WaterSense at Work

Laboratory and Medical Equipment

7.5 Fume Hood Filtration and Wash-Down Systems

Best Management Practices for Commercial and Institutional Facilities

EPA WaterSense

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WaterSense® is a voluntary partnership program sponsored by the U.S. Environmental Protection Agency (EPA) that seeks to protect the nation's water supply by transforming the market for water-efficient products, services, and practices.

WaterSense at Work is a compilation of water efficiency best management practices intended to help commercial and institutional facility owners and managers from multiple sectors understand and better manage their water use. It provides guidance to help establish an effective facility water management program and identify projects and practices that can reduce facility water use.

An overview of the sections in *WaterSense at Work* is below. This document, covering water efficiency for fume hood filtration and wash-down systems, is part of **Section 7: Laboratory and Medical Equipment**. The complete list of best management practices is available at www.epa.gov/watersense/best-management-practices. WaterSense has also developed worksheets to assist with water management planning and case studies that highlight successful water efficiency efforts of building owners and facility managers throughout the country, available at www.epa.gov/watersense/commercial-buildings.

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Fume Hood Filtration and Wash-Down Systems

Overview

A fume hood is a ventilated enclosure where hazardous materials can be handled safely to limit occupant exposure. Fume hoods draw contaminants within the work area away from the user to minimize contact. Ductless fume hoods use filters to remove contaminants from the air before recycling the air back into the working environment. Ducted systems either discharge contaminated air directly to the outside environment or exhaust fumes through a filtration system to remove contaminants before the air leaves the building.

Laboratory fume hoods

Not all laboratory exhaust from fume hoods requires intensive treatment. Therefore, as a first step, a facility should determine if treatment is needed prior to exhausting fumes back into the work environment or through the building ventilation system. Dry exhaust fume hoods use a fan to draw in air containing hazardous contaminants before expelling it without providing contaminant treatment. These systems might be appropriate depending upon the hazard level associated with the exhaust being ventilated. If minor treatment of exhausting fumes is necessary, a facility should consider using condensers, cold traps, or adsorbents such as activated charcoal, or neutralizing or converting toxic substances into other, less hazardous varieties. For example, ductless fume hoods can provide treatment of exhaust through use of activated charcoal or high-efficiency particulate air (HEPA) filters and return the treated air back into the work environment. These systems can reduce laboratory energy consumption compared to ducted fume hoods.

When dealing with certain hazardous substances requiring more intensive treatment (e.g., laboratory operations involving acid fumes, toxic materials, and perchlorate), a fume hood with a more specialized filtration system might be needed. There are two types of fume hood filtration systems typically used to handle hazardous substances: gas-phase filtration (includes wet scrubbers) and particulate filtration. Wet scrubbers require the consumption of water to remove hazardous substances. Other gas-phase filtration or particulate filtration systems might be suitable alternatives to wet scrubbers in certain circumstances, as discussed below. In all cases, laboratories should follow manufacturer instructions and facility health and safety guidelines in order to ensure safe operation of fume hoods.

This section focuses on fume hood filtration systems, including those that use water (e.g., wet scrubbers) and fume hood wash-down systems. It also describes systems that do not use water that could be considered as an alternative to wet scrubbers.

Fume Hood Filtration Systems

Depending on the fume hood and ventilation system design, the fume hood filtration systems can either be integrated into the fume hood or in a centralized location within the laboratory. For centralized filtration systems, exhaust air from each fume hood is directed to the filtration system through air ducts. In either instance, the filtration system provides treatment to the exhaust air prior to being released to the outside environment.

Wet Scrubbers

A wet scrubber uses a scrubbing liquid (typically water) to capture and trap hazardous substances that are exhausted from a fume hood. Contaminated air enters the scrubber system from below and passes through a packed bed. The packed bed is wetted from above with the water. As the contaminated air comes into contact with the water, water-soluble gases, vapors, aerosols, and particulates become dissolved. The trapped contaminants fall with the water and are discharged into a scrubbing liquor sump. This "scrubbing liquor" should be recirculated back though the scrubber with monitoring for saturation by the contaminants. All or some of the scrubbing liquor is removed periodically through a blowdown valve to control total dissolved solids, and make-up water is added as needed to replace water that is blown down or lost to evaporation. The treated air is released to the outside environment through an exhaust system. Mist eliminators installed in the discharge from the scrubber both prevent the release of the scrubber fluid and save water. See Figure 1 on the next page for a schematic of this process.[1]

Close the Sash

Many lab managers encourage users to close the fume hood sash when no work is occurring to reduce evaporation in the wet scrubber and reduce air loss from the conditioned laboratory space, thus reducing the energy required for heating and cooling. For laboratories with cooling towers, reducing the amount of conditioned air needed within a laboratory will reduce the cooling load, thereby reducing the tower's water consumption.

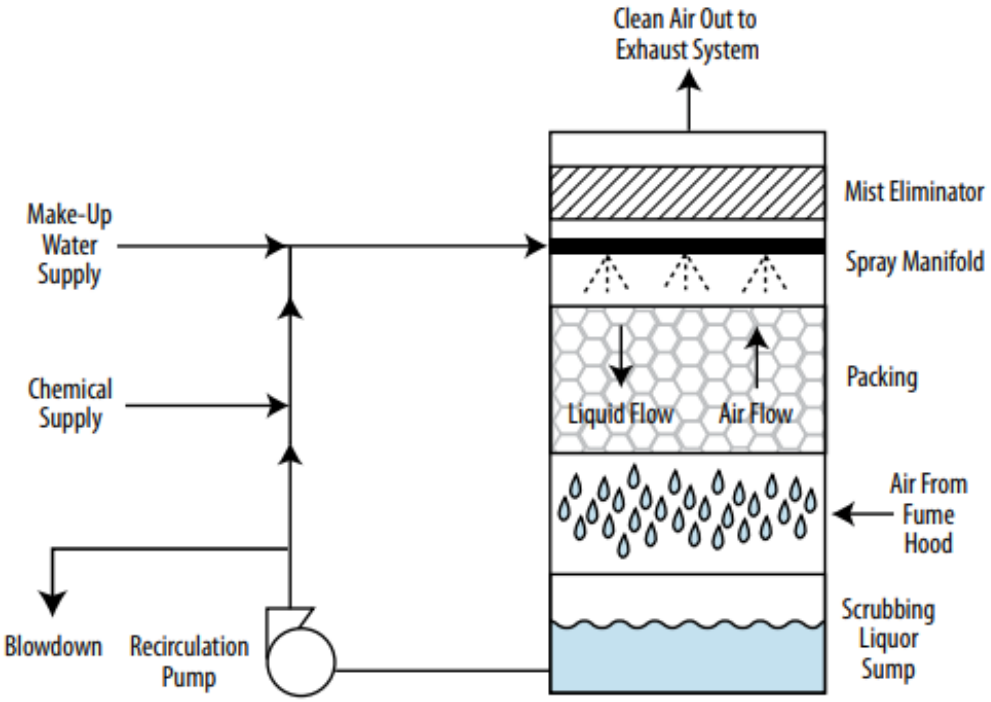
Other Gas-Phase Filtration

Besides wet scrubbers, there are two other basic types of gas-phase filtration systems for fume hoods: inert adsorbents and chemically active adsorbents, which do not require water use. Inert adsorbents include activated carbon, activated alumina, and molecular

[1] National Research Council. 2011. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version*. Pages 235-236. https://doi.org/10.17226/12654.

sieves. Chemically active adsorbents are inert adsorbents impregnated with a strong oxidizer, such as potassium permanganate.[2]

Figure 1. Fume Hood Wet Scrubber



Because contaminants build up in the adsorbent and can be desorbed if the concentration is too high or if the adsorbent has a higher affinity for another contaminant, the adsorbent bed and/or downstream exhaust must be monitored regularly to determine when to regenerate or replace the adsorbent. Adsorbent systems are not effective, however, in removing high concentrations of contaminants (e.g., spills inside the hood). Since these systems require a consistent check on contaminant concentrations and maintenance of the adsorbent, these factors should be taken into account when evaluating alternatives to fume hood wet scrubber systems, keeping in mind the contaminant and concentration that need to be removed to ensure that the hazard is fully abated.[3]

Particulate Filtration

If radioactive or biologically active materials or other hazardous particulates are present, a particulate filter might be necessary. HEPA filters are often used for this purpose. Proper procedures for changing filters should be taken into account to ensure the safety of occupants. If considering a particulate filtration system instead of a wet scrubber system, it is important to evaluate the contaminant and concentration that needs to be removed to

[2] *Ibid.*
[3] *Ibid.*

ensure that the hazard is fully abated. HEPA filters are often only recommended for highly toxic particulates that cannot be collected by scrubbers.[4]

The fume hood filtration systems discussed above are summarized in Table 1.

Table 1. Fume Hood Filtration Systems

Filtering Mechanism	How Does It Work?	How Are Contaminants Removed?	Does It Use Water?	What Are the Special Considerations?
Wet scrubber	Packed bed system that is wetted with recirculated scrubbing liquor captures contaminants from air and releases cleaned air.	Scrubbing liquor with dissolved contaminants is blown down and the liquor is periodically replenished with fresh water.	Yes	None
Inert adsorbents	Inert adsorbents such as activated carbon, activated alumina, and molecular sieves adsorb contaminants.	Spent adsorbent must be changed or regenerated regularly.	No	Adsorbent systems are not effective in removing high concentrations of contaminants (i.e., spills inside the hood). These systems require a consistent check on contaminant concentrations and maintenance of the adsorbent.
Chemically active adsorbents	Inert adsorbents impregnated with a strong oxidizer such as potassium permanganate react with and destroy organic vapors.	Spent adsorbent must be changed or regenerated regularly.	No	Adsorbent systems are not effective in removing high concentrations of contaminants (i.e., spills inside the hood). These systems require a consistent check on contaminant concentrations and maintenance of the adsorbent.
Particulate filtration	HEPA or other filters remove contaminants.	Filter must be changed regularly.	No	Filtration is useful for radioactive or biologically active materials or other hazardous particulates. HEPA filters are often only recommended for highly toxic particulates.

[4] *Ibid.*

Perchloric Acid Wash-Down Systems

Perchloric acid wash-down systems are a specialty fume hood used to remove perchloric acid, which tends to deposit on hood and ductwork surfaces. A laboratory using perchloric acid, a highly corrosive inorganic compound, requires a specialized fume hood identified by a label indicating suitability for use with perchloric acid procedures. These systems are constructed with special materials and equipped with their own ductwork, exhaust fan, and support systems. To prevent corrosion and reduce explosive perchlorate buildup, perchloric acid fume hoods use a system of nozzles to wash down the fume hood and exhaust system surfaces after each period of use, draining wash water to the sewer. Laboratories should follow instructions for wash-down provided by the manufacturer of the fume hood or facility health and safety guidelines, but might be able to minimize perchloric acid wash-down system water use by using automatic shut-off valves to limit the duration of wash-down time to only as long as necessary. Laboratories should design fume hood systems and ducts to minimize surface area, thereby reducing the amount of water needed for wash-down.[5,6]

Operation, Maintenance, and User Education

For optimum fume hood wet scrubber efficiency, consider the following:

- Turn off water flow when systems are not in use.
- Ensure water flow rate does not exceed manufacturer specifications.
- In recirculating systems, make sure the liquid level controller and water supply valve are functioning properly to avoid excess water overflow from the recirculation sump.
- In recirculating systems, calibrate the blowdown process so that it is sufficient to remove entrained contaminants, without being overly excessive. Control blowdown based on scrubber fluid chemistry, rather than allowing continuous blowdown or basing blowdown on a timer.
- Encourage users to close the fume hood sash when no work is occurring to reduce evaporation in the wet scrubber and reduce air loss from the conditioned laboratory space. For labs with cooling towers, safely reducing the amount of conditioned air needed within a laboratory will reduce the cooling load, thereby reducing the tower's water consumption.

[5] *Ibid.*, Page 233.
[6] Public Works and Government Services Canada. March 2006. *Perchloric Acid Fume Hoods and Their Exhaust Systems*. https://canadianscientific.ca/wp-content/uploads/2017/05/canadian-government-perchloric-acid-fume-hood-specs.pdf.

- Consider using onsite alternative water sources to supply water for use in the fume hood. See *WaterSense at Work Section 8: Onsite Alternative Water Sources* at www.epa.gov/watersense/best-management-practices for more information.

For optimum perchloric acid wash-down system efficiency, consider the following:

- Use systems only when necessary for perchloric acid handling.
- Consult with the equipment supplier to establish operating procedures to minimize runtimes and associated wash-downs, while still maintaining the necessary health and safety protocols.

Retrofit Options

There are currently not retrofit options available on the market to directly increase the water efficiency of fume hood filtration systems.

For facilities requiring a perchloric acid wash-down system, it might be feasible to retrofit the system with shut-off valves to control the duration of the wash-down cycle to only the length necessary to remove the contaminants. However, facilities should be sure to follow manufacturer-provided instructions for perchloric acid wash-down systems and facility health and safety guidelines to ensure that any changes will not affect health and safety or the performance of the system.

Replacement Options

When purchasing a new fume hood filtration system or perchloric acid wash-down system or replacing older equipment, consider the replacement options outlined below.

Fume Hood Filtration System Replacement

If replacing a wet scrubber system, be sure to size the equipment for the research tasks needed, incorporate a recirculating system for the scrubber fluid, and install mist eliminators.

Replacing an existing wet scrubber fume hood filtration system with a gas-phase filtration system to eliminate water use should only be done after careful consideration of occupant safety. Keep in mind the concentrations of contaminants that need to be removed to ensure the hazard is fully

Health and Safety Are the Priority

For laboratories using harsh chemicals and fume hood filtration and wash-down systems, health and safety considerations are the top priority. Facilities should follow appliable regulatory guidance in American National Standards Institute/American Society of Safety Professionals (ANSI/ASSP) Z9.5 *Laboratory Ventilation* and National Fire Protection Association (NFPA) 45 *Standard on Fire Protection for Laboratories Using Chemicals* when designing and operating laboratory ventilation systems and specifying fume hoods.

abated. Dry filters should not be used to replace a wet scrubber system if occupant safety will be compromised as a result.[7]

Perchloric Acid Wash-Down Retrofit or Replacement

For facilities requiring a perchloric acid wash-down system, consider a system with automatic shut-off valves, which limit the amount of water used during the wash-down process by controlling the duration of the wash-down cycle. Water savings will be dependent upon the reduction in wash-down cycle length and the flow rate of the wash-down sprayers.

Additional Resources

International Institute for Sustainable Laboratories (I2SL) and U.S. Environmental Protection Agency (EPA). May 2022. *Best Practices Guide: Water Efficiency in Laboratories*. www.epa.gov/system/files/documents/2022-06/ws-I2SL-Laboratory-Water-Efficiency-Guide.pdf.

National Research Council. 2011. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version*. https://doi.org/10.17226/12654.

Public Works and Government Services Canada. March 2006. *Perchloric Acid Fume Hoods and their Exhaust Systems*. https://canadianscientific.ca/wp-content/uploads/2017/05/canadian-government-perchloric-acid-fume-hood-specs.pdf.

[7] *Ibid.,* Page 236.

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