University of Pavia

Laboratory safety procedures

Hazardous chemical substances, gases, cryogenic liquids, Atex and equipment

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1. GENERAL LABORATORY STANDARDS

Personnel with access to laboratories should respect the following general standards:

- Strictly observe the general and the specific **operating procedures** as defined by the Activity Supervisor;
- Inform immediately the Activity Supervisor of any dangerous event and of any **malfunctioning equipment**, individual or collective protection device or emergency equipment;
- **never work alone** performing activities that, in the opinion of the Activity Supervisor, present a certain degree of danger, especially outside normal working hours;
- warn colleagues before executing any particularly dangerous operation;
- not approach any areas where hazardous operations are taking place, unless necessary;
- respect all **safety notices**;
- not introduce into laboratories items not strictly necessary for performing the activity (e.g. personal effects), especially bulky or easily flammable objects;
- always wear a protective **coat**; avoid coats in synthetic materials, especially acrylic, as they store static electricity and could cause a spark; further, in the event of fire, acrylic melts and adheres to the skin;
- always wear **safety goggles** when in the laboratory;
- keep all workbenches, fume hoods, instruments, equipment and machinery in a clean and orderly condition; before leaving the laboratory when

activities have concluded, ensure that all machinery used, except those necessary, have been switched off;

- observe fundamental hygiene standards (e.g. washing hands at the end of activities);
- do not use any containers that for the conservation of chemical substances lack a clear **label** and avoid leaving in the laboratory any non-identified materials;
- do not use containers or laboratory machinery (e.g. refrigerators) as containers for foodstuffs;
- do not smoke, it may cause fire.
- do not consume food or drink, do not chew gum and do not apply make-up;
- do not wear contact lenses as they may harbour harmful substances and, in the event of accident, may worsen the consequences and hamper first aid operations;
- wear closed shoes (do not wear sandals or perforated shoes) and, for certain operations (e.g. transfers of substances or the moving of heavy objects), safety footwear;
- wear long hair behind the neck;
- collect, separate and dispose of chemical waste correctly: **do not dispose of it in any sinks**.

2. CHEMICAL AGENTS

Chemical elements and their compounds, in their natural state or obtained through a manufacturing process, including the additives necessary to maintain their stability and the impurities that derive from the procedures used, are defined as 'substances' or 'mixtures'.

Hazardous chemical agents are substances or mixtures that correspond to the criteria relative to physical dangers, dangers to health, or to the environment, as defined in attachment I of the CLP regulations. Such substances are considered hazardous and classified in their respective classes as outlined in the attachment.

The use of chemical agents is reserved solely to those who have received adequate information and ***training*** on the correct procedures to be observed.

Handling

The use of chemical agents requires attention and respect of certain fundamental rules:

- always read carefully the **label** on the container as it provides fundamental indications on the hazards and precautions to be adopted; these indications are complementary to those on the **Safety Data Sheet**. This should always be consulted **prior** to using any hazardous chemical agent for the first time and each time the nature of hazards is unknown;
- consider as hazardous a product if its chemical-physical and/or toxicological properties are unknown;

- do not perform operations of any type if the potential effects are unknown; in the event of any doubt or uncertainty, always refer to the Activity Supervisor;
- do not leave **unattended** any incomplete chemical reactions unless the equipment being used is specifically designed to function in safety in the absence of an operator;
- have in place safety measures for particularly dangerous reactions (e.g. fugitive emissions), isolating them, if necessary, in specially designated and protected areas of the laboratory;
- do not substitute a product with another during an experiment or routine operation without the authorisation of the Activity Supervisor: every substance has physical, chemical and toxicological properties;
- use the personal protection equipment recommended on the Safety Data Sheet of handled substances and/or those suggested by the Activity Supervisor;
- work beneath a suitably efficient fume hood if the nature of the handled substance's hazard renders it necessary,
- do not sniff a product in order to identify it;
- use aspiration/erogation systems (e.g. pipette filler) rather than mouth pipettes.

Conservation

Keeping chemical agents in the laboratory in **quantities limited to those needed for ongoing experiments** is permitted. They must be stored in closed, preferably security, cupboards.
Open shelves should be avoided.

Any reserves should be stored separately, preferably outside, and suitably divided, equipped with fire protection measures and adequately ventilated (windows, forced ventilation systems); spaces adjacent to the laboratory may be used for the storage of products to be used during the working week.

Cupboards must be positioned away from corridors, work areas, laboratory access routes and rooms in general, emergency exits, open flames and heat sources (Bunsen burners, stoves, hotplates, etc.) and must not obstruct emergency equipment (extinguishers, first aid boxes, eyewash stations, etc.). Ventilated cupboards should be positioned so that air flows towards the exterior.

The reagents cupboard should be a cupboard with shelves in flameproof and acid-proof material. It should preferably be a secure cupboard (ventilated/fireproof) for certain categories of product (acids, bases, flammable and/or toxic substances), fitted with lockable doors; they should also be equipped with:

- shelves with a raised edge to prevent containers from sliding off and to contain eventual leaks or spillages; alternatively, tanks made from suitable materials may be used to store bottles and flasks;
- at least one collection tank at the base of the shelves;
- an indication of the product hazards via specific safety labelling;
- special fire resistance for cupboards containing flammable materials.

Each cupboard should also display:

- a list of the products stored within together with relative indications of the hazards posed and the date on with the list was updated;
- indications as to where the relative Data Sheets are kept;
- the name and telephone number of the Activity Supervisor/laboratory supervisor.

Inside the cupboard, the products should be arranged so that:

- corrosives, caustics and irritants are below eye level;
- larger containers and the most hazardous substances are placed on lower shelves;
- containers are not stacked above each other and the shelves are not overburdened;

- containers should carry the correct label with indications of the chemical name of the substance or mixture, its class and the hazard symbol;
- the specific indications on the Safety Data Sheet are respected (handling and storage section);
- reciprocal incompatibilities are respected;
- solids are kept separate from liquids;
- they are not in direct sunlight and away from other heat sources.

Some substances require particular precautions to be taken:

- flammable substances should only be kept in fire-resistant cupboards; substances to be stored at low temperatures must be kept in non-sparking refrigerators, that is without internal electrical contacts;
- highly toxic agents must be stored separately in locked, aspirated cupboards;
- for highly reactive products and those subject to a lowering in their chemical stability over time or when in contact with air (e.g. organic peroxides, perchloric acids) the date of acquisition and opening should be indicated on the label.

Transport and transfer of liquid chemicals

The moving, displacing and transfer of liquid chemical substances requires particular caution:

- solvents must not be transferred from vats to bottles in the laboratory; transfers must take place in suitable sites, away from the laboratory, and by personnel authorised by the Activity Director or Supervisor;
- metal vats containing flammable liquids must be earthed during transfers;
- plastic buckets fitted with a handle must be used to transport liquids stored in bottles and vats; for heavy weights, a trolley should be used;
- chemically incompatible products must not be transported at the same time, neither in the same bucket nor on the same trolley, e.g. oxidising substances and flammable liquids).

REACH
The new EU chemicals legislation

Labels and Safety Data Sheets

A substance or mixture **label** allows immediate and concise identification of the known chemical-physical and toxicological risks.

The following information can be found on the label:

- pictograms, black on a white background and red frame;
- hazard risk indicated by a 'H', that describes the nature of the risk;
- prudence advice 'P' that provides concise indications on how to operate in safety.

Information reported on the label concerns the main risks. Before using any product, it is necessary to observe and understand the label.

Data sheets (SDS) are comprehensive documents that provided all the necessary information. SDS are free, must accompany commercial hazardous products (CE Regulation 1907/2006 REACH) and are composed of 16 standardised entries in the language of the country the product is to be used. Data sheets contain the most important information in order to protect users and the environment from the risks deriving from chemical agents in the workplace. They must be updated each time something new is known about the properties of the chemical agent. Like the label, data sheets must also be consulted BEFORE beginning any handling of chemical agents. They may also be acquired before the supply stage so that risks can be evaluated and less hazardous products selected.

3. CARCINOGENS AND MUTAGENS

Carcinogens, mutagens:

- chemical agents classified by hazard risks:
  H350 – may cause cancer;
  H350i – may cause cancer by inhalation;
  H340 – may cause genetic defects;
- mixtures that contain more than **0.1%** of substances labelled with the above-mentioned hazard risks.

Handling

The use of carcinogens and/or mutagens requires prudence and the respect of several fundamental rules:

- minimise the number of operators who handle such agents;
- minimise the amount of agent used;
- isolate tasks using carcinogens or mutagens;
- flag hazards with the appropriate symbol (triangle featuring black skull on yellow background) and restrict access only to authorised personnel;
- use high-efficiency chemical fume hoods (C class, with a desired frontal velocity of 0.7 m/s) or dedicated glove boxes (especially for dust);
- use the personal protective equipment recommended in the SDS of the agent used or that suggested by the Activity Supervisor;
- for each contact, compile the dedicated daily use register of carcinogens and mutagens supplied by the university, respecting all the instructions (yellow register);

Conservation

After each use, store containers in a secure, locked, fireproof cupboard situated in a clearly signalled site away from the laboratory.

Separate carcinogens and mutagens from other chemical agents.

Emergency procedures

In the event of fire:

- do not intervene in any form;
- leave the site;
- contact the emergency team;
- advise fire crews of the presence of carcinogens and mutagens in the premises that caught fire;
- carry out assessments of environmental contamination before activities can begin again (refer to the *Servizio Prevenzione e Protezione*).

In the event of large spillages:

- the site should be declared unsafe until it has be cleaned and environmental decontamination measures have been taken;
- ventilate the site before any work is resumed.

In the event of intoxication:

- consult the data sheet of the product concerned.

Further provisions

Inform immediately the *Servizio Prevenzione e Protezione* of any new activity involving the use of these agents. The information form available at (http://www.unipv.it/safety) may be used for this purpose.

4. COMPRESSED, LIQUIFIED AND DISSOLVED GASES AND CRYOGENIC LIQUIDS

Based on their physical characteristics, gases may be classified as:

Compressed gas Fluid with a critical temperature lower than -10°C and transported in gas form compressed to a high pressure in dedicated canisters. The pressure depends on the quantity of gas introduced into the canister. Example: nitrogen.

Gas liquefied under pressure. Fluid with a critical temperature equal to or greater than -10°C that, in a canister, is in a liquid state in equilibrium with its gas phase, whose pressure depends on the temperature. Examples: Liquid Petroleum Gas, LPG (propane and butane and their mixtures), chlorine, ammonium, and carbon dioxide.

Dissolved gas. A gas dissolved in a dedicated solvent under pressure. Example: acetylene dissolved in acetone.

Cryogenic liquid or gas liquefied at low temperatures. Cryogenic liquids are fluids with a boiling point lower than –153°C that can only be liquefied at low temperatures. They are stored in thermally-insulated vessels. These may be distributed as a liquid or suitably vaporised at the end users'. Examples: liquid nitrogen, liquid helium.

Characteristics of storage containers

Container. In welded sheet steel; charging pressure of less than 20 kg/cm^2; capacity between 5 l and 150 l for storage and transport of liquefied gases.

Dewar flask. Containers used for the storage and transport of cryogenic fluids, made from materials able to withstand rapid and elevated variations in temperature. They are fitted with an airspace that must be kept empty to ensure the thermal insulation of the contents; they may be open to atmospheric pressure or fitted with valves and mechanisms to keep the contents pressurised.

Cylinders. Steel or light alloy tubes without welds; charging pressure greater than 20 kg/cm^2; capacity up to 150 l for the storage and transport of liquefied, compressed and dissolved gases.

For safety reasons, accurate identification of the gas is essential.

The main parameters for identification are:

- the colour of the cylinder collar;
- the stamp.

The colour of the cylinder collar does not usually identify the gas but the principal parameters associated to it.

The following information is also found on the collar:

- serial number;
- date of last test;
- the content;
- the reference standard and more.

The label is also present. Cylinder labels must respect the laws regarding transportation as well as the classification, packaging and labelling of hazardous goods.

It is attached to the cylinder collar and must be in excellent condition to enable it to be read easily.

It should be replaced if damaged or in poor condition.

Risks associated with use

The risks deriving from the use of gases is due, in part, to the chemical nature of the fluid itself and, in part, to its physical state, characterised by high pressure and/or low temperature.

The risks associated to the use of these agents results from their dispersion into the surrounding environment and the eventual accumulation, caused by unchecked or improper use or leaks resulting from accidental damage to facilities. The risk of the unintended development of gas due to chemical reactions should not be overlooked.

An accumulation of gas in any given space may result in the following consequences:

- risk of intoxication and damage to health (toxic gases and/or corrosives);
- risk of explosion and fire (flammable gases);
- risk of hyperoxia with an increased probability of causing an ignition of combustible substances;
- risk of asphyxia: (general risk, valid for all gases other than air and oxygen; accidental spillage of cryogenic fluids;
- uncontrolled increase in internal pressure with the possibility of damage, and eventual structural failure of the container itself, in the event of the sudden raising of the temperature of the containers;
- burns due to low temperatures, in the event of accidental contact with cryogenic liquids;
- uncontrolled reactions between incompatible substances in the event of accidental contact due to negligence, carelessness or accidental events.

Activities involving the use of gases and cryogenic fluids must be limited only to those who have received adequate information and training, from the Activity Supervisor, on the correct procedures to be observed. Further, all necessary technical and production precautions must be adopted in order to ensure the highest levels of collective protection, for instance, protective equipment devices (safety valves) and in the workplace (efficient ventilation systems, concentration sensors).
The Activity Supervisor must ensure that all operations respect codified and common standards.

Cylinder storage methods and handling

The Activity Supervisor and Centre Director are responsible for ensuring that any cylinders used in the laboratory for particular activities are not left unattended and are stored correctly after use.
Test expiry dates, indicated on the cylinder collar, must be checked on cylinders that have been used infrequently or which are owned by the university.

Each cylinder must be:

- stored vertically and securely fixed with a chain, belt or other suitable support, or on a trolley, to avoid accidents;
- stored so that the colour of the collar is not obstructed from view;
- clearly labelled “FULL IN USE”, “FULL IN RESERVE” or “EMPTY”;
- moved and stored (if not in use) with the protective valve cap in place and, for toxic gases, with the safety cap installed;
- moved using suitable trolleys with operators wearing safety footwear and work gloves, without dragging or rolling the cylinder.

Handling

The handling of compressed gas, liquefied gas, gases dissolved under pressure and cryogenic liquids requires care and attention and the respect of several fundamental rules.

General safety standards

- Follow the indications reported on the Safety Data Sheet that the company provides upon purchase; the sheets must be made available in the laboratory, divulged and studied by all users.
- Wear protective clothing appropriate to the level of risk associated to each gas and its physical state.
- DO NOT undertake any hazardous operation at the site where cylinders are stored.

Use of cylinders

- Check the exact nature of the gas in the cylinder.
- NEVER completely empty cylinders: leave some residual gas pressure.
- Close empty cylinders properly, repositioning the valve cap and, if necessary, the safety cap.
- DO NOT refill cylinders.
- DO NOT subject cylinders to treatment and events that may compromise their strength: thermal shocks, electrical arcs, impacts and falls.

- DO NOT use cylinders for any purpose other than that for which they are designed.

Operating the cylinder valves

- Open and close valves slowly and steadily.
- DO NOT tamper with or coerce valves using tools. Use only hand strength when both opening and closing.
- DO NOT use an open flame or incandescent materials to loosen frozen valves: use hot air.
- DO NOT open valves without first installing a pressure reducer, ensuring that the outlet fitting is free of dirt, oil or grease.
- Close valves after gas is delivered.
- Any malfunctioning cylinders should be safely stored outside the building, in an isolated and well-ventilated site. The Activity Supervisor should be informed and no attempts at repair should be made.

System maintenance

- DO NOT lubricate any part of the gas distribution equipment.
- Only use the outlet tubes that are specific to a particular gas.
- DO NOT operate pressurised outlet tubes.
- Ensure that cylinder valves are closed before removing the pressure reducer.
- Carry out leak tests using only soapy water or other foaming agents.
- AVOID elevated in-line pressures or elevated pressures in the pressure reducer during inactive periods.
- First close the cylinder valve, then the pressure reducer valve and, finally, the flow regulator or capacity regulator valve.

Specific procedures for liquefied gases

- AVOID cooling cylinders after elevated gas flows.
- AVOID instances of suction that may occur in stored cylinders and especially low ambient temperatures.

Specific procedures for toxic gases

- DO NOT move cylinders of toxic gas without a safety valve.
- Ensure that outlet tubes are kept in excellent condition.
- Store cylinders in locked cupboards, storerooms or bunkers.

Specific procedures for corrosive gases

- Disconnect cylinders after use and wash the kit with streams of dry nitrogen.
- Outlet tubes must be kept in perfect condition.

Specific procedures for gases heavier than air

- DO NOT store cylinders, even empty ones, in cellars or basements.
- AVOID leakages and stagnation in underground passages or basements.
- Ensure that there is no asphyxia risk by using low-oxygen monitors before accessing cellars, basements and underground passages.
- Ensure that there is no risk of explosion and/or intoxication before accessing cellars, basements and underground passages.

Specific procedures for oxygen and liquid oxygen

- Do not handle cylinders and oxygen and liquid oxygen distribution equipment with hands, gloves or clothing stained with grease or other flammable substances.
- AVOID placing ANY COMBUSTIBLE material into contact with liquid oxygen.
- Pay attention to the risk of impregnating and saturating porous clothing and materials that come into contact with oxygen.

Specific procedures for cryogenic fluids

- AVOID prolonged contact between liquid nitrogen and air: there is a risk of condensation and the formation of liquid oxygen.
- AVOID accidental contact with evaporated liquids and gases that are still at low temperatures.
- DO NOT touch with bare skin tubes and containers holding cryogenic liquids: there is a risk of frostbite.

- DO NOT spill unused cryogenic liquids into drains and onto the floor.
- Use only hot air to loosen frozen valves.
- Wear appropriate gloves, safety googles and shoe protectors during transfers.

Emergency procedures

Emergency procedures in the event of accidents constitute an indispensable system of protection from the risks associated to gas; such procedures must be made available to, and understood by, all operators. The Safety Sheets contain all the information necessary to carry out these procedures.

5. EXPLOSIVE ATMOSPHERES

The term 'explosive atmosphere' refers to a mixture of air, in atmospheric conditions, with flammable substances in the form gas, vapour, mist or dust in which, after ignition, the combustion spreads to the entire unburned mixture. The following zones, based on the frequency and duration of the presence of explosive atmospheres, have been defined (CEI Regulation 31/30).

- ***Zone 0.*** Area in which a substantial explosive atmosphere is **present permanently**, for extended periods or frequently in a mixture of air and flammable substance in the form of gas, vapour of mist.
- ***Zone 1.*** Area in which the formation of an explosive atmosphere, substantial in a mixture of air and flammable substances, in the form of gas, vapour or mist, is **probable** during normal activities.
- ***Zone 2.*** Area in which, during normal activities, **it is improbable**, for a substantial explosive atmosphere to form in a mixture of air and flammable substances in the form of a gas, vapour or mist or, if it does form, will be only for a brief period.

Given the extremely diverse activities undertaken in a university environment, the variation and the small quantities of substances used, it is difficult to predict the formation of potentially explosive atmospheres; such cases are likely to be accidental and take place in confined spaces (e.g. refrigerators, storage rooms). The greatest risk is connected to the presence of flammable gas (e.g. methane, hydrogen, acetylene). Particular attention should be paid to stores of flammable solvents, as well as to certain 'work spaces' represented by chemical fume hoods. As experience has shown, these may present a potential hazard due to the formation of explosive atmospheres depending on the efficiency of the suction and the nature of the agents used during particular activities.

Protection methods

The risk of an explosive atmosphere is communicated via warnings accompanied by other signs (e.g. prohibition on using open flames, having a mobile telephone switched on) in all areas classified as risky (zones 0, 1 and 2).

In all classified zones the following organisational-management interventions should also be made available:

- Specific operational procedures, in writing, regarding activities concerning the formation of explosive atmospheres (e.g. access to and conduct in laboratories and storage spaces; conservation, handling and transportation of flammable or explosive chemical agents and the use of particular equipment), providing adequate information to all operators, also via written instructions to be displayed at the sites concerned;
- limits on the concentration in rooms of flammable substances via adequate ventilation, both natural and forced, (e.g. open windows, use of hoods, recirculating air systems); the substitution of flammable substances with inflammable substances where possible;
- avoid the accumulation of dust as layers, deposits and clouds of combustible dust are considered to be another potential source for an explosive atmosphere;
- periodically check the condition of safety devices (outlet tubes, valves, reducers) fitted to flammable gas distribution equipment and the condition of electrical appliances;
- regulation of access and participation in particularly risky activities with the direct supervision of qualified personnel.

6. HAZARDOUS EQUIPMENT

The term 'hazardous equipment' refers to those which, during their normal functioning, have moving parts, are live, have high operating temperatures, involve the use of water, are pressurised or operated in a vacuum.
To follow is a list of the general and specific provisions to be observed when using hazardous equipment.

General provisions

- use only **certified equipment**: the CE symbol for recent acquisitions or, for older equipment, a certificate confirming the regulation is respected; all new machinery or equipment to be purchased or acquired free of charge must display the CE mark;
- before using any equipment, read carefully the dedicated **instruction manual** and the operating procedures that may, eventually, be provided by the Director or Activity Supervisor, who are responsible for the training of personnel who use the equipment;
- dedicated **signs** must warn of potential hazards associated to each piece of equipment and the relative prevention and protection measures to be adopted (e.g. prohibitions, obligations);
- a dedicated logbook should report periodical checks and maintenance of the equipment used, as planned by the manufacturer;
- knowledge of where **cut-off systems** connected to the equipment are located. These can be actioned in case of need (e.g. circuit breakers, valves and taps on gas lines, control valves on the plumbing system);
- whenever, provided safety regulations are adhered to, equipment is left unattended, the following information must be left: the date and telephone number of the experiment supervisor, the type and duration of the experiment, the substances and materials in use and details on how to switch off the equipment in the event of an emergency;
- evaluate the risk associated with the ongoing experiment and the relative counter-measures in order to be prepared in the event of an emergency situation.

Specific provisions

Electronic equipment and devices

- protect power supply cables from accidental damage and wear (e.g. crushing, cutting, corrosion, heat);
- avoid using extensions, the use of power strips, extension sockets and plug adaptors;
- protect all electrical connections from accidental contact with water or other conducting materials.

Equipment with moving mechanical parts

- mark and keep the area clear; the area may be blocked off using fencing fitted with micro-switches;
- securely fix the moving parts and accessories; anti-vibration systems may be employed, especially where glasswork is concerned;
- evaluate the effects of vibration on the equipment, accessories and devices and on the surrounding work area.

Equipment with glass and glasswork

- substitute, wherever possible, equipment in glass with that constructed in plastic or metallic materials;
- carefully check equipment before each experiment, ensuring that it is free from defects and cracks;
- before any operation, ensure that the glasswork is perfectly intact; glasswork that has been used frequently and exposed to ultraviolet rays or thermal stress tends to become fragile;
- assemble and use glass equipment so that mechanical tension and/or vibrations is avoided;
- avoid sudden changes in temperature; the use of open flames is highly discouraged, blankets or electrically-heated baths are favoured;
- use glasswork that is designed for a specific purpose (e.g. Pyrex if it must be heated or used in an oven);
- provide adequate shielding for glasswork equipment that operates in a vacuum, under pressurised conditions and that has moving parts;

- place a tray under glasswork equipment that contain hazardous chemical agents to collect the material in the event of accidental breakage;
- protect hands with cut-resistant safety gloves and always wear safety goggles and a face mask;
- transport glass vessels (e.g. bottles, flasks) by supporting them from below or using containers;
- place broken glasswork and shards of glass in the dedicated rigid containers, using cut-resistant safety gloves, pincers (not bare hands), a dustpan and broom to do this; glass that has not been contaminated with chemical agents, or other substances, must be recycled by placing it in the appropriate bin.

Equipment with high temperature parts

- use heating equipment with the temperature controlled by a thermostat and safety systems;
- mark hot parts, especially during cooling periods after use, on heating equipment like blankets, hotplates and baths;
- check the heat resistance of materials that come into contact with, or are subject to, the action of heat sources and that are in the vicinity (e.g. workbenches, shelves);
- provide and use thermal gloves to protect the hands.

Equipment and devices involving the use of water

- regulate the pressure and flow to the characteristics of the equipment, taking into account the effects of eventual changes in water supply in certain conditions (e.g. increased pressure during nocturnal hours);
- secure the ends of pipes with clips so that uncontrolled jets of water are avoided should joints fail;
- avoid contact between water and any live parts (e.g. electrical equipment, sockets), fluids at high temperatures (e.g. oil baths), incompatible substances that may react violently or result in hazardous products,

providing for any possible accidental event including the failure or breakage of pipes, damage to the apparatus, above all to glasswork etc.

Equipment using methane gas

- limit the use of open flames in the laboratory – blankets or electrically-heated baths should be used as an alternative;
- only use equipment that is fitted with a safety lock tap, a safety thermocouple and flexible connecting tubes that conform to UNI-CIG regulations, to be substituted every 5 years;
- know the location of the cut-off valve on the methane gas supply line;
- isolate the workspace within the laboratory where an open flame is being used to at least 150 cm from all flammable materials (e.g. organic solvents and paper);
- only use methane gas under a fume hood.

Equipment operated in a vacuum or in pressurised conditions

- carefully check the equipment whenever it is to be used, checking that it is free from defects, cracks or damage;
- use only parts and accessories designed for use under pressurised conditions or in a vacuum, especially when using glasswork parts;
- use the appropriate measures to ensure that all joints and flanges are secure and that these can be easily and safely dismantled, especially the glasswork parts;
- adequately shield the equipment in order to separate it physically from the user and the surrounding area;
- wear safety googles and use a face shield;
- provide information regarding the procedure to safely restore atmospheric pressure;
- use autoclaves only if specifically trained to do so.

7. PROTECTIVE EQUIPMENT

Collective protection devices (DPC)

The principal collective protection device, designed to safeguard the health of operators who use and handle hazardous chemical agents (vapours, fumes, aerosols, dust) in laboratories is the **chemical fume hood** and relative suction systems. These systems protect operators from splashes, fire or explosion, injuries and damage to health by efficiently removing vapours, gas and dust that may spread during the activity and by reducing, to a minimal level, the dispersion of hazardous substance in the workspace.

Chemical fume hoods should also be considered a potential hazard as, internally, extremely flammable, explosive or toxic atmospheres may develop. This is why hoods must be kept in excellent condition; the efficiency of the entire system must be checked before installation, and during its working life, through periodic checks.

Fume hood classification

At the University of Pavia, chemical fume hoods are classified as follows:

Frontal velocity (metres/second)	Class	Usable chemical agent
Vf < 0,3 m/s	**NC**	None
0,3 m/s ≤ Vf < 0,4 m/s	**A**	Low-toxicity chemical agents (e.g. harmful, irritants)
0,4 m/s ≤ Vf < 0,5 m/s	**B**	Medium-toxicity chemical agents (e.g. toxic agents)
Vf ≥ 0,5 m/s	**C**	High-toxicity chemical agents (e.g. highly toxic agents, carcinogens, mutagens)

Operating procedures

Operators must observe the following procedures in order to correctly use aspiration systems:

- **Check that the hood is switched on and functioning**. Before beginning any activity, check that the switch is in the 'ON' position. When the hood is not in use, turn off the suction and the close the front flap. An on light does not indicate that the hood is functioning.
- **Introduce only necessary materials**. Position all the objects in the workspace, at least 15-20 cm from the frontal aperture and at least 5 cm from the back wall. Large objects should be raised at least 2 cm, using spacers, from the worktop to allow air to circulate underneath.
- **Lower the sash window to the working position**. Always keep the window lowered to the working position. Raising the front is allow permitted for introducing or removing equipment and while setting up the hood at the beginning and end of the activity. In any case, the hood must only be raised after leaving it switched on for a few minutes to eliminate contaminated vapours present in the working area. The window should be fully lowered whenever the operator is absent, even if this is only for a few seconds.
- **Never place the head into the hood.** Dangerous concentrations of gas and toxic vapours may develop in the work zone that may, if inhaled, cause sudden loss of consciousness. Always raise the sash window and glass sections slowly; never suddenly.
- **Always work inside the hood**. Always maintain a working position that is at least 15-20 cm from the opening. Draw a line in indelible ink or apply adhesive tape to mark this distance.
- **Always use personal protection equipment**. Chemical hoods only protect from the risk of inhalation. Always wear goggles and gloves that an appropriate to the substances. Never lean against the edge of the worktop with a fastened lab coat; hands, forearms and the upper part of the body are to be considered potentially contaminated.
- **Minimise air currents behind operators**. When working at a chemical hood, ensure that there is not an excessive flow of people behind the operator nor the presence of air flows that derive from cooling/heating systems; check that doors and windows are closed in order avoid air currents that may alter the position of the protective window.

- **Check the materials introduced in the fume hood**. Ensure that there are no vessels containing chemical substances incompatible with those to be used during the activity. If flammable or explosive substances are to be used, check that there are no electrical plugs or devices, inside the hood, which might create a spark or flame. Place all electrical connections outside the hood.
- **Clean the hood after work has ended**. Not only is it polite to leave the hood in a clean condition but it is also of fundamental importance in terms of safety. All hood surfaces should be considered as being potentially contaminated.
- **Do not remove or modify hood components**. Do not obstruct the rear aperture at working height: it is fundamental that air suction at the working height is guaranteed.
- **Immediately report any anomalies**. Immediately inform the laboratory supervisor and colleagues of any anomalies that are encountered, or suspected, in the functioning of the hood.
- **Check the *Servizio di Prevenzione e Protezione* label**. Always use hoods that are suited to the class of substance used (e.g. C class hoods for very toxic substances).

Ductless fume hoods

For ductless fume hoods fitted with filters, it is necessary to:

- keep a register in which the following are reported: type of filter, principal chemical agents used, hours of use, substitution date;
- use the hood at its maximum suction speed only in emergency situations (e.g. spillages of chemical products on the worktop): excessive suction speeds prevent the hood from adequately absorbing the pollutant;
- use filters suitable to the substances used;
- periodically check any eventual automatic sensors of filter saturation.

Personal protection equipment (PPE)

Personal protection equipment is the final step in protecting operators, whenever prevention measures adopted (reducing hazards at source, substituting dangerous materials and procedures with less dangerous ones,

isolating the most hazardous activities, introducing forced ventilation systems and localised suction devices) are not sufficient in reducing the risk to a level that renders other protection measures superfluous.

Selection criteria and training

Activity supervisors must select personal protection equipment and make it available to operators. If necessary, they may contact the *Servizio Prevenzione e Protezione* for advice.

Each Personal Protection device must be accompanied by the appropriate documentation (declaration of conformity from the manufacturer, a CE mark, informative sheet issued by the manufacturer).

The Safety Data Sheets of chemical products used provide an essential indication as to which types of Personal Protection equipment should be used in their handling.

Eye and face protection

Safety goggles are always compulsory in any chemical laboratory, that is where reactions and experiments of any type take place. They are also obligatory for those assisting in operations.

For especially hazardous operations, which may involve splashes or involve substances that can penetrate the eye or skin of the face (e.g. corrosive, caustic, explosive substances and the use of pressurised equipment or in a vacuum, and cryogenic gases) a **face shield** is indispensable whenever working under a fume hood with a lowered sash window is not possible.

Respiratory tract protection

In the event that an operator is exposed to:

- dust, gas, vapour or aerosol in high concentrations and/or in closed or poorly-ventilated spaces;
- smoke from a fire,

a **gas and/or dust mask** specific to the substance handled must be used. In the event of exposure to more than one substance, or during a fire, a polyvalent filter should be used.

A full-face mask is preferable to a half-face mask as it protects the whole face from coming into contact with hazardous agents.

Masks fitted with a filter must only be used if it is certain that the quantity of oxygen in the air is greater than 17%, otherwise breathing apparatus should be employed.

Masks should adapt to the face without causing discomfort or friction but should, nonetheless, be a perfect fit. To check the fit, the operator, before inserting the filter, should close off the inspiration valve using the palm of the hand and then breathe in: a well-fitting mask should not allow the passage of air.
Operators should always refer to the user instructions supplied with the equipment and to the indications given by the activity supervisor.

The filter should be connected correctly to the mask and opened only at the moment of use.

If reusable, masks should be cleaned after each use, following the instructions provided by the manufacturer. Masks used by more than one person should be disinfected as well as cleaned.
Filters must be replaced when empty and, in any case, when used infrequently (they have a factory-set expiry date).

Masks and filters must be conserved in dry places, away from heat sources, sunlight, dust and contaminated environments.

Protection of hands and arms

Gloves are used to protect the hands and arms. These must be *specific to the type of procedure carried out and to the substance used*. They must be used in the event of:

- the handling of chemical agents that can easily penetrate the body through the skin, or react with skin;
- work at low or high temperatures (e.g. cryogenic substances/stoves/hot blankets);
- the handling of sharp objects.

Gloves must be:

- suited to the handling of the substance used (as indicated on the relative Safety Data Sheet);
- one size larger than those usually worn by the operator when used for transferring cryogenic liquids or other hazardous liquids. This is to allow them to be removed quickly and easily in an emergency;
- checked before being worn (grip check)
- worn **above sleeves** so that any drops of liquid are not conducted under the lab coat.
- worn in a double layer (one pair above the other) when using particularly hazardous substances, e.g. carcinogens and mutagens;
- dried and later washed before being removed whenever they need to be reused;
- removed before answering the telephone, opening doors, consulting texts etc., in order to avoid contaminating the work environment;
- replaced if worn for an extended period and, in any case, based on the permeation time and the effective protection duration;
- cleaned and stored in a secure place and, if disposable, placed in the appropriate container.

Other protective clothing

Laboratory coats must be worn for work in a chemical of chemical-biological laboratory.

Safety shoes with reinforcements must be worn when moving heavy loads (e.g. canisters or vats of liquid).

For certain tasks, which involve exposing the entire body to particularly aggressive chemical agents, (e.g. pesticides), or when working in extremely high or low temperatures, **protective aprons** may be worn and, in the most demanding situations, **dedicated protective overalls**.

8. EMERGENCY PROCEDURES

The *Servizio Prevenzione e Protezione* must always be informed of emergencies regardless of whether individuals have been harmed. The form to report incidents can be found on the website at: www-3.unipv.it/safety/index.php?pag=modulistica/pps.html

Emergency equipment

In each laboratory, or group of laboratories (adjacent spaces and/or small spaces), the following must be present:

- eye wash facilities (fountain or spray with saline solution);
- a fire blanket;
- a kit for the absorption and neutralisation of chemical substances;
- a gas mask with a universal filter.

Each floor of the building that houses at least one chemical or chemical-biological laboratory must have at least one **emergency shower** and a **first aid room**.

All emergency facilities must be:

- indicated by appropriate signs;
- quickly and easily accessible;
- checked periodically and kept in efficient working condition.

Spillage of chemical products

In the event of chemical spills:

- consult the Safety Data Sheet of the spilled substance before taking any action;
- put on the appropriate Personal Protection clothing for the spilled substance, as indicated on the Safety Data Sheet;
- isolated the affected area;
- raise the alarm and report the incident to the emergency team in the event of large spillages and/or of especially hazardous substances (e.g. highly toxic agents, carcinogens and mutagens and highly flammable liquids).

Flammable and toxic liquids

- use an extinguisher in the event of fire, employing the appropriate extinguisher as indicated on the Safety Data Sheet;
- first spread the absorbent around the spilled liquid and then over it;
- place the absorbed material into the proper container and send it to be disposed of.

Corrosive liquids

- Absorb or, preferably, neutralise the agent;
- place the absorbed or neutralised material into the proper container and send it to be disposed of.

Solid toxic agents

- dampen the material with a suitable liquid (paying attention to incompatibilities) and place everything into a plastic container;
- alternatively, suction the material after it has been filtered.

Personal contamination

- refer to the information provided on the Safety Data Sheet;
- use an absorbent paper towel to dab the area of skin or clothing affected by the spillage;
- remove any contaminated clothing (cutting is an most effective method) using protective equipment (mask, gloves etc.); place all objects into plastic bags to prevent contaminating other objects and areas; pay attention not to contaminate the eyes, mouth or nostrils;
- cut any contaminated sections of hair but do not, under any circumstances, shampoo the hair;
- wash under running water (do not use hot water) only areas that have come into contact with the substance and only after having carefully removed it with an absorbent paper towel, taking care not to spread the contamination and paying attention not to damage the skin; rinse the eyes several times with water or a saline solution; do not ingest liquids or medicines of any type.

Injury and intoxication

- Report the incident to the first-aider;
- Accompany the injured person to hospital with the Safety Data Sheet of the substance in question or the exact name of the substance (or its CAS number).

Final procedures

- check that the cause of the spillage has been eliminated;
- thoroughly clean all surfaces affected by the spillage;
- ventilate the area before re-commencing any activities.

Gas leaks

In the event of fire

- cut off the gas supply to the laboratory or entire building;
- cool cylinder casings in order to prevent them exploding;
- place any cylinders close to the emergency area in a secure zone;
- raise the alarm and contact the emergency team.

In the event of leak of flammable gas or fuel or combustion air

- if possible, cut off the gas supply (do not attempt to extinguish the flame if the leak has not been tapped);
- extinguish any eventual naked flames;
- open windows only if doing so will not create greater damage (the formation of an explosive mixture)
- leave the site and close the door;
- cut off electrical supply to the affected site (only if the switch is located outside the affected area);
- raise the alarm and contact the emergency team.

In the event of leak of toxic or inert gas

- cut off the gas supply;

- open the windows and activate the site's ventilation systems (hoods, forced ventilation);
- leave the site and close the door;
- raise the alarm and contact the emergency team;
- allow some time to pass before re-entering the site;
- re-enter the site in the presence of at least one other operator who must say outside the affected space, ready to intervene.

In the event of injury or intoxication

- report the incident to the first-aider;
- refer to the information provided on the dedicated Safety Data Sheet;
- Accompany the injured person to hospital with the Safety Data Sheet of the substance in question or the exact name of the substance (or its CAS number).

Final procedures

- check that the cause of the leak has been eliminated;
- ventilate the site before re-commencing any activities.