Laboratory Ventilation Terms & Definitions

Properly functioning ventilation is necessary to minimize chemical exposure risks for people working in laboratories. Nearly all laboratories have a local exhaust ventilation system comprising a local exhaust device (e.g., a fume hood), exhaust ducts, and exhaust fans located on the roof. All elements of the system must be synchronized and function properly to minimize chemical exposure risks for workers. Maintenance, testing, and repair are typically the responsibility of facilities staff (or a vendor) in consultation with a ventilation engineer, an industrial hygienist, or environmental health and safety staff. As a laboratory worker, you are likely to encounter terms associated with laboratory ventilation. Knowing the laboratory ventilation terms provided here and understanding the role of mechanical, electrical, and electronic control systems will enable you to recognize the limitations of the ventilation system, spot operational issues, and provide valuable feedback that is critical for those who maintain the system. Unless otherwise noted, most of these definitions are adapted (with permission) from *Laboratory Fume Hoods Explained: Chemical Containment – Exposure Control*.[1]

Airborne contaminants:

Airborne contaminants are classified as dusts, fumes, smoke, aerosols, mists, gases, or vapors.[2]

- **Aerosol:** Liquid droplets or solid particles that are small enough to remain suspended and dispersed in air, where they may be inhaled.
- **Dust:** Solid particles suspended in air that range in diameter from 0.1 µm to 25 µm. Dusts result from handling, crushing, grinding, etc. of organic or inorganic materials. Dusts with diameters of >5 µm typically do not remain airborne long enough to present an inhalation hazard.
- **Fume:** A fume forms when a volatilized solid condenses in cool air. Often the fume reacts with air to form an oxide. Fume particles are very fine; most are <0.1 µm in diameter.
- **Gas:** A phase of matter traditionally defined as taking both the shape and the volume of its container. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) defines a gas as a substance or mixture that at 50 °C (122 °F) has a vapor pressure >300 kPa (2.96 atm) or that is completely gaseous at 20 °C (68 °F) and a standard pressure of 101.3 kPa (1 atm).[3] Gases do not exist as liquids or solids at normal laboratory temperature and pressure.
- **Mist:** A suspension of finely divided liquid particles in the atmosphere resulting from mechanical force or other actions (nebulization). May be referred to as fog. Large and visible aggregates of many liquid molecules.
- **Smoke:** Smoke is the result of incomplete combustion when carbon-containing materials burn. Similar in size to a fume, the particles are <0.1 µm in diameter. Smoke may also contain wet droplets, depending on the fuel and the temperature.
- **Vapor:** Vapors are formed by liquids or solids that are volatile, by evaporation at room temperature. Vapor formation involves a phase change.

Air changes per hour (ACH): The number of times that air is theoretically replaced in a space during an hour. The optimal ACH is calculated based on factors such as heat load (room air temperature and the need for optimization of humidity) and control or dilution of fugitive chemical emissions.

Typical ventilation choices to consider when working with chemicals:

- no ventilation required (0 ACH);
- general laboratory ventilation (≥6 ACH);
- fume hoods (>40 ACH for gently released gases);
- outdoor settings (variable ACH, depending on wind speed and direction).

1 Albright, C. *Laboratory Fume Hoods Explained: Chemical Containment – Exposure Control.* Creative Solutions Publishing: Ohio, 2020.

2 Plog, B. A., Overview of Industrial Hygiene. In *Fundamentals of Industrial Hygiene,* 5th ed.; Plog, B. A., Quinlan, P. J, Eds.; Occupational Safety and Health Series; National Safety Council Press: Itasca, IL, 2002; Chapter 1.

3 Globally Harmonized System of Classiÿ cation and Labelling of Chemicals, GHS (Rev.10) (2023). United Nations Economic Commission for Europe (UNECE). https://unece.org/transport/documents/2023/07/standards/ghs-rev10 (accessed Dec 5, 2023).

Air foil: A horizontal member installed across the lower part of the sash opening on the hood surface to provide a smooth airflow into the fume chamber across the work surface and into the baffles.

Air volume: A quantity of air, expressed in cubic feet (ft^3) or cubic meters (m^3).

ANSI/ASHRAE 110: The definitive standard for laboratory fume hood performance testing, issued collaboratively by the American National Standards Institute (ANSI) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It is revised periodically, and its revision date is added as a suffix (e.g., "-2016"). Sometimes referred to as "ASHRAE 110".

Auto sash closure: Auto sash closure is an energy-saving feature that is available on some fume hoods with motorized sash control. It uses a motion sensor or presence sensor to automatically close the sash when a user walks away from the hood.

Auxiliary air hood: A laboratory fume hood with an external supply air plenum at the top. The auxiliary air plenum provides a makeup airstream comprising unconditioned or only minimally conditioned outside air, to substantially reduce the amount of conditioned room air exhausted by the laboratory hood. Newer exhaust designs do not use this system anymore.

Baffle: A panel located across the rear wall of the fume hood that directs the airflow through the fume chamber. The ba e creates a plenum at the rear of the hood to direct air to the exhaust outlet, while providing a rather consistent air face velocity across the hood sash opening area.

Building automation system (BAS): An intelligent system of both hardware and software, which allows the elements of the heating, ventilation, and air conditioning (HVAC) system to communicate on a single platform.

Biological safety cabinet (BSC): A filtered and/or exhausted device that is intended for use with biological agents and not for chemical use (Figure 1).

Bypass: A compensation opening in a fume hood that functions to limit the maximum face velocity and to allow air to continue to enter the hood as the sash is lowered and/or closed.

Canopy hood: A suspended canopy above the work area to exhaust heat, vapor, or odors. This device is not a laboratory fume hood.

Clean air bench (hood): These hood-like, laminar-flow filtered devices are designed to provide product protection. Often found in clean rooms, they are not intended to protect the user from exposure.

Combination sash hood: A fume hood with a sash that can be opened vertically or horizontally.

Figure 1. Typical biological safety cabinet (BSC).

Constant air volume (CAV) ventilation system or fume hood: A ventilation system or fume hood that is designed to maintain a constant airflow within its ductwork. CAV hoods do not provide any energy saving by closing the sash when not in use.

Containment: The ability of the hood to protect the user from exposure to the materials within. The ANSI/ASHRAE 110 standard includes several measures of containment.

Containment ventilated enclosure (CVE): Containment ventilated enclosures, sometimes called powder containment hoods, use HEPA-filtered exhaust. They protect the user from particles when weighing, mixing, preparing, or compounding drugs or finely divided hazardous chemical powders.

Cross-draft: An air draft or current that flows parallel to or across the face opening of the fume hood. A cross-draft may compromise fume hood containment and needs to be kept below 50% of the hood average face velocity.

Design sash position: The maximum allowed open area of the hood, or sash height, is a point determined to ensure user safety. This point should be marked on the side of the sash opening.

Differential pressure (DP): The difference in pressure measured between two points of a system, such as between a room and the adjoining hallway.

Differential pressure gauge: This measures and displays the difference between two absolute pressures, one of which is usually atmospheric pressure. It is mainly measured in inches of water gauge (in.w.g.).

Diffuser: Usually a ceiling-mounted grid. An exhaust or outlet diffuser allows continuous removal of air from the room, and a supply or inlet diffuser allows continuous replacement of fresh conditioned air.

Dilution ventilation: Ventilation airflow that dilutes concentrations of contaminants by mixing with contaminated air, as distinguished from capturing the contaminated air. Laboratory general room exhaust is usually referred to as dilution ventilation.

Diversity design: The practice of designing the air supply and exhaust system capacity based on the assumption that only a fraction of the hoods will be running simultaneously at any given peak time. For example, to conserve energy in a VAV system, a 50% diversity design will provide only enough supply and exhaust air capacity to allow for 50% of the existing hoods to run simultaneously.

Duct: A round, square, or rectangular conduit (usually sheet metal or stainless steel) used to connect system components, or to connect system components to the outside. For example, a duct connects a hood to the exhaust fan on the roof or in a penthouse.

Duct velocity: Duct velocity is the speed of air moving in a duct, usually expressed in feet per minute (fpm) or meters per second (m/s).

Ductless, recirculated, or filtered hood: A limited-application fume hood that is not connected to a laboratory ventilation system. A ductless hood incorporates an exhaust fan and exhaust filters as an integral part of the design and discharges the exhaust directly back into the room after passing the air through a single filter or a combination of the particulate and chemical adsorption filters. Ductless hoods have limited applications and must be approved after a hazard review and risk evaluation, considering the limitations outlined by hood manufacturers.

Exhaust air: Air that is removed from an exhaust device, such as a fume hood, or from a room.

Exhaust collar: The connection between a duct and a fume hood through which all exhaust air passes.

Exhaust enclosure: An enclosure, often built in-house, designed to contain and exhaust hazardous material emitted from equipment or a process setup. These devices do not meet the definition or performance criteria of a laboratory fume hood.

Exhaust fan: A mechanical device, located on the roof or in a penthouse, that moves the exhaust air from a fume hood to the exhaust stack and ultimately to the outside environment.

Exhaust plume: The stream of contaminated air being discharged from the exhaust stack on the roof.

Exhaust stack: The duct connected to the output of the exhaust fan on the roof. It should have a minimum height of 10 feet (3 meters) above the roofline.

Exhaust stack discharge velocity: The speed at which air is exhausted from the fume hood exhaust stack. The minimum stack velocity is 3000 fpm (15.2 m/s).

Face opening: The front access or sash opening of a laboratory fume hood. The face opening area is calculated by multiplying the hood width by the sash height.

Face velocity: The average speed of air flowing perpendicular to the face opening and into the fume hood chamber. The face velocity is the calculated average of the multiple velocity reading points at the plane of the sash and is expressed in feet per minute (fpm) or meters per second (m/s).

Face velocity monitor: A device mounted on the face of the fume hood, displaying the average face velocity, the duct static pressure, or simply the hood function status. It often has an alarm when the velocity drops below the programmed minimum or exceeds the pre-set maximum flow or velocity.

Filter: A device to remove particles, hazardous gases and vapors, or both. Filters are used in ductless hoods and some exhausted fume hoods with specific applications, such as iodination.

Floor-mounted hood (incorrectly called a walk-in hood): A larger laboratory hood with a sash and/or door arrangement that enables access from the floor to the top of the hood interior. Users must never step inside or move their head beyond the plane of any type of fume hood.

Fume hood: An exhausted or ÿ ltered enclosure with a usually adjustable sash opening (Figure 2). Fume hoods are engineered to capture, contain, and exhaust (or filter) hazardous material. Note that "fume hood" is a generic term used to describe this piece of equipment. Technically, vapors and gases are the most commonly exhausted substances in the chemistry laboratory.

Fume hood test: Any test intended to ensure the proper function of a fume hood, air supply, or exhaust system. Examples include, but are not limited to, hood face velocity check, smoke test, room pressurization check, ANSI/ASHRAE 110 containment test, and fume hood alarm calibration check.

General exhaust: Air that is discharged from a building through a general exhaust vent and not through a fume hood stack. In some designs, local and general exhaust are consolidated into one system.

General supply: The conditioned outside air provided to the laboratory after primary filtration to replace the air removed through general exhaust, fume hoods, and other exhausted devices. Supply air optimizes the room air pressure, humidity, temperature, and carbon dioxide concentration.

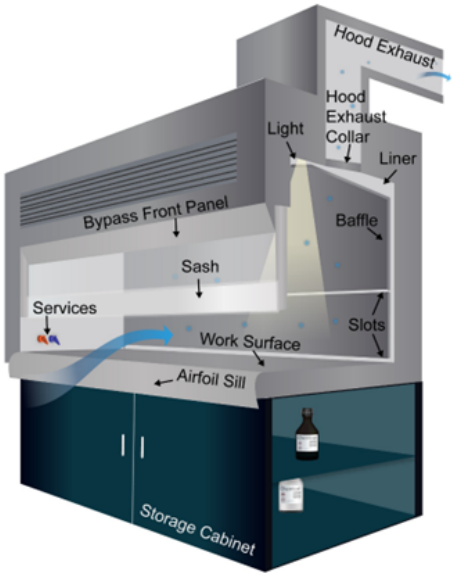

Figure 2: Basic elements of a fume hood.

Glove box: A fully enclosed and controlled work environment that provides a physical barrier to confine and contain hazardous and/or air-sensitive materials within. This device is not a laboratory fume hood.

High-efficiency particulate air (HEPA) filter: A type of filter required for ductless/recirculated fume hoods and biosafety cabinets. A HEPA filter must remove at least 99.95% (European Standard) or 99.97% (American Society of Mechanical Engineers and U.S. Department of Energy Standard) of particles with a diameter equal to 0.3 µm from the air that passes through it.

Heating, ventilation, and air conditioning (HVAC): Ventilation systems designed primarily for control of temperature, humidity, odor, hazardous materials, and overall air quality. Local exhaust ventilation or fume hoods are usually part of the building HVAC system.

Indoor air quality (IAQ): A measure of air quality in the indoor environment (e.g., offices, classrooms, laboratories, living spaces) related to optimizing temperature and humidity and minimizing carbon dioxide concentration and airborne contaminants.

Laminar-fl ow hood: A laminar-fl ow hood, also known as a laminar-fl ow cabinet or tissue culture hood, is an enclosed workbench that creates a contamination-free work environment by using HEPA filters to capture all particles entering the cabinet. Laminar-fl ow hoods are used to protect sensitive materials from contamination. Laminar-flow hoods work by blowing a constant, unidirectional stream of HEPA-filtered air over the work area. This airflow pattern creates a barrier that prevents airborne contaminants from entering the work area.

Lazy flow: See "Reverse flow" (below).

Local exhaust ventilation (LEV): Ventilation devices such as snorkels and tabletop hoods that are directed at a specific emission source or work surface to remove low-hazard air contaminants at the point of generation. These are typically constant-fl ow, with an on/off switch.

Loss of containment: A condition in which the fume hood fails to capture and contain contaminants, allowing them to escape into the room air as fugitive contaminants.

Low-velocity laboratory fume hood: A type of fume hood designed to provide a significant reduction in the required exhaust air volume, compared with the volume required for a conventional fume hood of the same size operating with a face velocity of 100 fpm. Low-velocity fume hoods are also referred to as high-performance fume hoods and high-efficiency fume hoods.

Manifold: A fitting or pipe with many outlets or connections relatively close together. In a fume hood application, this refers to several hoods on a single exhaust duct.

Occupancy sensor: A room motion sensor that detects human movement. The ventilation rate can be reduced to conserve energy when an occupancy sensor detects that a laboratory has not been occupied for an extended period.

Perchloric acid hood: A fume hood designed specifically for working with perchloric acid (Figure 3). The hood, duct, and exhaust fan have a water washdown system to prevent the buildup of explosive perchlorate salts.

Plenum: A chamber or enclosed space through which air moves. This term is usually used when the space is part of a system unit (e.g., fume hood).

Radioisotope hood: A fume hood designed specifically for protection of personnel working with radiochemicals. It has a fully sealed integral work surface reinforced to support lead shielding, and coved interiors to facilitate decontamination.

Recirculation: Air is removed or exhausted from a building area and ducted back to an air-handling system, where it is mixed with outside fresh air. Unlike office spaces, laboratories and any other spaces that use hazardous material must use a one-pass[4] or 100% fresh air system with no air recirculation.

Reentrainment or reentry: The flow of contaminated air back into a building after it has been exhausted. This typically happens when the fume hood exhaust and the building intake are located in close vicinity to each other.

Figure 3: Perchloric acid hood with washdown system for the hood and duct.

Reverse flow (i.e., lazy flow): During the fume hood smoke visualization test, the smoke released inside the hood can be observed to be moving too slowly inward or in an opposite direction outside the hood. This indicates improper hood function or flow instability.

Room air pressure balance: A description of the ratio of the quantities of supply air to exhaust air. Laboratories are typically designed to maintain a negative pressure balance relative to adjacent spaces, to contain leaks and odors within the laboratory. Clean rooms are designed to maintain a positive pressure balance, for particulate containment and contamination control purposes.

Setback: A setpoint that is below normal. For example, laboratory exhaust systems may have a night setback, meaning that the exhaust rate will be reduced to conserve energy during a period when the laboratory is unoccupied.

Smart laboratory: A smart laboratory integrates several smart devices that can be controlled with a digital interface. A smart laboratory can reduce laboratory exhaust flow rates based on a combination of the chemical detection sensors and occupancy sensors.

Variable air volume (VAV) ventilation system or fume hood: A demand-based ventilation system or fume hood that will reduce the fume hood exhaust flow and the room supply as the hood sash is lowered. The VAV system will provide substantial energy cost savings by reducing the hood exhaust flow if the hood sash is closed when it is not actively used.

4 "One-pass" refers to the one-time-only use of supply air from a non-hazardous occupancy (e.g., an oÿ ce space) to ventilate a hazardous occupancy (e.g., a laboratory). The supply air is not 100% fresh, but it will not contain contaminants.