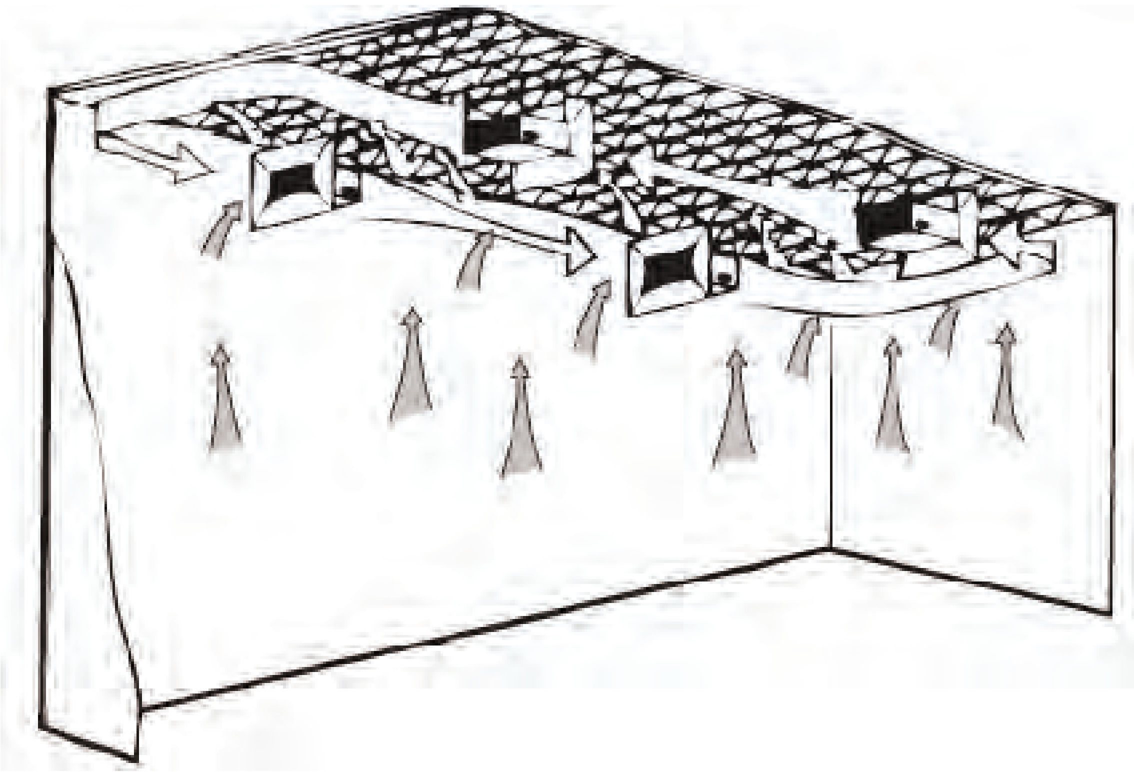


Figure 3: Description of racetrack method of general air cleaning using air cleaners suspended from the ceiling.

Note: Rising contaminant plumes are entrained by aspiration and carried to "capture zones" near each air cleaner inlet by the closed-loop recirculating airflow pattern.

See Appendix One for a detailed drawing and formulas for Racetrack Air Circulation.

Figure 4: Source Capture Arm for Exhaust Ventilation. Courtesy Plymovent North America

Welding Source Air Cleaning Method

As mentioned earlier, source capture of welding fumes is the best method of removal. Connecting a source capture hood to a flexible duct which is suspended over the welding source allows for direct removal. Attaching this duct to air cleaning equipment (either stationary or mobile) then allows for removal of contaminants and recirculation of this air. Downdraft or sidedraft welding tables also offer direct removal of fumes with somewhat less mobility.

Mechanical Filter Removal Equipment:

Mechanical filtration removal equipment describes those devices using fiber and/or fabric filters that, because of their high efficiency on particles, remove particulate contaminants to acceptable levels. Progressive filtration describes the use of several filters in a system, each having a higher efficiency than the one previous to it. This allows larger particles to be removed by lesser priced filters, thus providing longer life to those filters with the highest efficiencies.

Single pass progressive filtration commonly uses spark arrestor deflectors to prevent fire hazards in the first part of the system. The first-stage disposable filter should be a minimum MERV 6 to remove the largest of particles.

Intermediate stages of filtration should utilize MERV 15 filters unless welding specific metals containing chromium, nickel, or other regulated compounds. In these instances the use of a HEPA filter must be used as a final filter.

Figure 5: Progressive filtration unit with spark arrestor, MERV 14 filter and HEPA final filter configuration. Courtesy Plymovent North America

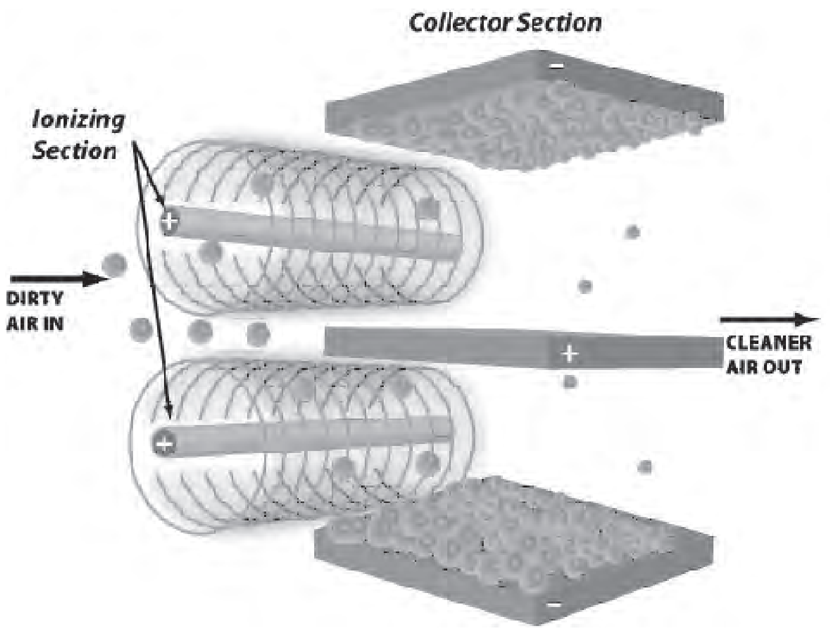


Figure 6: Two-stage electrostatic precipitator (also called an electronic air cleaner). Courtesy Honeywell

Typical filters used for mechanical filter removal equipment listed in their progressive order include combinations of metal washables (used as spark arrestors), pleated filters, pocket filters, cartridge filters or cell-style filters, molecular filters, HEPA filters.

Large volume airflow systems - in excess of 2000 CFM – may be single pass, self-cleaning cartridge filters. These systems use "Reverse Pulse Air Cleaning" to extend the filter life. Such filters are designed to allow formation of a heavy filter cake to increase filter efficiency, and may come with a pre-coat powder (see System Integrity below). Refer to the manufacturer's literature for the final change-out point.

Electrostatic Precipitator

This filtration device uses a multiple stage process to clean the air for re-circulation into the environment. Electrostatic precipitation describes the use of an ionizing section that creates a highly charged corona of air that imparts a charge to the incoming particles, and a collector section with oppositely charged plates that capture the particle by positive/negative attraction.

The efficiency of this collector type depends on the velocity of the air passing through the filter, (slower flow yields higher efficiency), collector plate spacing, and the magnitude of the imparted ionization charge. In addition, the efficiency of this filter type depends on the maintenance interval in which the collector plates are pulled and cleaned. The unit has the highest efficiency when the plates are completely clean. For air that is being recirculated, it is recommended that a double-pass system – two collector sections – be used to assure complete capture of particles.

Molecular Filtration

Molecular Filtration filters such as activated carbon may be included to remove specific molecular contaminants determined with the welding process. Standard activated carbon filters are most commonly used, but there may be instances where a treated carbon or other specialty media should be used to remove specific molecular contaminants. This is determined by the welding process. For proper molecular filtration selection please contact a NAFA Certified Air Filter Specialist (CAFS).

Operation and Maintenance of Welding Fume Removal Systems:

Installation of Filters:

Refer to the manufactures instructions when installing or replacing filters. As a supplement, the NAFA Installations, Operation and Maintenance of Air Filtration System, 2nd Edition text may be referenced. Use of filter types and efficiencies other than those designed for the removal system may result in improper airflow or malfunctions.

System Integrity

Start up and maintaining the collector system's integrity is vital to proper air filtration. Certain systems and system manufacturers, usually those using a cartridge filter system and reverse pulse cleaning, may recommend that certain types of filters be pre-coated using recommended pre-coat powders to enable a filter cake to form over the filter surface area which increases the minimum efficiency of the filter to higher levels and helps prevent bypass of smaller particulates. Pre-coat powders can also extend effective filter life in certain applications. Follow the manufacturer's recommendations for this procedure.

Mechanical air filter efficiency is determined by testing to ANSI/ASHRAE Standard 52.2 method of test. This testing provides the user with a Minimum Efficiency Reporting Value (MERV) referenced in this Guideline. Results of independently tested filters should always be obtained to assure they meet system requirements.

Maintenance

A preventative maintenance program should be in place and should include inspection of the filter holding device and gaskets to ensure a correct and secure fit of the filters. Replacing damaged or defective gasketing will help keep air from bypassing filters.

As mechanical filters become loaded with contaminants, the resistance to air flow through the filter increases. This resistance, known as "pressure drop" should be monitored by a pressure sensing device, such as a red oil manometer or mechanical dial-and-pointer gauge. Reverse pulse systems are typically designed to initiate a cleaning sequence when pressure drop reaches an upper control limit and continue to pulse the cartridges until pressure drop reaches the lower control limit. When the pulse cleaning operation no longer lowers filter resistance to the lower control limit or when the filters reach a manufacturer's recommended maximum pressure drop, filters should be replaced.

If the system is fitted with a reverse pulse compressed air cleaning system, check to ensure the manufactures recommended pressure settings are correct and that the compressed air valves are functioning. This ensures the filters will be cleaned within the design specifications and extends the life of the filters. Filter life may vary significantly with the type of application and filter media used.

Molecular Filtration

Molecular filters, when operated properly, will not materially increase in pressure drop over time and effective life cannot be measured by differential pressure gages. Particulate filters that are impregnated with a molecular filter substance may need to be replaced due to high resistance to airflow whether or not the molecular filtration is still effective. Service life of molecular filters are a function of types and concentration of contaminants, filter design, adequacy of prefiltration, and amount of molecular filtration substance exposed to airflow. Most manufactures of this type of filter offer testing services to determine remaining filter service life. It is important to note that as the media life decreases, so does the efficiency of the molecular filter. Most molecular filters are changed out before the media reaches 100% saturation.

Filter Disposal

When welding typical metals, most welding fume materials captured by mechanical or electrostatic precipitators can be disposed of in regular landfills. When in doubt, it is always prudent to check with local, state, and federal regulations, especially when welding those materials described in this Guideline as having highly toxic byproducts.

Special Precautions and Employee Protection

NAFA recommends that all employees follow the OSHA Code of Federal Regulations Chapter 29 part 1910.134 which provides completes guidelines for respiratory protection. Additional protective measures including personal protective equipment is covered in OSHA 29CFR part 1910.252 – 1910.255.

If installing filters in a large dust separator, where entry is required, it is necessary to follow OSHA's guidelines with regards to Confined Space. Strict adherence to OSHA's lockout/tag out guidelines while servicing large dust separators must also be followed.

Summary

Any fume and particulate local exhaust system used in the control and removal of weld fumes must be sufficient to remove the contaminant from the breathing zone of the welder and the surrounding employee working environment. The system design must remove fume contaminant while not disturbing the welding process in accordance with the manufacturer's recommendations.

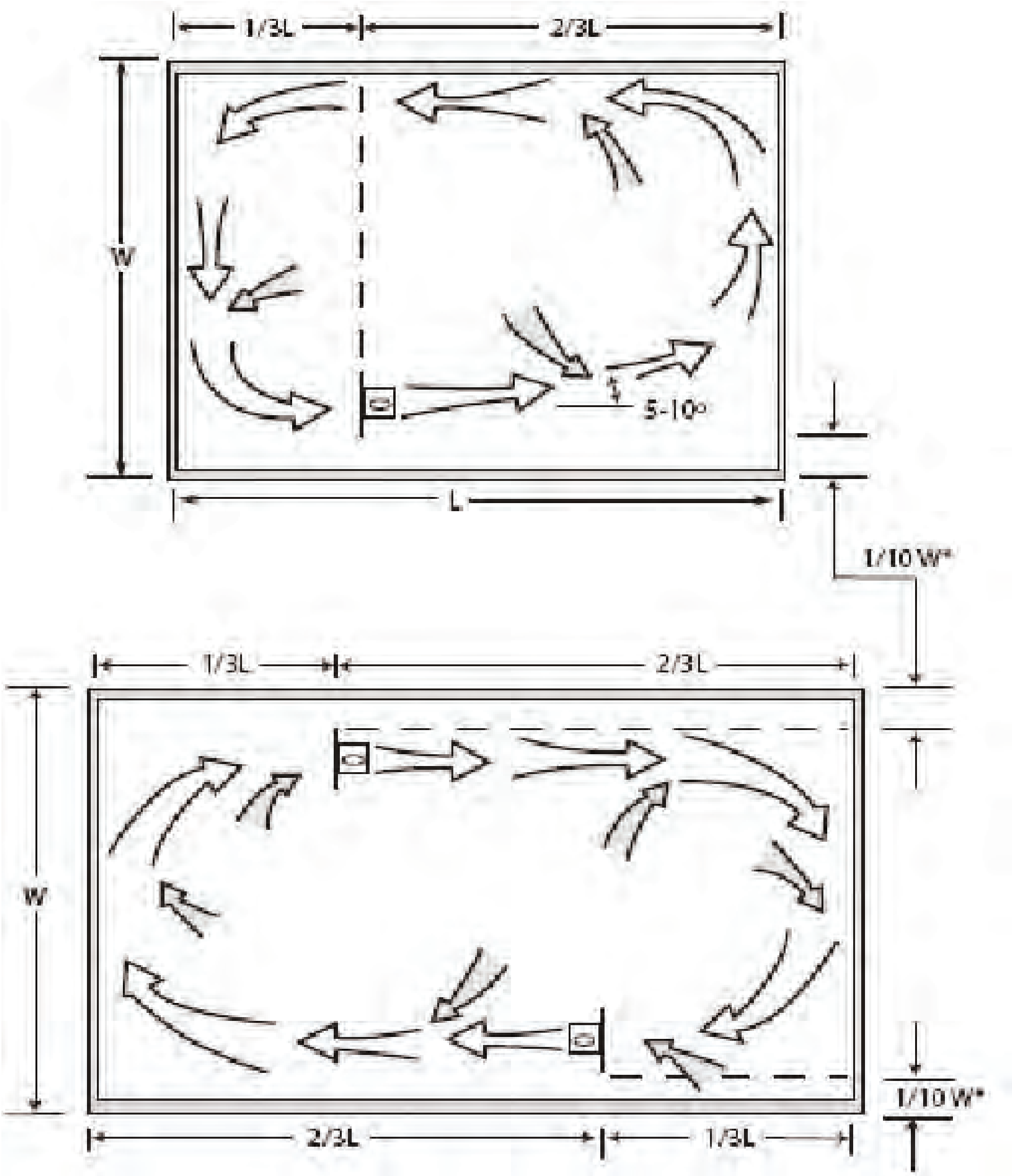
In order to help meet accepted exposure limits, NAFA recommends that the efficiency potential of filters and/or filtration devices is documented by independent testing. However, adequate performance of a filter or collector even with appropriate ventilation engineering, does not guarantee a safe work environment and the real-world performance of various collectors and filtration systems in use may materially differ from laboratory testing of similar devices. For these reasons, employee-occupied areas should be tested to ensure compliance with relevant regulations.

Existing exposure limits are subject to change because these values are constantly under review and amended as technological advances, medical knowledge and more data becomes available.

Appendix One

Detail of Race Track Air Circulation

Basic concept of the peripheral flow recirculating air pattern for unducted air cleaner installations.



Inlet flange edges should not be more than 5 ft. from wall, regardless of shop width (W).

Note: Rising contaminant plumes are entrained by aspiration and carried to "capture zones" near each air cleaner inlet by the closed-loop recirculating airflow pattern.

Glossary

ACGIH:American Conference of Governmental Industrial Hygienists.

ACH: Air Changes per Hour.

C-Ceiling Limit: Maximum exposure limits at any one time.

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

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

DOP: Dioctlyphthalate.

FPM: Feet per minute; a measurement of the air velocity used in calculating CFM requirements.

HEPA: High Efficiency Particulate Air.

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; United States.

PEL: Permissible Exposure Limits; standard levels set by government regulations.

PPM: Parts Per Million.

PRP: Personal Respiratory Protection.

TWA: Time Weighted Average.

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