Design Standard - Fume Hoods & Fume Hood Exhausts

1.0 Introduction

The fume hood is the primary control device in most laboratories for protecting employees and students from exposure to hazardous chemicals. It is also an integral part of the building air handling system. The efficiency of operation is essential in maintaining good air quality in laboratories. It is therefore imperative that it function properly and that it be designed appropriately. This standard was developed in accordance with the *Canadian Standards Association* (CSA) *Standard Z316.5-15 Fume Hoods and Associated Exhaust Systems*.

2.0 Application

This standard primarily applies to project managers overseeing the design and installation of a fume hood system on campus and to faculty or staff at the University of Toronto that may be invested in such a project to the point where their expertise or guidance may be required for the design process. This includes installing new fume hood systems or the replacing an existing fume hood system or component of a fume hood system. The purpose of this standard is to ensure that any components of a new or replacement system comply with the most recent CSA standard and any relevant legislation.

3.0 Definitions

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers.

Bypass Fume Hood: A fume hood that contains an open grill/louver above the front face of the working chamber. This grill compensates for the reduction in face area, and thus the significance of face velocity changes, when the sash is operated.

Working Chamber: The section of the fume hood system that includes:

- The fume hood sash;
- The fume hood work space;
- The structural frame of the fume hood.

4.0 Responsibilities

4.1 Project Managers

Project managers that are managing a fume hood system installation or modification project are responsible for:

- Adhering to the design requirements of this standard;
- Informing the Office of Environmental Health and Safety of the project;
- Providing all information that the Office of Environmental Health and Safety requests regarding the project;
- Modifying the design, as necessary, to ensure the conditions of this standard and compliance requirements are met; and
- Ensuring the project is implemented as designed.

4.2 The Office of Environmental Health and Safety (EHS)

The Office of Environmental Health and Safety is responsible for:

- Where possible, providing guidance when requested and required to help ensure that the fume hood system's design meets this standard and compliance requirements; and
- Maintaining this standard.

5.0 Design Standard

The fume hood is one component of the exposure control system; its performance therefore cannot be judged in isolation from the rest of the system. The total system consists of:

- The working chamber;
- The exhaust system;
- Fume hood location;
- Make-up air to the fume hood;
- System indicators;
- Operational parameters; and
- System maintenance.

The following specifications provide the standard for acceptable performance and efficiency of fume hood systems; all new installations shall conform to these specifications and existing installations should be brought to this standard as funding permits.

5.1 The Working Chamber

The working chamber should:

- Be by-pass type when constant volume systems are required;
- Be constructed from non-flammable, acid/corrosion resistant materials;
- Include a back baffle system to more evenly distribute the air across the face of the chamber such that uniform air flow through the face of the fume hood will result;
- Include a stainless steel air foil along the lower, front edge at the face of the fume hood workbench which provides a streamlined and aerodynamic entrance profile;
- Include vertical and/or horizontal sliding sash to minimize the size of the working aperture and to act as a safety screen. The sash should be constructed of transparent glazing that is resistant to discoloration and crazing by age or exposure to chemicals; and
- Contain a recessed work surface to retain spilled liquids. The work surface must be able to bear the weight of any equipment or radiological shielding material that is required.
- Be labelled with a unique identifier. This identifier should also be labelled on:
  - The fume hood fan; and
  - The exhaust stack.

5.2 The Exhaust System

5.2.1 Fume Hood Ducting

The fume hood ducting shall:

- Be designed to provide optimum air flows in the working chamber;
- Be designed and sized to minimize noise levels from fume hood fan operation;
- For VAV systems be designed along with the fan system to provide a buffer in addition to the design face velocity. E.g. if a 60fpm face velocity low flow hood is specified the fan and ducting should allow for 80fpm.
- Avoid horizontal runs as much as feasible to minimize collection of corrosive condensates;
  - Where horizontal runs do exist, the duct must slope at least 2.5 cm downward to a suitable drain, in the direction of airflow, per 3 meters of horizontal run;
- Contain circular cross-section to reduce the number of corners and crevices where corrosion might occur;

- Be constructed with type 316 stainless steel welded construction, except where the chemicals used require compatible materials;
    - Ensure that these materials comply with the requirements of the Ontario Building Code and the Fire Code.

5.2.2 Fume Hood Exhaust Fan

The fume hood exhaust fan shall:

- Be fitted with flexible couplings – which connect the fan to the ductwork – that are made of a fabric which is highly resistant to a wide range of chemicals and environmental conditions;
- Be located so as to ensure that the exhaust ducting below the fan within the building remains at negative pressure and the ducting above the fan remains at positive pressure;
- Be located in a well-ventilated location; and
- Be of sufficient capacity to maintain negative pressure and operational parameters (See section 5.6 for operational parameters) of all connected fume hood cabinets.

5.2.3 Radiation Fume Hood Exhaust

The fume hood exhaust stack shall:

- Discharge vertically upwards at a velocity of at least 1.4 times the average wind velocity;
- Be so positioned as to ensure that emissions are unable to re-enter the building or adjacent buildings;
    - The recommended minimum straight-line distance between the exit point of the exhaust and the building or intake opening is 15.24m;
- For new buildings, be at least 3.05m above the highest point of any adjacent buildings;
- Where possible to determine the prevailing wind direction, be downwind of any air intakes; and
- Be attached to a properly installed trap and drainage system.

5.2.4 Environmental Compliance Approvals

Notwithstanding any of the above, the fume hood must meet all Environmental Compliance Approval (ECA) requirements. The Office of Environmental Health and Safety requires that all needed modelling of proposed exhaust stack locations and is

conducted and can recommend any required mitigation of or alterations to a fume hood installation project.

5.3 Fume Hood Location

A fume hood shall be located:

- At least 2.4 m from entrances to the lab;
- So that the sidewall of the fume hood is no less than 500 mm away from any wall to ensure that air flow is uniform across the face of the fume hood;
- So there is no less than 2.0 m spacing between fume hoods facing each other;
- In such a way as to minimize risks to persons in the event of fire or explosion;
- Away from predominant foot-traffic areas (doorway, etc.); and
- Away from major air patterns or equipment that produces cross-draughts.

5.4 Make-Up Air to the Fume Hood

- The HVAC system shall provide for a negative pressure condition at all times in the lab according to the chemical/biological/radiation classifications as directed by the Office of EH&S to avoid intrusion of lab air into other areas of the building;
- Supply air distribution in the lab space shall be designed to minimize turbulence in such a manner that the air distribution velocities (cross-drafts: vertical and horizontal) does not exceed 30% of the fume hood face velocity at any point across the face opening at any location and ideally no more than 20%. The cross draft requirement also applies to biosafety cabinets BSC Class I and Class II-A1, which operate at 0.38 m/s and BSC Class I-B2, Class II-B1, Class II-A2 operate at 0.50 m/s (100 fpm).
- Low throw, low velocity perforated diffusers shall be used. Louver and/or air nozzle grilles are not acceptable. Unless cleaner air than supplied as part of the base building HVAC is required, filtered diffusers are NOT allowed. Delivered air filtration, if requested, shall be reviewed and accepted by EH&S and F&S;
- The HVAC system shall be designed using fume hoods operating at 0.30 m/s (60 fpm) to 0.40 m/s (80 fpm), 460 mm sash height, for constant air volume fume hoods (when CAV is accepted by EH&S and F&S) and at any sash height for VAV fume hoods. New installations shall use high efficiency hoods with a target maximum face velocity of 60fpm at 18”. A diversity factor of 70% shall be used for research laboratories and 100% for teaching laboratories and confirmed by EH&S and F&S during the Schematic Design review stage.
- The minimum exhaust flow rate through the hood will be 10–25 CFM/ft^2 of fume hood work surface.

- An example of an acceptable perforated air distribution diffuser is the E.H. Price RFD (non-filtered).

5.5 System Indicators and Alarms

All University of Toronto fume hoods must be fitted with an alarm device:

- On the front of the fume hood;
- That indicates to fume hood users that the fume hood is not functioning properly.

All UofT fume hood alarms must:

- Have an audio indicator of fume hood failure;
- Have a visual indicator of fume hood failure; and
- Be accessible at all times.

All UofT fume hood alarms should:

- Have user accessible controls that do not require third party (non-UofT) access for repairs or recalibration;

All UofT fume hood alarms may:

- Have a digital display of current fume hood conditions;
- Have a power switch;
- Have flow control; and
- Have an audio level control.

5.5.1 Fume Hood Alarm Design Restrictions

The following design restrictions apply to UofT fume hood alarms:

- Fume hood alarms that rely on pressure switches shall not be used on variable air volume fume hood systems.

5.6 Operational Parameters

5.6.1 High Efficiency Fume Hoods

The basis for design is to be variable air volume, high efficiency fume hoods (HEFH) that are designed for 0.30 m/s (60 fpm) or lower face velocities and certified according to some or all of the current ASHRAE-110 Test Protocols "as manufactured".

For high efficiency fume hoods, the operational parameters will be determined using a containment test "as installed". Therefore, operational requirements for high efficiency fume hoods may vary and will be determined on a fume hood by fume hood basis and will be based on the outcome of containment testing.

The University of Toronto Office of Environmental Health and Safety can provide the standard containment testing. Third party organizations can be contracted to conduct such testing, however the EHS office should be consulted, to help address any containment issues that may be revealed by the standard testing procedure.

5.6.2 High Efficiency Fume Hood Important Considerations

There are some additional planning considerations that are recommended for high efficiency hoods. These recommendations may prevent additional costs and/or unforeseen complications prior to commissioning:

- Where possible, avoid installing a high efficiency fume hood system in a pre-existing laboratory without also retrofitting the make-up air system to be better suited to the fume hood's reduced air flow;
- Install sashes with automatic closers that activate a few minutes after the hood becomes unoccupied in order to prevent walk-by wake effects that compromise containment in open, but unoccupied hoods; and
- When designing the exhaust system, allow for extra fan capacity in case the flow in the fume hood must be increased in order to achieve containment. Typically this would mean a hood designed for 60fpm face velocity would have ducts sized for 80fpm.

5.6.3 Standard Variable Air Volume and Constant Air Volume Fume Hoods

When the fume hood is in operation, the air velocity through the face of the fume hood – at a minimum of one operating sash height, which is no lower than 12 inches above the airfoil and no higher than 18 inches above airfoil – must be:

- No less than 80 feet per minute;
- No greater than 130 feet per minute; and
- Relatively uniform across the entire aperture.

5.6.4 Fume Hoods for Radioactive Materials

Regardless of the above, radioisotope fume hoods must have 0.50 m/s (100 fpm) average face velocity according to the Guidance Document GD-52 Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms 2010 – CNSC.

For fume hoods used for nuclear substances:

- The working chamber will be marked with a radiation warning sign;
- Any accessible sections of fume hood exhaust ducts connected to a radiation fume hood must be marked with radiation warning symbols at intervals no greater than every 3 metres;
- If the fume hood is used for radioactive material storage, then the fan servicing that fume hood must remain operational at all times;
- If the fume hood is used for radioactive material storage, then it must remain under negative pressure, below the fan, at all times;
- If the fume hood is used for continuous exhausting of radioactive substances, then:
    - The exhaust fans will be connected to an emergency power system; and
    - The fume hood exhaust will not connect with other exhaust systems.
- The fume hood will not contain any kind of air filtration. If filtration is required, then:
    - Radiation monitoring and change out schedules must be confirmed with the Radiation Safety Officer.

5.7 Ductless Fume Hoods

Ductless fume hoods are only to be used if approved by the Office of Environmental Health and Safety, and only in situations where a fume hood is absolutely required and a ducted fume hood is not a feasible option.

Lab supervisors or managers that wish to use a ductless fume hood in place of a ducted fume hood must be able to make the following information available to the EHS Office at all times:

- A filter change-out schedule;
- Current record of filter changes; and
- An assessment of filter compatibility with respect to the chemicals that are planned on being used in the fume hood.

6.0 Dispersion Modeling

Prior to a new fume hood system or exhaust stack installation appropriate dispersion modeling will be conducted by:

1. The University of Toronto EHS Office
2. A party that has been delegated responsibility by the UofT EHS Office to complete the dispersion modeling.

A new fume hood system or exhaust stack cannot be installed until:

1. Dispersion modeling of the proposed system has been completed; and
2. The dispersion modeling results adequately demonstrate that the new fume hood system or exhaust stack will not put the UofT out of compliance with:
    a. Existing Environmental Compliance Approvals granted to the UofT by the Ontario Ministry of the Environment; and
    b. The Ontario Environmental Protection Act, Section 9.

If the dispersion modeling results indicate that the proposed fume hood system or exhaust stack will put the UofT out of compliance with environmental regulations, then the location or specifications of the proposed fume hood system or exhaust stack must be modified until the dispersion modeling indicates compliance.

7.0 Fume Hood Commissioning

All fume hoods at the University of Toronto must be commissioned before they can be used. Commissioning is conducted by the University of Toronto Office of Environmental Health and Safety.

The commissioning process requires:

- Evaluation of the installed fume hood system with respect to this design standard;
- Measurement of fume hood operation parameters;
- Testing of the fume hood alarm system;
- Cross-draughts validation to ensure these are below 30% of operating average face velocity;

- Containment testing of all fume hoods;
- Communicating any discrepancies for correction to the project and lab manager; and
- Conducting the commissioning process again following any such corrections.

8.0 Standard Revisions

On an annual basis, the University of Toronto Office of Environmental Health and Safety may evaluate this standard with respect to:

- Efficacy;
- Changes in the guiding standards or legislation;
- Applicability to UofT operations;
- Relevance and functionality of the standard with respect to the regulatory requirements and safety;
- Clarity of the standard and procedures to all responsible parties; and
- Feasibility of implementation and management of the standard.

If, upon evaluation, gaps are identified with respect to the evaluation criteria, the standard may be revised in such a way as to correct those gaps.