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Requirements
for

Local Exhaust Ventilation

REVISION

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1. PURPOSE AND SCOPE

1.1 The purpose of this document is to establish the minimum requirements for providing adequate exhaust ventilation on operations which have the potential for generating hazardous dust, fumes, mist, vapors, or gases. Adequate exhaust ventilation is required to protect employee health and to avoid unnecessary interruptions due to odors.

1.2 This document pertains to local exhaust ventilation system components. It does not cover general exhaust or air handling systems.

2. DEFINITIONS

2.1 **TLV (Threshold Limit Value)** - The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

2.2 **Action Level** - The level of pollutant at which actions or counter measures are to be taken.

2.3 **Face Velocity** - The average linear air velocity at the opening of a hood, cabinet or enclosure expressed in feet per minute.

2.4 **Local Exhaust Ventilation** - A specific type of engineering control that is a system consisting of a hood, ductwork, fan, motor and abatement control device designed to capture and remove process emissions prior to emitting into the workplace environment.

2.5 **Velometer** - An instrument used to measure air flow velocity.

3. RESPONSIBILITIES

3.1 Environmental Health and Safety (EHS) is responsible for program development and advice and counsel to management and employees, professors, students, tenant, contractor, and vendor employees.

3.2 Facilities Operations Group (FOG) is responsible for the implementation, oversight and recordkeeping of this program.

3.3 Employees are responsible for following this program.

3.4 Supervisors, Managers and Professors are responsible for the implementation and oversight of this program.

4. VENTILATION REQUIREMENTS

4.1 At no time shall an operation be used where employee exposure levels for the chemicals used exceed the established TLV for those chemicals. CNSE employs 1/2 the TLV as an action level requiring at a minimum industrial hygiene sampling annually. Exposures above the TLV require immediate shutdown or adequate exhaust provided. Levels between the action level and TLV require additional engineering controls whenever feasible.

4.2 In the event that engineering controls, such as exhaust ventilation is not feasible, then protection such as an appropriate cartridge respirator must be used.

4.3 An exhaust ventilation system shall provide the following typical design and test exhaust parameters:

4.3.1 Fume Hood: 80-125 fpm, face velocity.

4.3.2 Wet Stations: 55 - 100 fpm, face velocity for non-heated stations with 70 - 150 fpm, face velocity for heated stations and 110-125% of the laminar flow volume flow rate across the top of the deck.

4.3.3 Gas Cylinder Cabinets: 200 – 250 fpm, face velocity.

4.3.4 Gas Panel Enclosure such as on-board gas cabinets and VMBs: 4-5 air changes per minute and -0.05 to -0.1” of water static pressure.

4.3.5 Chemical Dispense Units (CDUs): 2-3 air changes per minute and -0.05 to -0.1” of water static pressure.

4.3.6 Glove Box: No consensus for a reference at this time.

4.3.7 Supplemental/Snorkel Exhaust: 100 – 150 fpm capture velocity.

4.4 Face velocity measurements shall be taken at the following points:

4.4.1 For chemical sinks and fume hoods, the velocity measurements should be taken with a splash shield or moveable sash height of 12 to 14 inches.

4.4.2 For sinks with a horizontal face, velocity measurements should be taken across the open face of the working area.

4.4.3 For gas cylinder cabinets and valve manifold boxes (VMBs), the velocity measurements should be taken at the face of the gas cabinet window.

4.4.4 For ozone generators the average velocity of ventilation at make-up air openings with cabinet doors closed shall not be less than 200 fpm.

4.5 Ventilation requirements and measurement locations for all other equipment will need to be evaluated on a case by case basis.

5. FUME HOOD DESIGN FACTORS

5.1 Fume hoods are devices designed for work with toxic or hazardous chemicals with the effect of safely capturing the harmful gases, vapors, and fumes generated and exhausting them to the outside air. The fume hood is very effective if installed and used properly and maintained in good working order. Fume hoods are not just fixtures but are installed into the ventilation system of a building and so affect the ventilation of the entire building and the exhaust at the stack. As a result, fume hood function and proper installation not only affects your safety but the safety of others in the building.

5.2 The primary parts of the fume hood are:

5.2.1 Face – The face of the hood is the opening where air capture takes place.

5.2.2 Sash – The sash is the glass “window” that travels in the plane of the hood face that opens or closes the hood and protects the user during use.

5.2.3 Baffles – The baffles are located in the back of the hood and direct air in the appropriate direction. The baffles can also be adjusted to account for different vapor densities of chemicals (heavier than air and lighter than air).

5.2.4 Duct – The duct connects the hood to the ventilation system and exhausts to the outside air.

5.2.5 Air Foil – The air foil is fixed to the bottom front edge of the hood and is a vent that keeps a minimum gap open at all times but more importantly gives aerodynamic properties that allow better, less turbulent air flow and better capture.

5.3 Function of a Fume Hood

5.3.1 As the user works at the sash, the air is drawn in at a laminar (even) flow and ideally at about 100 fpm. With regard to capture, we are only concerned with velocity (fpm) because this is what actually carries vapors and particles. The air volume is of more concern to the designers of the ventilation system. The air is drawn around the baffles and up to the duct like a chimney. The space around the baffles (slots) can be adjusted so air flow is concentrated at desired areas of the hood. It is important for there

to be at least an inch or two opening for the rear lower baffle since many vapors handled in hoods are heavier than air.

5.4 Types of Hoods

5.4.1 Variable Air Volume (VAV) – VAV hoods maintain a constant velocity as the sash moves but changes the volume of air. This can be done by a variety of methods including changing motor speed or closing or opening baffles in the duct. This is desirable since lower sash heights results in less air being used, which translates into substantial energy savings on heating and cooling.

5.4.2 Standard or Bypass – With standard hoods the volume of air changes as the sash moves so that as the sash is lowered the velocity increases. Bypass hoods are the same design but have a vent in the top so that as the sash is lowered and the sash opening is closed, it simultaneously opens the top (bypass) vent. In this way, even though the sash opening is getting smaller, the proportion of air volume flowing through the face is smaller and the velocity remains more constant. This does not save as much energy as a VAV hood, but performs better than a standard hood.

5.4.3 Auxiliary Air – These hoods not only draw air but also have a blower that injects air at the face of the hood. These hoods are no longer used much on campus and their performance is not as good as VAV and bypass hoods. If you have one of these hoods and have problems, please contact EHS.

5.4.4 Ductless Hoods – These hoods are not ducted to outside air but remove contaminants from the air and return it back to the room. The contaminants may be removed by a variety of means such as HEPA air filters, carbon adsorption or catalyst reactions filters. The filters should be changed on a schedule according to the manufacturer and the appropriate filter should be used for the particular contaminant being removed. It is vital that these units work properly since the air is reticulated and exposure is eminent. In order to select the best filter and to make sure the unit is working properly, EHS must conduct a consultation with the lab and evaluate each chemical used in that hood. If any new chemicals are introduced, then EHS should be called to evaluate that chemical. It is recommended that ductless hoods not be purchased unless the benefits outweigh the hazards and inconvenience because of potential for problems. Also, ductless hoods are not indicated when using many liquid, non-aqueous chemicals since the vapors of these chemicals are heavier than air and ductless hoods do not generally have a rear baffle. As a general rule EHS does not recommend the use of ductless hoods.

5.5 Safety Guidelines for Fume Hoods

5.5.1 Keep the sash as low as possible to minimize the risk of exposure. The sash acts as a safety shield and protects your face, so you should be looking through the sash to perform your work. The green arrows are a good guideline for sash position, but sash height should be adjusted depending on the height of the person using the hood.

5.5.2 If an airfoil is not installed on your hood, consider having one installed. This will provide more laminar air flow and better capture of contaminants.

5.5.3 Always use an airflow indicator. This is a small piece of crepe paper (or similar) attached to the bottom of the sash that blows with the air current. This is the only way to know for certain that air is flowing through the hood in the proper direction. The indicator should be blowing into the hood (sometime the flow is reversed by accident during maintenance). Please note, an airflow indicator only indicates the direction of airflow and does not indicate whether the fume hood has the proper face velocity.

5.5.4 Keep lab doors and windows closed. These extra sources of inlet air can: affect the performance of the hood, cause turbulent air currents in the room or cause the room to lose its negative pressure.

5.5.5 Limit traffic near hoods when in use. Pedestrian traffic or fast movement in front of hoods can cause turbulence and can negatively affect the capture ability of the fume hood.

5.5.6 Reduce clutter and do not store large amounts of chemicals in the hood. Excess clutter and chemicals can impede airflow especially to the lower openings. Necessary bottles and equipment should be elevated an inch or two to allow airflow underneath to the rear baffles (a small shelf or blocks of some kind will work for this). Excess chemicals can be a hazard in themselves due to their properties. Store chemicals in cabinets or on shelves, except for the chemicals you need immediately for the work at hand.

5.5.7 Work at least 6 inches into the hood from the plane of the sash. This will reduce the risk of eddy currents blowing vapors back at you and will maximize capture ability of the hood.

5.5.8 If hoses or cords must be inserted through the face of the hood, run them underneath the airfoil so the sash can close completely.

5.5.9 If there is a potential for an explosion hazard due to the chemicals you are using or the experiment you are conducting, special shielding should be used in addition to the sash.

5.5.10 Protect against blockage of ducts. Lightweight materials such as aluminum foil or tissues can be sucked into the vents and reduce the performance of the hood.

5.5.11 In a power outage, lower the sash to within an inch or two so the chimney effect will keep some air flowing into the hood and contain any vapors.

5.5.12 Other than sash height and baffle adjustment, never make changes to the hood without the advice of EHS.

5.5.13 If other apparatus requires venting, the exhaust should not be injected into the face of a hood but rather should be ducted to the ventilation system. This kind of work should be cleared through the EHS Department.

5.5.14 Evaporations and digestions using Perchloric acid should only be done in a specially designed Perchloric acid fume hood with a wash down function. Heated Perchloric acid can form shock sensitive crystals in the duct work that can explode.

5.5.15 Whenever you are not using the fume hood, always close the sash of the hood as low as possible. Closing the fume hood sash provides added protection of better capture ability of any chemicals being stored in the hood as part of an experiment and also greatly enhances energy conservation measures for the laboratory.

6. SPECIALTY EXHAUST SYSTEMS

The following is a list of specialty exhaust systems that are also used at the CNSE facility. Please ensure that you contact EHS for authorization to use such exhaust systems and for proper operation and maintenance.

6.1 Walk-In Hood – A walk-in hood is a hood which sits directly on the floor and is characterized by a very tall and deep chamber that can accommodate large pieces of equipment. Walk-in hoods may be designed as conventional, bypass, auxiliary air, or VAV.

6.2 Fume Exhaust Connections: "Snorkels" – Fume exhaust duct connections, commonly called snorkels, elephant trunks or flex ducts, are designed to be somewhat mobile allowing the user to place it over the area needing ventilation. However for optimal efficiency, these connections must be placed within six (6) inches of an experiment, process, or equipment. These funnel-shaped exhausts aid in the removal of contaminated or irritating air from the cleanroom/lab area to the surrounding area. The average capture velocity for snorkels taken at the face of access ports shall be 100-150 feet per minute (fpm); recommended air flow for these connections is 100 cubic feet minute (cfm), unless otherwise specified by the tool vendor or manufacturer.

6.3 Canopy Hoods – Canopy hoods are horizontal enclosures having an open central duct suspended above a work bench or other area. Canopy hoods are most often used to exhaust areas that are too large to be enclosed within a fume hood. The major disadvantage with the canopy hood is that the contaminants are drawn directly past the user's breathing zone.

6.4 Glove Boxes – Glove boxes are used when the toxicity, radioactivity level, or oxygen reactivity of the substances under study pose too great a hazard for use within a fume hood. The major advantage of the glove box is protection for the worker and the product.

6.5 Clean Hoods – Clean hoods are sometimes called laminar hoods but these should not be confused with the type of hood mentioned below. These hoods are safety devices designed to bath the work area with HEPA filtered air to protect sensitive processes from contamination. They are commonly used in clean rooms. These hoods draw the majority of air through a filter, and drop the air gently from the top of the hood into the work area. They draw only a small percentage of air through the face of the hood (about 10%). The result is face velocities that are lower than other hoods, however, the hood is designed to capture well in this fashion. Due to this style of capture, it is important to have a visual capture test (such as a dry ice test) done on these hoods at least annually.

6.6 Biosafety Cabinets (BSC) – These units are used for biological applications to remove potentially infectious agents such as microbes and spores. The air is passed through a HEPA filter and back into the room. The filter removes small particles but not vapors and gases, so BSCs should not be used with chemicals (a little Ethanol or Isopropanol for decontamination is OK). It is the responsibility of the lab to have these tested and certified by a third party on an annual basis. EHS can provide the names of companies that can test and certify Biosafety Cabinets.

7. EXHAUST DUCT SYSTEMS

7.1 All local exhaust ventilation systems must be connected to the facility exhaust system through a series of ductwork. Such ductwork must comply with the following:

7.2 **Materials:** Materials for exhaust ducts shall comply with the Mechanical Code. All duct materials should be selected based on the operation to be controlled. The presence of corrosive gases, vapor and mist may require the selection of corrosive resistant materials, plastics or coatings. The presence of flammable, toxic or reactive gases, vapor and mist require the use of stainless steel. If there are any questions regarding selection of material, consult with the EHS staff.

7.2.1 In general, gas cabinets, Valve Manifold Boxes (VMBs), ozone generator cabinets, gas interface boxes (GIBs), Chemical Dispense Units (CDUs), Bulk Chemical Distribution units (BCDs) and waste cabinets are all connected to the facility's general or heat exhaust.

7.3 **Reactives:** Two or more operations shall not be connected to the same exhaust system when either one or the combination of the substances removed may constitute a fire, explosion or chemical reaction hazard within the duct system.

7.4 **Penetration:** Exhaust duct systems penetrating occupancy separations shall be contained in a shaft of equivalent fire-resistive construction. Ducts shall not penetrate area separation walls.

7.5 Fire dampers shall not be installed in exhaust ducts.

8. STATIC PRESSURE MEASUREMENT

8.1 Static pressure is an indirect measure of the amount of exhaust supplied to each piece of equipment.

8.2 Static pressure is measured by devices such as magnahelic or photohelic gauges or pressure transmitters.

8.3 All equipment that utilizes Hazardous Production Materials (materials with an NFPA rating of 3 or 4 for health and flammability) must have a static pressure indicator (magnahelic or photohelic or pressure transmitter) installed with high and low point marked to clearly indicate to the user that the system is operating within its required parameters. This allows for continuous monitoring for proper equipment exhaust.

8.4 The static pressure measurement devices shall be equipped with a visual alarm to alert the operator to discontinue use of the system they are working on or within and shall be designed to shut down the device upon loss of exhaust.

8.5 **Magnahelic/Photohelic Set-up:**

8.5.1 Differential pressure sensors shall only be placed in the exhaust ducts coming from gas cabinets, fume hoods, glove boxes, CDU's, VMB's, GIB's and exhausted enclosures if they are not already monitored by onboard pressure devices.

8.5.2 The static pressure tap, for the magnahelic/photohelic pressure transducer shall be mounted at least one duct diameter from the source cabinet and upstream from the damper. The distance from the damper should also be positioned at a distance of one duct diameter.

8.6 Set points for pressure transducers placed in laterals will be as follows:

8.6.1 Low Alarm – 80% loss of exhaust pressure for 30 seconds, of the operating value before an alarm is initiated.

8.6.2 Low Warning – 90% loss of exhaust pressure for 30 seconds, of the operating value before a warning alarm is initiated.

8.6.3 The magnahelic must be mounted in a location where it is easily accessible and clearly visible.

8.6.4 The magnahelic should not be placed in a location where it can be blocked by other objects such as wafer boats, boxes, etc.

8.6.5 The magnahelic gauge used must have the proper static pressure scale. A normal reading should be close to the mid-point of the gauge. Using gauges with too large of a scale will result in readings very close to zero and are difficult to read.

8.6.6 The proper static pressure reading must be clearly marked with an arrow or pointer on the face of the magnahelic. The proper reading is determined by equipment exhaust monitoring. Once the 100 fpm requirement is met, the observed static pressure should be marked on the magnahelic and the survey sticker.

8.6.7 In the case of a range of static pressures, the acceptable range must be clearly marked on the magnahelic face.

8.6.8 The lower range should be 0.81 x static pressure.

8.6.9 The upper range should be 1.19 x static pressure.

8.6.10 The magnahelic gauge must be properly "zeroed" and calibrated prior to being put into operation.

8.6.11 Equipment operators must check the exhaust monitoring device prior to using the equipment. Static pressure readings that are less than that marked must be immediately reported to Facilities for follow-up. If necessary, the equipment must be shutdown until proper exhaust is provided.

8.6.12 Damaged or defective magnahelic gauges must be immediately replaced.

9. VENTILATION SURVEY/MONITORING

9.1 All exhausted equipment including chemical sinks, gas cabinets, VMBs, CDUs, waste and chemical cabinets and fume hoods must be inspected and surveyed by FOG to ensure adequate exhaust ventilation:

9.1.1 When the equipment is newly installed;

9.1.2 After rebalancing of the exhaust system; and/or

9.1.3 After major modifications such as the addition of other equipment on the same exhaust system.

9.2 During the inspection process the following must be checked and corrected if necessary:

9.2.1 Proper calibration of hood air flow monitor;

9.2.2 Correct fan rotation and proper position of motor guards;

9.2.3 Condition and proper tension of drive belts;

9.2.4 Proper lubrication and condition of bearings;

9.2.5 Condition of fan blades;

9.2.6 Integrity of ductwork and local hoods for:

- Corrosion damage, blockage and leaks;
- Proper operation of all dampers and blast gates;
- Filters (resistance to air flow); and
- Proper operation of fan switch and flow indicator, if present.

9.3 Exhaust ventilation measurements shall be obtained by using a velometer. Consult the equipment instructions for proper operation.

9.4 Air Flow

9.4.1 Determine that individual air flow rates meet original design specifications by measuring velocity at the plane of the hood opening using a directional anemometer and calculating the air flow rate.

9.4.2 (Air Flow Rate (CFM) = Face Velocity (fpm) x Area of Face (ft. 2)). An alternative method can be used by measuring the hood static pressure and calculating the air flow rate, or pitot traverse.

9.4.3 If the air flow rate has decreased more than 10% from the original design data or earliest data available, corrective action should be taken.

9.4.4 Check system air flow using a smoke tube. Look for excessive air turbulence, incomplete capture of smoke and cross drafts.

9.5 Face Velocity

9.5.1 Determine the face velocity at hood/equipment opening using a directional velometer that has been calibrated within the past year. Face velocity must not be below 80 fpm or above 120 fpm in any of the grid areas. The overall average face velocity must not be below 100 fpm. The exception to this rule is if the hood were especially designed to operate out of these limits. Check and compare to design records if this is the case.

9.5.2 Record the average face velocity, date of inspection, and inspector's initials on the hood and remove any old labels.

9.5.3 If minimum average face velocity of 100 fpm is not obtained on hoods with vertical sliding sash, position the sash to obtain 100 fpm, then prominently mark the position on the hood with an approved label. If the sash height to obtain 100 fpm is less than 20 inches, the hood should be taken out of service until it is repaired.

- For auxiliary air hoods, the face velocity should be measured with the auxiliary air off in addition, the downflow velocity (parallel to the sash) at the face of the auxiliary supply grill should not exceed 200 fpm at any point.
- For hoods with horizontal sliding sash, the velocity measurements should be made with the maximum opening possible with the number of sashes normally used.
- Check the air flow using a smoke tube or equivalent with the sash in the open position. Look for excessive air turbulence, incomplete capture of smoke and cross drafts.

9.6 The area to be measured must be divided up into equal rectangular areas with velocity measurements at the center of each.

9.7 If equipment does not meet the 100 fpm ventilation requirement, the equipment or exhaust system shall be tagged with a "DO NOT OPERATE" tag and must be modified until the requirement is met.

9.8 For equipment with a moveable sash, indicator arrows must be placed at the sash level which meets the required velocity.

9.9 Equipment operators must not open the sash further than the indicator arrows except to move objects in and out of the hood.

9.10 The indicator arrow location needs to be evaluated during each survey. If necessary, it should be adjusted.

10. EMERGENCY POWER FOR VENTILATION AND CONTROLS

10.1 The exhaust ventilation system shall have an emergency source of power. The emergency power shall be designed and installed in accordance with the Electrical Code.

10.2 The emergency power may operate the exhaust system at not less than half fan speed when it is demonstrated that the level of exhaust will maintain a safe atmosphere.

11. RECORDS

11.1 All inspection records, balancing reports, records on installation and maintenance of exhaust ventilation systems shall be kept on file in the EHS office.