Working safely with hazardous substances in a fume hood

Introduction

Hazardous substances and fume hood
According to the Working Conditions Decree (Article 1), dangerous substances suffice:
“Substances, mixtures or solutions of substances to which workers are or may be exposed in the course of their work that, because of the properties of or the conditions under which those substances, mixtures or solutions occur, may present a health or safety hazard”.
The health problems that can be caused by working with and/or exposure to hazardous substances range from mild irritation of eyes, skin and mucous membranes to serious effects such as cancer, reproductive problems and offspring abnormalities. The health effects can occur either acutely after exposure or in the long term. Some substances have a cumulative effect. Often, in addition to health risks, safety risks are also present with hazardous substances. For example, the risk of fire, explosion or suffocation or a combination of different safety risks.

Within the UNS50 laboratories, various forms of local ventilation and extraction have been integrated to eliminate health hazardous fumes and gases to minimize exposure to hazardous substances for employees and students
In this context, to this end, within the faculties of FHML and FPN, one is required to work with hazardous liquids in a special facility that provides protection against exposure to hazardous substances, namely a fume hood. This involves firstly direct physical protection in that the fume cupboard provides a barrier against fire, splashes, explosions. Secondly, indirect protection because the fume cupboard extracts gases and aerosols of hazardous liquids to minimize the employee's exposure outside of the fume hood - when used correctly - to well below the hazardous limit.

Fume hood
A fume hood is a special working space within the laboratory that is enclosed and in which the air present is extracted. This extraction takes place through a fan that is either integrated into the top of the fume hood (the technical part) or located on the roof of the respective building. By extracting air from the fume hood, an air flow is created inward. This protects the worker at the front of the cabinet from volatile substances. The working opening at the front can be opened with a sash (working position) or closed (closed position). Fume hoods are generally used when working with volatile organic compounds and when working with toxic and/or health-damaging substances with long-term effects.

Figure

Fume cupboards connected to a VAV system in the organic laboratory of the Department of Biochemistry, FHML, Maastricht University

Within the research building UNS50 in which the majority of the FHML's laboratories are housed, there are approximately 160 fume hoods. Within these laboratories there are two different systems present to which fume hoods are connected: a CAV (Constant Air Volume) system and a VAV (Variable Air Volume) system.

Fume hoods connected to a CAV system
A CAV type fume hood extracts a constant volume of air per unit of time. This volume remains constant regardless of the position of the fume hood sash. By varying the open position/height of the sash, the bypass opening at the top of the fume hood is opened more or less and the air inflow speed into the fume hood remains the same. This generally concerns the somewhat older fume hoods in the UNS50 that are not included in the renovation project.

Fume hoods connected to a VAV system
A VAV (Variable Air Volume) type fume hood adjusts the volume of air drawn in per unit of time, the flow rate, according to the position of the sash. The inflow rate into the fume hood varies depending on the flow rate. Sensors and especially the interaction between them play an important role in fume hoods connected to a VAV system. For example, there is a pressure regulator in the exhaust duct that measures the inflow velocity in the duct and controls the air flow rate via a damper in the exhaust duct according to demand. In addition, a sensor is present in the fume hood enclosure above the sash. This is a motion sensor that detects if an employee is in close proximity to the fume hood. Once the sensor detects movement, the sash moves into the validated working position and the exhaust rate is increased relative to the closed position of the fume hood window. This generally affects the majority of fume hoods positioned within renovated UNS50 laboratories. An advantage of using VAV fume hoods is that the room ventilation system can be used optimally and thus sustainably.

Tasks and responsibilities in fume cupboards
The FS (Facility Services) department is responsible for regular maintenance and for the annual inspections and validations of fume hoods. The most authoritative documents in this regard are the Dutch Practical Guideline for Fume cupboards (NPR 4500) and the European NEN-EN 14175.

The application of the use of fume hoods within the FHML faculty and the possible impact on (adjustments to) the technical functioning is the responsibility of the HSB department. This is monitored through RI&Es and audits. The HSB department gives instructions and information on the correct use of fume cupboards to the Armico's in the Armico training and during in-service training. The Armico then provides this instruction to all fume hood users within his/her department. The responsibility for the correct and safe use of a fume hood, cleaning and reporting a malfunction or technical defect lies with the user and with the responsible laboratory manager.

Substances to be used in a fume cupboard

The HSB department has developed a Safe Working Method within set frameworks within which the range of substances listed below, with or without limits, can be used safely provided the set rules are met. The vapor pressure (DS) and the health-related limit value (GW) of a substance are crucial in this.
These include:

- Acids
- Bases
- Volatile organic compounds (with a vapor pressure greater than 20 mbar and less than 250 mbar)
- Non-hazardous solids and powders.

→ The weighing of hazardous solids and powders (e.g. CMR substances) should be done in the VAS lab (Facility for Weighing Highly Toxic Substances).
→ Before using a (new) liquid that has a vapor pressure greater than 250 mbar, the HSB department should be contacted in order to make a risk assessment in advance, whether it is safe to work with this liquid in an appropriate fume hood.
→ For working with liquids with a DS lower than 59 mbar and a GW lower than 5 mg/m3 additional additional rules apply, which can be read in the remainder of this instruction under the heading rules for the safe use of a fume hood.

Rules for the safe use of a fume hood

Before work is carried out in a fume hood, the general rules and safety within a laboratory must be observed. The instruction “Working safely in laboratories of FHML/FPN” is leading in this regard. For example, wearing safety glasses, closed laboratory coat, closed shoes and gloves is mandatory for working at a fume hood.

The following conditions are of specific importance for optimal and safe use and thus optimal protection by fume hoods:

- The (protective) operation of a fume hood is checked regularly. This can be done simply by holding a strip of tissue paper in the sash opening. A much more accurate impression of the operation of the fume hood can be obtained by measuring the air velocity in the sash opening with a validated air velocity meter;
- The air flow pattern in the fume hood is affected by movement in front of the hood. This may cause contaminated air to exit from the cabinet. Therefore, walking in front of the fume hood should be avoided and unnecessary rapid movements should not be made when working in a fume cupboard. In this context, when setting up a new laboratory or rebuilding an existing laboratory, a fume hood should not be located near an (access) door or frequently used walking routes;
- The fume hood window should always be kept closed as much as possible or opened to the (validated) working position. In any case, while performing work, the head shall always remain protected by the sash;
- A fume hood in which work is being performed is not used as a storage area for equipment, chemicals and waste. Apart from the fact that a cluttered situation entails additional risks, a full fume hood cannot function optimally. Evaporation - often overnight - of disposable waste contaminated with volatile organic or health hazards is, of course, permitted;
- Disruption of airflow by larger arrangements is avoided as much as possible. To maintain adequate extraction over the work surface, it is recommended that such setups or large equipment be placed on cubes at least 10 centimeters in height;
- Work at least 20 centimeters inside the fume hood behind the plane of the sash. This is important for safety as a good work practice and prevents on swirling of air and thus exit of air outside the fume hood as demonstrated by smoke tests. The above relates to regular operations such as pipetting, transferring, decanting and so on. The safe working distance of 15 cm has been demonstrated by means of smoke tests.

Figure: Smoke tests during work in the fume hood ZK1 1.323 biochemistry in which smoke was blown into the sash opening of the fume hood was blown in at 3 different distances from the sash opening (left photo 10 cm, middle photo 15 cm and right photo 20 cm).

- Setups are placed as deep as possible at the back of the fume hood, while remaining easily accessible;
- A fume hood is not suitable for the extraction of harmful dust particles. Depending on the quantities and particle size, additional measures are required when working with harmful substances.
- The sash of the fume hood does not provide adequate protection in the event of explosions. Additional measures, such as the use of a face shield or explosion shield, are necessary when working with explosive substances.
- For liquids with a low limit value (< 5 mg/m3) and low vapor pressure (< 59 mbar), there are additional restrictions to work safely.
  These restrictions are:
  1. A duration of no more than 4 hours per working day is set for work in the fume hood, which may not be exceeded.
  2. All equipment and especially disposable gloves will remain in the fume hood during work and should remain in the fume hood for at least 12 hours after work is completed to evaporate. This means that gloves, if necessary, are changed in the fume hood and gloves (including non-contaminated and therefore clean gloves) do not leave the fume hood.
- If the automatic alarm of a fume hood is activated, the work should be terminated as soon as possible after closing open containers (bottles, tubes, etc.). The laboratory administrator should then be notified of the alarm.

If additional advice on this instruction or on working with certain substances in fume hoods is needed, occupational hygienists of HSB may be contacted.

Abbreviations List

ARMICO	Occupational Health and Safety and Environment Contact
CAV	Continuous Air Volume
CMR	Carcinogenic Mutagenic Reprotoxic
DS	Vapor Pressure
FHML	Faculty of Health, Medicine and Life Sciences
FS	Facility Services
GW	Limit Value
HSB	Health Safety and Buildings
Mbar	millibar
Mg/m3	milligrams per cubic meter of air
UNS50	University Singel 50
VAS	Lab Facility Weighing Highly Toxic Substances
VAV	Variable Air Volume