LABORATORY SAFETY GUIDELINES

Version 1

October 2019

UNIVERSITÀ DI CAMERINO

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1. INTRODUCTION

Safety and health at work are the right of every employee, and, in order to be guaranteed, they require compliance with certain duties. The duties fall, as far as pertinent, on all the members of the organisational line, who are involved, directly or indirectly, in the exercise of the various activities that are carried out daily at Unicam. This organisational line is made up of: Employer, Director, Foreperson, Employee.

In the university system, the Employer is the Rector, the Directors are Directors of the Schools and Unicam Managers, the Administrative executives in charge are the Heads of the departments and divisions who implement the Employer's and the Directors' directives on safety, while the Employees are all the persons (with permanent or temporary contracts) who work in departments: Teachers, Technical-Administrative Staff, PhD students, Research Fellows, Contractors, Undergraduate Interns and Students.

In addition to these roles, envisaged by regulations on safety in the workplace, the role of the Head of Laboratory is also identified and appointed, and responsible for implementing the Employer's directives on Safety, in collaboration with the Director or the Administrative executive in charge.

In laboratories, be they research, analysis, or teaching laboratories, safety is a fundamental aspect of the methods of carrying out the activities. It is up to, not only the School Directors and Managers, but above all, the Administrative executives in charge and the Employees, each according to their skills, to endeavour to ensure the creation and maintenance of safety conditions.

The types of risks potentially present in Unicam laboratories are linked to a series of factors, including, for example:

- Risks represented by the materials used: dangerous substances - toxic, harmful, corrosive, carcinogenic, capable of causing irreversible effects, capable of exploding, flammable, etc.), hazardous biological agents, radioactive materials, etc.;
- Risks represented by the equipment: electrical equipment, moving mechanical parts, pressure and vacuum systems, equipment at high or low temperatures, etc.;
- Risks represented by facilities, premises, plants, furnishings (scarcity or misuse of spaces,

crowding, unsafe gas distribution, work surfaces consisting of unsuitable benches, cabinets and hoods, etc.);

- Risks represented by inadequate training of operators (both permanent and temporary staff).

The risk levels may be different, in relation to the specific situations present, and are essentially linked to the extent of the possible damage and to the probability that the harmful event will occur. The level of risk may be reduced by means of information and training, which lead to awareness of all the aspects connected with the work activity. Correct operation reduces the possibility / probability of the occurrence of a hazardous event, or at least prevents its occurrence from causing serious damage. These Guidelines contain general indications regarding conduct in laboratories, and represent minimum measures to be followed. They are addressed to all staff, both permanent and temporary, who work in the laboratories of the Unicam facilities (students, research fellows, PhD students, technicians and teachers).

2. GENERAL PRINCIPLES

2.1. PARTICULARS

All activities, including those that take place in research, analysis or teaching laboratories, are subject to safety laws and regulations and must be taken into consideration already from the activities planning stage; if necessary, it is possible to contact Unicam Prevention and Protection Service for any clarifications or advice.

2.2. INFORMATION

Head of the Laboratory has the obligation to provide information to the staff working in the laboratory under his/her supervision, including students, interns, research fellows, guests, and other non-permanent staff members; these subjects are required to follow the indications of the Head of the Laboratory and of the Administrative executive in charge. The instructions provided must be in relation to the specific activities that will be carried out in the specific laboratory and must ensure that everyone is informed about the following:

- specific risks relating to the workplace and to duties;
- possible damage deriving from the use of equipment or dangerous substances without due precautions;
- prevention and protection measures to be implemented in each specific situation;
- firefighting measures, escape routes and emergency plan.

The Head of the Laboratory, in collaboration with the School Director and the Administrative executive in charge, is required to provide all instruments needed to achieve these purposes, including the delivery of this manual to each person who intends to operate in the laboratory, and is also required to supervise the correct application of prevention and protection measures by all visitors to the laboratory, with particular attention to students.

All staff, permanent and temporary, related to the laboratory must:

- refer constantly to the Head of the Laboratory of their pertinence;
- respect the current operational safety standards and submit to all the provisions that are issued for the purposes of collective and individual protection;
- report immediately to the Head of the Laboratory, the School Director or the Administrative executive in charge any malfunction of the prevention and protection measures.

In particular, the non-permanent staff members related to the laboratory must:

- actively collaborate with permanent staff members in order to keep the implemented safety system efficient;
- participate in all courses aimed at safety and health organised by the department;
- read these guidelines before entering the laboratories.

2.3 EMERGENCY AND EVACUATION PLAN

Before entering a workplace, it is advisable to read the Emergency and Evacuation Plan relating to that specific workplace, the methods of evacuation and the arrangement of escape routes.

3. GENERAL RULES OF CONDUCT

In order to behave correctly in the laboratory, the operators (teachers, technicians, undergraduate interns, research fellows, PhD students, etc.) must be able to interpret the safety signs and the labelling of chemical products. They must also be informed on the rules contained in these Guidelines, on the procedures to be adopted in emergency situations, on where the safety data sheets of the materials used and the manuals of the equipment to be used are placed and made available.

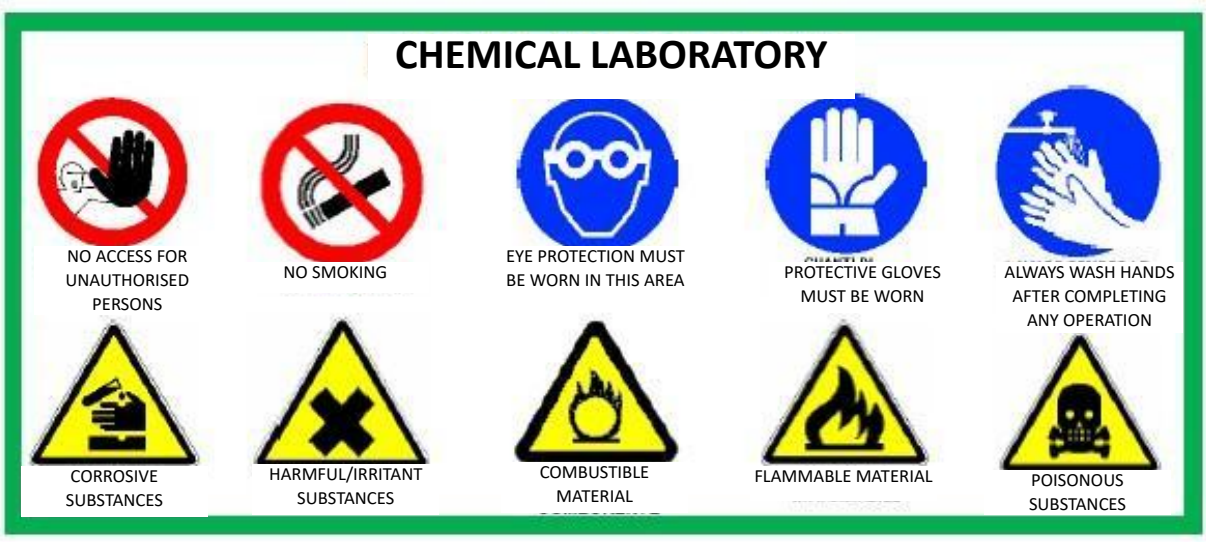
3.1 FIRST ACCESS TO THE LABORATORY

Access to a scientific laboratory is allowed only to the staff authorised by the Head of the Laboratory.

When accessing a laboratory for the first time, you must:

- read the sign poster at the entrance, bearing the name of the Head of the Laboratory, and the emergency telephone numbers (Head of the Department, Fire and Rescue Service, Concierge, etc.);
- read any hazard and safety symbols present;
- inquire about the presence and location of safety devices (first aid kit, fire extinguishers, eye showers, exit routes, emergency stairs, etc.);
- inquire about how to access the available documentation (safety data sheets, manuals, disposal procedures, laboratory regulations, etc.);
- be informed about general conduct procedures in laboratories.

Example of a sign poster that may be found at the entrance of a laboratory



3.2 GENERAL OPERATING MODES

- The laboratory user must comply with all the rules defined by The Head of the Laboratory (safety standards, waste disposal, instrument reservation, etc.).
- The users must not use equipment or devices the correct use of which they are not familiar with, or for which they do not know how to intervene in the event of an emergency or malfunction.
- In the case of the use of electrical equipment, the users must ensure that they are connected to the electricity grid correctly, maintaining the connection with the earthing system, and absolutely avoiding any tampering and intervention on the electrical system.
- The users must never leave unattended dangerous equipment in operation.
- The users must not block or obstruct in any way the emergency exits, fire-fighting and rescue equipment, the electrical panels and the panels containing the interception and regulation devices for fluids (gas from cylinders, methane, water).
- The users must report any failure, malfunction or safety issue to The Head of the Laboratory.
- The users ,must report any incident, even if it is not serious, to the Administrative executive in charge.

3.3 SPECIFIC OPERATING MODES

During the daily laboratory activities, the operators must always apply the following specific indications useful risk minimisation and safe operation.

1. Read carefully in advance both the labels on the containers and the safety data sheets of the products you intend to use, with particular reference to the hazard symbols and Hazard statements H, and the Precautionary statements P of the CLP regulation (*appendices A and B*)
2. Always use Collective Protective Equipment (CPE) (cabinets, hoods, localised aspirators, screens, etc.) envisaged for the operations you are carrying out.
3. Always use Personal Protective Equipment (PPE) appropriate for each type of risk (gowns, gloves suitable for the agent to be handled, safety glasses, visors, masks suitable for the agent to be protected from, footwear, etc.), which must be used correctly and always kept in a good state of maintenance, notifying any deficiencies to the Head of the Laboratory and the Administrative executive in charge.
4. The lab coat and other clothing worn may retain a fair amount of toxic substances and transmit them by inhalation or skin absorption. Therefore, it is recommended to wash your lab coat or other protective clothing frequently and separately from other personal clothing, preferably in specialised laundries.
5. Always correctly label all containers, even and above all if they contain substances diluted or mixed with other products, in order to be able to recognise their content and hazards at all times. If you intend to reuse a container previously used for products other than those you intend to use it for, drain it carefully, completely remove the label relating to the old product, and apply the label for new one.
6. Always keep all containers with hazardous products and substances tightly closed.

7. Do not leave unidentifiable material in the work areas.
8. Do not leave unattended ongoing potentially hazardous chemical reactions or experiments (they must be interrupted in the absence of personnel, unless the necessary safety precautions have been taken, prepared by following specific procedures).
9. Do not work alone in the laboratory in hazardous situations (dangerous substances, equipment or reactions, high pressure boxes, cold cells, etc.); inform other persons present in the laboratory about the dangers or critical issues of the experiment that you intend to carry out.
10. Keep your workplace clean and tidy. Cleanliness reduces any possible contact with dangerous substances, tidiness reduces the possibility of causing accidents, such as the overturning of containers or glassware, or accidental mistakes in the use of substances; Finally, an orderly workstation makes intervention in the event of an accident easier.
11. Avoid the excessive presence of appliances, tools and materials on the worktops. Promptly remove glassware and equipment when it is no longer needed.
12. Avoid storing unnecessary chemicals.
13. Collect, separate and properly eliminate any chemical, solid and liquid waste produced in the laboratory. *It is absolutely forbidden to discharge into the sewer or, in any case, to leave chemical or biological residues of any species in the environment, whatever their origin may be.*
14. If it is necessary to transport, on long journeys, dangerous liquids (flammable, corrosive, toxic, etc.) contained in glass containers, they must be inserted in special containers. This operation facilitates their transport and, in case of breakage of the container, provides a containment action.
15. It is forbidden to consume food or drinks in the laboratories; avoid, even for a short time, storing any foodstuffs intended for consumption in the laboratory. The risk of contamination also affects candies, chewing gums, cigarettes present in the pockets of lab coats. Do not use laboratory containers as food containers.
16. Do not bring in the laboratory materials and objects unrelated to the working activity (coats, jackets, bags or backpacks) which can carry out potential dangerous substances; it is also forbidden to wear coats or jackets or other clothing over the lab coat, so as to avoid obvious contamination.
17. It is absolutely forbidden to keep the gloves on outside the laboratories; even inside the laboratories, do not touch the door handles, computer keyboards or the control panels of instruments with gloves with which dangerous substances have been handled..
18. Always check whether particular work processes require the application of specific operating procedures (e.g. operations in cold rooms, operations with appliances under pressure, operations at very high temperatures, with cryogenic liquids, etc.).
19. Avoid wearing contact lenses as they can cause an accumulation of harmful substances; moreover, in the event of an accident, they can worsen the consequences or jeopardize first aid operations.
20. Avoid wearing high heels and open shoes. Where provided, use the appropriate accident-prevention footwear; long hair should be kept tied. Jewellery, especially if dangling, (earrings, bracelets, necklaces) could represent risk factors.
21. Do not smoke.
22. **Always report any unsafe conditions or accidents promptly to The Head of the Laboratory, even if there were no consequences.**

4. DANGEROUS SUBSTANCES: CLASSIFICATION AND LABELLING

A ***substance*** consists of a chemical element or its compounds in their natural state, or obtained by means of a production process. The substance normally includes the additives necessary to maintain its stability, and impurities deriving from the production process, while solvents are excluded. A ***mixture or preparation***, on the other hand, is a homogeneous system obtained by intimately mixing two or more different substances, each of which retains its own chemical structure.

Substances and mixtures can be divided into four hazard groups:

1. Not hazardous. In these cases no special precautions are to be taken.
2. Not hazardous but used in conditions that could be dangerous (e.g. high temperature water, compressed air). In these cases, the hazard is not of a chemical nature but mainly derives from the alteration of physical variables, such as temperature, pressure, concentration, or from particular conditions of use.
3. Hazardous but not classified by the rules on the classification, labelling and packaging of hazardous chemical products (e.g. degraded, smelly or infected organic materials, waste water with biological risk, or materials and products excluded from the regulations, such as drugs, waste, etc.). Not all dangerous substances are regulated by the same rules used for the treatment of "traditional" chemical products.
4. Hazardous as indicated by the rules on classification, labelling and packaging of hazardous chemical products (this group includes most of the chemical substances and preparations normally present in the workplace).

The classification systems for dangerous substances change according to whether they are designed to be applied to the transport or use of the products. This distinction is due to the different effects deriving from exposure to hazardous products: occasional for transport and prolonged over time in the areas of use, consumption and distribution.
With **regard to the transport of dangerous goods,** the UN has issued a model regulation called "Recommendations on the transport of dangerous goods", which specifies the criteria for classification, labelling and packaging of dangerous goods. Based on the UN recommendations, a series of international regulations has been defined regarding the various modes of transport (mode regulations), in particular: the ADR for road transport in Europe; the RID for carriage by rail in Europe; the ADN (and ADNR) for inland waterway (river) transport; the IMDG Code for maritime transport (IMO) and the ICAO T.I. for air transport. The pictograms to be included in the UN hazard labels for the transport of dangerous goods are shown in Appendix C. *Since they also appear on the outer packaging of packages, it is good that they are known to users who receive the goods*..

The classification, labelling and packaging of dangerous substances and mixtures within the European Union is governed by the European regulation EC No. 1272/2008 (called the CLP regulation - Classification, Labelling and Packaging of substances and mixtures), which incorporates the *classification criteria and labelling rules of the United Nations Globally Harmonized System (GHS).* The CLP regulation is legally binding in all Member States of the European Union, it has replaced the existing regulation based on Directive 67/548/EEC (DSD - Dangerous substances Directive) and Directive 1999/45/EC (DPD - Dangerous Preparations Directive).

4.1 EC REGULATION NO. 1272/2008 (THE CLP REGULATION)

The classification governed by the CLP regulation is based on a hierarchical structure consisting of hazard classes and categories. The classes identify the nature of the hazard, and the categories indicate different levels of hazard, within the same class (e.g. categories 1, 2 and 3). The categories are numbered in descending order of danger. In some cases there is a further subdivision into distinct subcategories by means of letters (e.g. 1A, 1B and 1C). CLP also uses other types of groupings called "division" for explosives, "type" for self-reactive substances / mixtures and organic peroxides, and "group" for gases under pressure. These terms come from the UN recommendations for the transport of dangerous goods; in these cases the classification criteria do not refer only to the danger deriving from the intrinsic properties of the material.

In the CLP regulation, a total of 28 hazard classes are defined: 16 physical hazard classes, 10 human health hazard classes, one environmental hazard class, and one additional class not present in the GHS system. This class, called "*hazardous to the ozone layer",* has been added as it was already present in the previous European classification and labelling system consisting of directives 67/548/EEC and 1999/45/EC.

Physical hazards

1. Explosives (Unstable explosives, Divisions 1.1,1.2,1.3,1.4,1.5 and 1.6)
2. Flammable gases (Categories 1 and 2)
3. Flammable aerosols (Categories 1 and 2)
4. Oxidizing gases (Category 1)
5. Gases under pressure (four groups: compressed, liquefied, refrigerated liquefied, dissolved)
6. Flammable liquids (Categories 1, 2 and 3)
7. Flammable solids (Categories 1 and 2)
8. Self-reactive substances and mixtures (Type A, B, C, D, E, F and G)
9. Pyrophoric liquids (Category 1)
10. Pyrophoric solids (Category 1)
11. Self-heating substances and mixtures (Categories 1 and 2)
12. Substances and mixtures which, in contact with water, emit flammable gases (Categories 1, 2 and 3)
13. Oxidizing liquids (Categories 1, 2 and 3)
14. Oxidizing solids (Categories 1, 2 and 3)
15. Organic peroxides (Type A, B, C, D, E, F and G)
16. Corrosive to metals (Category 1)

Health hazards

1. Acute toxicity (Categories 1, 2,3 and 4)
2. Skin corrosion / irritation (Categories 1A, 1B, 1C and 2)
3. Serious eye damage / eye irritation (Categories 1 and 2)
4. Respiratory or skin sensitization (Categories 1 and 2)
5. Germ cell mutagenicity (Categories 1A, 1B and 2)
6. Carcinogenicity (Categories 1A, 1B and 2)

7. Reproductive toxicity (Categories 1A, 1B and 2 plus an additional category for effects on breastfeeding)
8. Specific target organ toxicity - Single exposure (Categories 1, 2 and Category 3 for narcotic effects and respiratory irritation only)
9. Specific target organ toxicity - Repeated exposure (Categories 1 and 2)
10. Aspiration hazard (Category 1)

Environmental hazards and hazard to the ozone layer

1. Hazardous to the aquatic environment - Acute toxicity (Category 1)
2. Hazardous to the aquatic environment - Chronic toxicity (Categories 1, 2, 3, and 4)
3. *Hazardous to the ozone layer (additional class)*

4.2 LABEL

In addition to identifying the product, the manufacturer and the quantity packaged, the label contains easily understandable standardised elements that indicate the hazards and precautions to be followed when handling the product; however, it should be noted that the labelling of packaging that does not contain ***a quantity greater than 125 ml*** may be incomplete, as the container dimensions are too small to allow the affixing of a label with all the elements communicating the hazards (the minimum dimensions of the label are standardised).

According to the CLP regulation, a substance or mixture classified as hazardous, contained in a package, is provided with a label which contains the following elements:

- name, address and telephone number of the supplier or suppliers;
- nominal quantity of substance or mixture in the package if made available to the general public, unless specified elsewhere on the packaging;
- product identifiers;
- hazard pictograms (if necessary);
- warnings (if necessary);
- hazard statements (if necessary);
- precautionary statements (if necessary);
- a section for additional information (if necessary).

Product identifiers contain the information that allows you to identify the substance or mixture. In the European Union, if a substance appears in the *classification and labelling inventory*, the *identification number and the name* that have been assigned to it are included. Otherwise, the *CAS number* (if available) and the *IUPAC name* or other internationally recognised names are included. In the case of a mixture, the identifier contains the *commercial name or the name of the mixture*, and the identity of all the substances composing the mixture which contribute to its classification, with respect to acute toxicity, skin corrosion or serious eye damage, to mutagenicity on the germ cells, to carcinogenicity, reproductive toxicity, respiratory or skin sensitization, specific target organ toxicity or aspiration hazard. It is limited to a *maximum of four names,* unless a greater number is necessary due to the nature and severity of the hazards.

A ***pictogram*** is a graphic composition that includes a symbol and other graphic elements (border, pattern or background colour, etc.), intended to communicate specific information on the hazard in question. In the case of CLP/GHS, the symbols and the shape of the pictograms (rotated square) on the labels have been adopted, when possible, from those of the UN recommendations for the transport of dangerous goods. All symbols are black, the colour of the frame is red and the background colour is white.

Pictograms adopted from the GHS/CLP system

Pictogram	Code	Description	Symbol
	GHS01	Explosive	Exploding bomb
	GHS02	Flammable	Flame
	GHS03	Oxidizing	Flame over circle
	GHS04	Compressed gas	Gas cylinder
	GHS05	Corrosive	Liquid that corrodes hand and material
	GHS06	Toxic cat. 1-3	Skull and crossbones
	GHS07	Various	Exclamation mark
	GHS08	Health hazard	Radiant man
	GHS09	Environmental hazard	Dead fish, dead standing tree

In the case of a ***single label with the labelling for use and for transport***, meaning, in the case of a single packaging, the GHS hazard pictograms are not included, if the hazards have already been reported by an analogue pictogram recommended by the UN for the transport of dangerous goods. For example, if the UN pictogram for flammable liquids appears on the label:

then the GHS02 pictogram indicating flammability does not appear

A ***Warning*** is a word indicating the relative degree of hazard severity; in the GHS, there are two signal words:

- Danger: indicates more severe hazards;
- Warning: indicates less severe hazards.

When the word "Danger" is present on the label, the word "Warning" is not present.

A ***hazard statement*** is a standard phrase attributed to a hazard class or category, which describes the nature of the hazard of a hazardous substance or mixture and, if applicable, the degree of hazard. All hazard statements must appear on the label, except in cases of evident repetition or redundancy.

The European classification system prior to CLP indicated the nature of the hazard by means of standard phrases called *risk phrases*. Since some of these phrases don't have equivalents in the hazard statements of the GHS system, in order not to lose this information, the CLP regulation has added ***additional hazard statements***. The code of these statements consists of the letters EUH followed by the number of the code of the risk phrase from which they derive preceded by zeros until obtaining three digits. For example, the dry explosive risk phrase corresponding to code R1 has been included in the CLP as an additional hazard indication with code EUH001.

There are CLP/GHS hazard statements which can be supplemented with specific information. In these cases, the hazard statements with the supplementary information are coded by adding letters to the three numbers. For example, the hazard statement "May cause cancer" (H350) may be completed with the indication of an exposure route, if it is ascertained that no other exposure route implies the same danger; in the case of inhalation it becomes "May cause cancer if inhaled", the additional code of which is H350i.

A ***precautionary statement*** is a standard phrase that describes the recommended measure or measures to minimize or prevent the harmful effects of exposure to a dangerous substance or mixture resulting from its use or disposal. The label should not include clearly redundant or superfluous precautionary statements so as to avoid the presence of more than six precautionary statements on the label, unless a greater number is necessary due to the seriousness of the hazards. To reduce the number of precautionary statements it is possible to combine them so as to form a single statement.

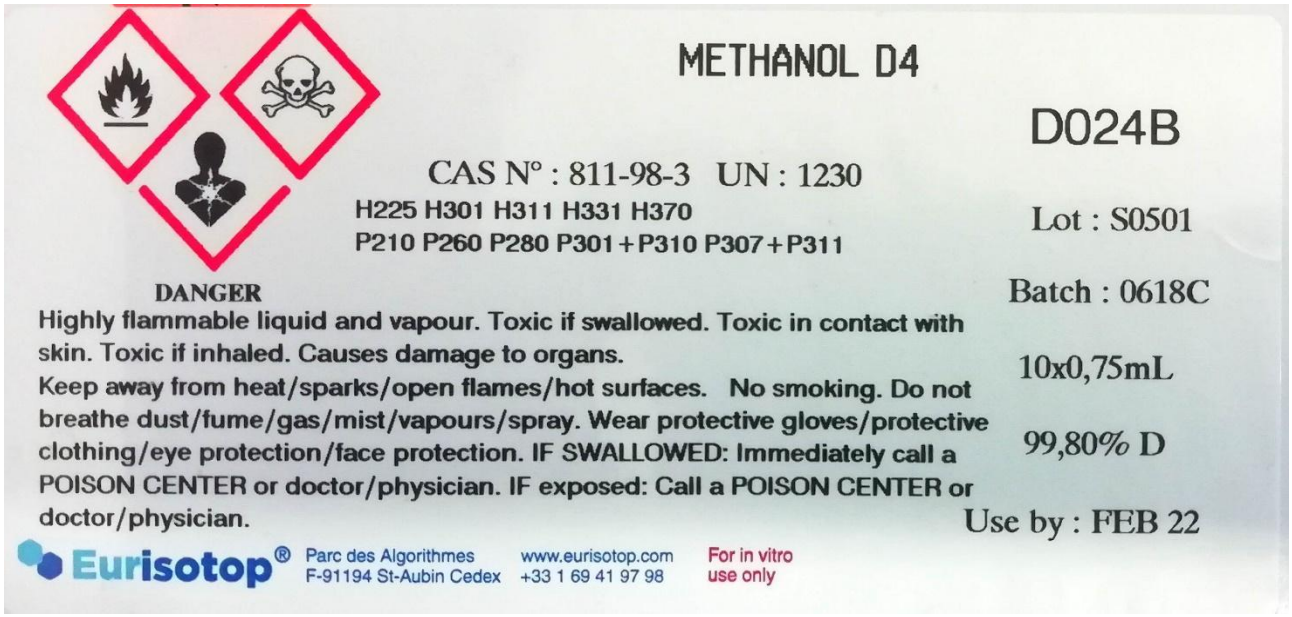
To all hazard statements and precautionary statements, codes are assigned, consisting of a letter followed by three numbers. The first letter of the hazard statement code is an H (Hazard statement) and the first number designates the type of hazard, while in the precautionary statements, the first letter is a P (Precautionary statement) and the first number designates the type of statement.

Hazard statements	Precautionary statements
	P101-P103 General
H200-H290 Physical hazards	P201-P285 Prevention
H300-H373 Health hazards	P301-P391 Reaction
H400-H413 Environmental hazards	P401-P422 Storage
	P501 Disposal

The list of all hazard statements and precautionary statements is shown in Appendices A and B.

An example of a label is shown in the figure below.

Label for Deuterated Methanol



5. HANDLING OF DANGEROUS SUBSTANCES

the knowledge of the hazardous characteristics of the products used is an indispensable condition for implementing the necessary measures to avoid risk situations.

The Head of the Laboratory, having acquired all the knowledge on the hazardous characteristics of a substance, **carries out a correct programming of the operational phases of use in order to prepare an operating procedure containing the most suitable and effective systems for operating safely** and protecting the operators, minimizing the effects of any accidents that may occur.

It is important that the programming assesses, if possible, not only the characteristics of the substances directly involved in the process but also the reaction intermediates, the final products and all those substances or products that participate in the process indirectly such as the service fluids and the materials used for the various equipment.

5.1. GENERAL RULES OF CONDUCT WHEN USING DANGEROUS SUBSTANCES

1. Before handling any hazardous substance, it is necessary to inquire about its chemical-physical properties and its dangerousness, in order to take all the necessary precautions so as to operate in safety. *In the case of commercial products, immediate information on the safe handling of products can be obtained by observing the pictograms shown on the label (Appendix C) while more detailed information regarding all aspects of the handling of a product must be found on the safety sheets. For additional and more extensive information, also keep in mind the possibility of consulting paper-based or computerised databases.*
2. When using and handling dangerous substances, it is necessary to follow the **pre-established operating procedure and follow the indications of the Head of the Laboratory**, using all parts of the Personal Protective Equipment (gloves, filtering facepiece respirators, etc.) and Collective Protective Equipment (cabinets, hoods, aspirators, screens, etc.) prescribed.
3. Before starting the activity, you must be familiar with, and be trained for the correct execution of the necessary operational and emergency procedures and, in particular, for the use of the Protective Equipment envisaged by the procedures.
4. It is good practice to check the laboratory for the availability and efficiency of the Protective Equipment, and any other equipment or materials necessary for both, normal operations and in the event of an emergency (for example fire extinguishers, adsorbent material to be used in case of accidental spillage of a liquid, etc.).
5. It is advisable to keep in the laboratory very limited quantities of dangerous substances, sufficient for a few days of work, leaving the larger quantities in the appropriate storage rooms outside the laboratory.
6. Dangerous substances must be stored in appropriate safety cabinets, suitable for the type of danger (for flammable, corrosive or health-threatening products, possibly equipped with a ventilation system), the outside of which bear the hazard symbols specific to the content.
7. It is recommended to keep the incompatible products (products that could react with each other, see Appendix E) adequately separated.
8. Flammable substances to be stored at low temperatures must not be placed in domestic-type refrigerators or in other environments where possible ignition sources such as sparks or hot spots are present. It is mandatory to affix a notice on unsuitable refrigerators, bearing

the following wording: ***"Do not use for flammable substances***". Like cabinets, refrigerators must also be marked on the outside with the danger symbols, specific to the products contained within.

9. For the handling and storage of self-flammable substances or substances that develop highly flammable gases in contact with atmospheric humidity, follow the instructions in *the safety data sheets*. Keep in mind the need to operate in the absence of air, replacing it with inert gas.
10. Explosive materials, due to their sensitivity to impacts or particular reactivity, must be handled delicately and used only after having performed a detailed and accurate risk assessment, using shields of adequate resistance.
11. Use extreme caution in the use and storage of peroxidable products. Normally, these products contain stabilisers, the effectiveness of which decays over time (hence the importance of checking the expiry date indicated on the label); however, one must always be very cautious, especially during distillations, when elimination of stabilisers and change in the concentration of peroxides may occur. It is recommended to verify the presence of peroxides using the appropriate starch-iodide paper strips equipped with a colorimetric scale.
12. Keep in mind that inert gases can be very dangerous in the event that the leaked (or evaporated) quantities cause the oxygen concentration in the air to drop below 17%, with risks for survival.
13. Keep in mind that oxygen can be very dangerous, with a risk of fire, if the quantity released results in its concentration in air of 25% or higher.
14. Avoid contact of strongly oxidizing substances (e.g. perchloric acid) with combustible materials (wood, plastic, etc.)
15. All operations and processes using hazardous materials (in relation to their chemical-physical properties or their health hazard, such as toxicity, harmfulness, etc., or suspected as such) must be carried out under a chemical or biological laboratory cabinet/hood (the suction efficiency of which must be ensured with periodic checks), keeping the front sliding panel as low as possible, and possibly also using shields.
16. Weighing of dangerous powder substances must be carried out under the hood, or by preparing the materials to be weighed under the hood, transferring them subsequently to an external scale, or, if indispensable, in a dedicated room used for the use of the scales in still air conditions; it is recommended to protect the operating area with paper sheets, in order to collect any residues to be eliminated in a correct manner. In the case of very toxic, carcinogenic or mutagenic compounds, in addition to being necessary to adopt all the preventive measures required for these types of products, it is advisable to carry out a single weighing operation and then work on the quantity of solvent to obtain the desired concentration.
17. Immediately clean up spills of dangerous substances; if the quantity and/or nature of the spilled product so requires, use the appropriate absorbent materials with which the laboratory must be equipped.
18. The transport, including internal transfer, of chemicals and hazardous materials in general must be carried out in a proper way, using suitable racks or, for larger quantities or weights, special carts, in each case equipped with containment systems that are capable of retaining any spillages.

5.2 CONDUCT IN CASE OF AN INCIDENT

A situation of "immediate danger" may occur during the use, storage and disposal of chemical agents and may cause environmental emergencies and / or more or less serious risks for the safety of persons. Proper management of these situations, for example the spillage of a liquid following the breaking of a container, allows to avoid or, if this is not possible, to limit harmful consequences for workers and for the environment. It is therefore necessary, in case of spillage of chemical agents, to immediately implement emergency procedures, so as to limit risks of environmental pollution and damage to the persons involved. The procedures to be followed must be drawn up by the Head of the Laboratory, taking into account the type of work carried out, the substances used, and the methods of handling, storage and disposal of these substances. In any case, below are some rules with indications for developing specific procedures.

1. Before carrying out any type of emergency intervention, wear specific PPE for protection against contact with the spilled substance (e.g. gloves, splash guard goggles, protective clothing), as well as against inhaling its vapours (masks with filter), according to the indications provided on the product safety data sheet;
2. Open all windows and doors and put in operation all available means of mechanical ventilation (hoods, wall fans, etc.) to assist ventilation and the dispersion of any dangerous vapours present in the air;
3. Try to make the place of the accident safe by removing, for example, possible ignition sources, by stopping the ongoing work operations, and by disconnecting power supply from all electrical equipment, and disconnecting gas supply;
4. Stop the leakage of liquids with suitable absorbent material, specially prepared for this purpose;
5. Once the spill has been contained, collect the contaminated absorbent material, inserting it in special containers, and then send it for disposal as special waste;
6. After removing the spilled material, thoroughly clean the area and materials affected by the spillage;
7. Replace contaminated Personal Protective Equipment.

The interventions described above must be carried out only if it is possible to operate in safe conditions, and you must always try to avoid dealing with the emergency by yourself alone; therefore, you must always call the emergency number available, so that emergency teams are called in.
Furthermore, it is very important to quickly find the *safety data sheet* for the substance in question, in order to find the indications on how to carry out the interventions.

In the event of contamination of persons, it is necessary, first of all, to do the following:

- ❖ remove clothing and any contaminated PPE, using the necessary precautions;
- ❖ wash any exposed skin or mucous membranes with running water, showers, eye showers, etc.;
- ❖ read the emergency first aid measures indicated in the contaminating substance safety sheet;
- ❖ call the emergency number in order to notify the emergency first aid team and, if necessary, external help;

- ❖ if external help is needed (118 or a physician), send them all the useful information relating to the substance and deliver the safety data sheet to them.

Finally, replace or carefully clean the used PPE before wearing them again.

5.3 SAFETY DATA SHEET

All dangerous substances or mixtures placed on the market in Europe must be accompanied by a Safety Data Sheet (SDS). It is a detailed information document, the purpose of which is to allow professional users to take the necessary measures for the protection of the environment, as well as of health and safety in the workplace. The sheet, drawn up by and under the responsibility of those who place the product on the market (manufacturer, importer, distributor), must be updated on the basis of the most recent technical and scientific knowledge, must be written in Italian and must include the date of issue, and that of the last revision, if any (for an example of contents of the Safety Data Sheet, see Annex D). The form currently adopted in Europe is structured so as to comply with the GHS system.

The Safety Data Sheet to be consulted must always be exactly that of the product to be used. Apparently identical substances or mixtures can present completely different dangers. For example, the presence of a minimum amount of a carcinogenic agent (0.1%) is sufficient to classify a non-dangerous substance/mixture as a carcinogen substance; or a monomer which is stable in the presence of a polymerisation inhibitor, may become dangerously unstable in its absence. The physical characteristics of a substance/mixture are also important, for example a solid material can be stable, or it can give rise to self-ignition phenomena, depending on its size; if it is very small, it is easier to have high temperatures locally, due to the lower heat loss.

6. CARCINOGENIC AND MUTAGENIC AGENTS

6.1 DEFINITIONS

According to the art. 234 of Legislative Decree 81/2008 and subsequent amendments, the following definitions apply:

Carcinogenic agent:

1. A substance that meets the classification criteria for carcinogenic categories 1 or 2, established pursuant to Legislative Decree No. 52, and subsequent modifications;
2. preparation containing one or more substances referred to in number 1), when the concentration of one or more of the individual substances meets the requirements relating to the concentration limits for the classification of a preparation in carcinogenic categories 1 and 2, according to the criteria established by Legislative Decree No. 52 of 03 February 1997, and No. 65 of 15 March 2003, and subsequent modifications thereof;
3. A substance, a preparation or a process referred to in Annex XLII, as well as a substance or a preparation created during a process described in Annex XLII;

Mutagenic agent:

1. A substance that meets the classification criteria for mutagenic categories 1 or 2, established pursuant to Legislative Decree No. 52, and subsequent modifications;
2. A preparation containing one or more substances referred to in number 1), when the concentration of one or more of the individual substances meets the requirements relating to the concentration limits for the classification of a preparation in mutagenic categories 1 and 2, according to the criteria established by Legislative Decree No. 52 of 03 February 1997, and No. 65 of 15 March 2003, and subsequent modifications thereof.

Legislative Decrees No. 52/1997 and No. 65/2003 have been issued in transposition of mother Directives Nos. 67/548/EEC (Dangerous Substances Directive, DSD) and subsequent amendments, and No. 1999/45/EC (Dangerous Preparations Directive, DPD), respectively.

6.2 CLASSIFICATION AND LABELLING

The old EU classification (Directive 93/21/EC) classified carcinogenic and mutagenic substances into three **carcinogenicity / mutagenicity** categories, described in the two tables below:

Carcinogenicity Categories

Category 1	Substances known for their carcinogenic effects on humans
Category 2	Substances that should be considered carcinogenic to humans
Category 3	Substances to be considered suspected for possible carcinogenic effects

Mutagenicity categories

Category 1	Substances known for their mutagenic effects on humans
Category 2	Substances that should be considered mutagenic to humans
Category 3	Substances to be considered suspected for possible mutagenic effects

Specific symbols, pictograms and risk phrases (R) were associated with each category, and appeared on the labels and safety data sheets of the substances.

Since in the various laboratories there are many packages bearing the old labelling, it is considered appropriate to include, in the following tables, the labelling of carcinogenic and mutagenic substances associated with the classification categories according to the old system.

Labelling of carcinogenic substances

Category	Symbol / Pictogram	Risk phrase (R)
1	 T o T+ Carc. Cat. 1	**R 45:** *May cause cancer,* or **R 49:** *May cause cancer by inhalation* for substances presenting a carcinogenic risk only by inhalation, e.g. in the form of dust, vapours or fumes
2	 T o T+ Carc. Cat. 2	**R 45:** *May cause cancer,* or **R 49:** *May cause cancer by inhalation* for substances presenting a carcinogenic risk only by inhalation, e.g. in the form of dust, vapours or fumes
3	 Xn Carc. Cat. 3	**R 40:** *Limited evidence of a carcinogenic effect*

Labelling of mutagenic substances

Category	Symbol / Pictogram	Risk phrase (R)
1	 T o T+ Muta. Cat. 1	**R 46:** *May cause inheritable genetic damage*
2	 T o T+ Muta. Cat. 2	**R 46:** *May cause inheritable genetic damage*
3	 Xn Muta. Cat. 3	**R 68:** *Possible risk of irreversible effects*

The new system for classification, labelling and packaging of dangerous substances, called the CLP (*Classification, Labelling and Packaging of Chemicals*) as of 01 June 2015 has revoked the old classification and labelling system, as well as all the implementation regulations that have followed over the years.

Currently, the classification categories of carcinogenic and mutagenic substances have been modified as follows:

CLP carcinogenicity categories

Category 1A	Substances known to have carcinogenic potential for humans
Category 1B	Substances presumed to have carcinogenic potential for humans
Category 2	Substances suspected of having carcinogenic potential for humans

CLP mutagenicity categories

Category 1A	Substances known to induce hereditary mutations in the germ cells of humans
Category 1B	Substances presumed to induce hereditary mutations in the germ cells of humans
Category 2	Substances of concern because they could induce hereditary mutations in the germ cells of humans.

The new CLP labelling system for carcinogens and mutagens provides, among other things:

- introduction of new danger symbols and pictograms;
- introduction of new signal words *Warning!* and *Danger!*
- replacement of R phrases with *Hazard Statements* (H).

The table below shows the new pictograms with the related hazard statements for the various categories of carcinogenic and mutagenic substances..

CLP labelling of carcinogenic substances

Category	Symbol / Pictogram	Signal word	Hazard statement (H)
1A	 Carc. 1A	*Danger!*	**H350:** *May cause cancer (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)* *or* **H350i:** *May cause cancer if inhaled*
1B	 Carc. 1B	*Danger!*	**H350:** *May cause cancer (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)* *or* **H350i:** *May cause cancer if inhaled*
2	 Carc. 2	*Warning!*	**H351:** *Suspected of causing cancer (*state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard*)*

CLP labelling of mutagenic substances

Category	Symbol / Pictogram	Signal word	Hazard statement (H)
1A	 Muta. 1A	*Danger!*	**H340:** *May cause genetic defects (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)*
1B	 Muta. 1B	*Danger!*	**H340:** *May cause genetic defects (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)*
2	 Muta. 2	*Warning!*	**H341:** *Suspected of causing genetic defects (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)*

The new CLP system for labelling carcinogens and mutagens also classifies mixtures and preparations based on the classification of the component substances, with the following differences compared to the old system:

- the word *preparation* is replaced by *mixture*;
- the concentration limits that determine the classification are generic, valid unless specific limits exist for certain substances and apply both to non-gaseous mixtures (weight/weight percentage) and to gaseous mixtures (volume/volume percentage).

The table below indicates the carcinogenicity / mutagenicity classification of a mixture according to CLP.

CLP mixture classification

Substance classification	Concentration limits	Mixture classification
Cancerogenic / Mutagenic Category 1A or 1B	≥ 0,1%	Cancerogenic / Mutagenic Category 1A or 1B
Cancerogenic / Mutagenic Category 2	≥ 1%	Cancerogenic / Mutagenic Category 2

Given the coexistence, in the laboratories, of labels showing both the old and the new classification system, the following table shows, for convenience, the correspondence between the DSP and the CLP systems for classification of carcinogenicity and mutagenicity.

Correlation between the two classification systems

DSP	CLP
 T/T+ Carc. Cat. 1; R45 o R49	 *Danger!* Carc. 1A; H350 o H350i
 T/T+ Carc. Cat. 2; R45 o R49	 *Danger!* Carc. 1B; H350 o H350i
 Xn Carc. Cat. 3; R40	 *Warning!* Carc. 2; H351
 T/T+ Muta. Cat. 1; R46	 *Danger!* Muta. 1A; H340
 T/T+ Muta. Cat. 2; R46	 *Danger!* Muta. 1B; H340
 Xn Muta. Cat. 3; R68	 *Warning!* Muta. 2; H341

6.3 PREVENTION MEASURES

In the case of carcinogens and/or mutagens, the most important exposure prevention measure is the replacement of these agents (substances or MIXTURES) with others that are not hazardous to health or are less hazardous in the conditions of use. By replacing them, the risk is, in fact, eliminated directly *at the source*, **therefore it is strongly recommended to take action to find valid alternatives to the use of these products.**

If replacement is not possible, *the number of the exposed employees must be minimised*, *and the duration and intensity of exposure must be reduced to the lowest possible values.*

All the indications previously given for the handling of harmful substances are to be followed even more scrupulously in the case of carcinogenic and mutagenic products. It is also important to prepare and implement specific technical, organisational or procedural measures, such as:

- Adopting "closed-loop" processing systems, characterised by the absence of exchange of the material with the surrounding environment;
- Using quantities of carcinogens and/or mutagens strictly necessary for the purpose, avoiding their accumulation in the laboratory;
- Isolating at-risk operations within specially marked areas accessible only to employees;
- Cleaning regularly, systematically, and thoroughly, premises, equipment and systems.
- Making sure that the storage, handling, transport and disposal of carcinogenic and/or mutagenic products are carried out in conditions of maximum safety, based on the requirements contained on the product safety data sheets, using airtight containers, clearly and legibly labelled, according to the legal provisions;
- Washing the hands thoroughly before leaving the workplace, and disposing of work clothes that could be contaminated, storing them separately from the clean clothing;
- Non-exposure to these products, following a compliant opinion by the Occupational Physician, of particularly sensitive categories of employees, such as pregnant or breastfeeding women, minors, hypersensitive subjects (e.g. smokers, immunocompromised people).

Information and training of exposed or potentially exposed employees is of the utmost importance in this case.
In particular, based on the available knowledge, employees must be adequately informed and trained on the following:

- Type of carcinogens and/or mutagens present in the working cycles, their location, the health risks associated with their use, including the additional risks due to smoking;
- Precautions to be taken in order to avoid or decrease the exposure;
- Accident prevention modalities and measures to be taken to limit their consequences.

Installed equipment, containers and packaging containing carcinogens and/or mutagens must be labelled in a legible and understandable way. The markings used and other indications must comply with Legislative Decree No. 25/97 (substances), Legislative Decree No. 65/2003 (preparations) and subsequent amendments (CLP Regulation).

7. COLLECTIVE AND PERSONAL PROTECTIVE EQUIPMENT

The activities carried out in a laboratory, and in particular, the use of dangerous substances, involve a danger of operators' exposer. The methods and procedures adopted must be designed to eliminate or minimise these risks. For this purpose, protection means are used, which can be

divided into two groups: means that exert a protective action on all staff members present (Collective Protective Equipment - CPE) and means that, worn by the operators, exercise individual protective action (Personal Protective Equipment - PPE).

When choosing the means of protection, it is preferable to adopt Collective Protective Equipment; only when the Collective Protective Equipment is inadequate should the individual operators be equipped with Personal Protective Equipment.

7.1 COLLECTIVE PROTECTIVE EQUIPMENT

The most frequent Collective Protective Equipment (CPE) in laboratories are systems which, by intervening directly on the polluting source, reduce or eliminate the risk of operator exposure and contamination of the work environment. Examples of Collective Protective Equipment are conventional total-exhaust chemical hoods, molecular filtration chemical hoods, ventilated and safety cabinets for flammable materials, BioHazard hoods (microbiological safety cabinets), and glove boxes.

CHEMICAL HOODS

Laboratory fume hoods are considered the main tool for protection both from the risks of fire and explosion caused by uncontrolled chemical reactions, and from the risk associated with the toxicity of the chemicals used. Therefore, they constitute the most important collective protection system in laboratories; the installation of these devices allows for the isolation of the emission of pollutants, and for the intervention at the source of the risk. Normally, the hood represents the area of greatest danger in a laboratory and therefore must meet all the safety requirements defined in the technical regulations, and must be periodically checked and kept efficient.
Presence of a chemical hood in the laboratory is not by itself sufficient to guarantee safety; in fact, hoods must be used correctly. The staff must therefore be trained so as to obtain the greatest possible advantages in terms of protection, and to avoid any incorrect use that can create situations of greater danger.
Below are tips and recommendations for the best possible use of this device:

1. All operations involving dangerous chemical products must be carried out under the hood and, in any case, at all times when this indication is given in the safety data sheet of the products to be handled.
2. Always leave the hood ON when toxic chemicals are stored inside, and when there is no certainty that the room ventilation system is efficient.
3. The hood must be positioned in the room away from any source of air turbulence (doors, windows, ventilation systems, heaters, convector heaters, stoves, passage of persons, etc.). In particular, during any activity performed under the hood, any cause of turbulence in the room air must be avoided.
4. Before starting the work activities, check that the hood is working correctly, for example, using with a tissue or a sheet of paper.
5. After inserting the material, lower the front screen at least about 40 cm from the work surface. If the hood has automatic speed adjustment, lower the screen to the minimum height necessary to work safely and comfortably, obtaining significant energy savings. If the

front panel has horizontally sliding glass doors, keep them closed. If the hood is ON, but not used, keep the front screen completely lowered.

6. During experiments, keep the front screen as low as possible. The lower the front screen, the less the operation of the hood is affected by the currents in the room.
7. Work standing up or sitting down, in an upright position, avoiding leaning your head towards the work area.
8. Keep your body slightly away from the front opening area as not to generate turbulence.
9. Do not use the hood as a storage for toxic chemicals without adequate protection, or for disposal of the same by forced evaporation.
10. All the electrical appliances introduced into the laboratory must be powered from the outside, and must be certified suitable for explosive atmospheres, if necessary.
11. The presence of electrical outlets inside the hood compartment is prohibited.
12. When possible, choose the hoods with remote controls of the technical fluids, in order to avoid inserting the arms inside the hood compartment.
13. At the end of the activity, clean the worktop and internal walls with suitable systems.
14. Reduce the tools and materials in the work area to the bare minimum in order to minimise turbulence. Emission sources (chemicals or equipment) should be kept at least 15-20 cm inside the hood. This precaution prevents substances from escaping from the hood when environmental turbulence interferes with the suction. It may be appropriate to mark this line on the work bench of the hood itself.
15. Avoid creating drafts near a hood in operation (opening of doors or windows, frequent transit of people).
16. Keep only the material strictly necessary for the experiment under the hood. Do not obstruct the passage of air along the surface of the hood and, if it is necessary to use equipment that clutters the surface, lift it at least 5 cm from the surface itself and keep them it away from the walls. In any case, the suction slots on the hood must not be blocked..
17. Draw up an emergency action plan in the event of a malfunction during an experiment or in the event of an explosion or fire in the hood.
18. Keep the worktop clean and tidy after each operation. At the end of each use of the hood, each operator should clean it using specific products according to the substances used in order to avoid improper risks for those who will use the hood after them.
19. When the hood is not in use, turn off the suction and close the front screen.

MAINTENANCE AND PERIODIC CHECKS CHEMICAL HOODS

The first rule to follow in order to keep a chemical hood efficient is daily cleaning at the end of the day to remove the stains produced by any splashes of material: many chemicals can stain and damage the internal surfaces of the hood if they are not promptly removed.

Any malfunctions found should be reported immediately to the Head of the Laboratory or to Administrative executive in charge, and a check should be made if a lowering of the frontal suction speed is suspected.

To prevent malfunctions of the hood, it is however necessary to define an annual program of verification and maintenance of the installed hydraulic and electrical systems, ventilation and mechanics.

All data relating to maintenance, periodic checks or any interventions must be noted chronologically, with a date, on a register attached to the hood and signed by the person who performed the operation.

SAFE USE OF CHEMICAL HOODS.

With a view to compliance with the regulations on periodical checks, to be carried out with precise schedules, and related maintenance interventions, aimed at guaranteeing safety for the operators, it is necessary to carefully check the efficiency of the various equipment with the aid of an anemometer (preferably of the hot-wire type) so as to allow the measurement of the front flow of the hoods for a classification of the same, based on their efficiency, as required by UNI and ASHRAE standards, and the UNICHIM manual No. 192/3. These standards give guidelines both on the method of detecting the average frontal speed, and on the consequent classification. The front speed must be determined with the mobile protection panel positioned 15 and 40 cm from the work surface. At the maximum possible closure at the height of 15 cm, the hoods will have maximum efficiency, since made-to-measure clashes will have to be positioned in order to safeguard the upper limbs of the operators against sudden breakages of the latches, even if the 15 cm available will allow very few operations inside the hood. The height of 40 cm of the protection panel is the one deemed suitable for the correct use of the hoods, always according to the standards mentioned above, and will effectively provide the possibility of using the equipment.

The hoods, according to their suction speed, will be classified into three classes according to the following scheme:

Hood identifying colour	**Class**	**Suction speed (m/sec)**	**Recommended use**
	Not classifiable	**v** < 0,1	not usable
	1	0,1 ≤ **v** < 0,5	Irritating and low -toxicity chemical agent
	2	0,5 ≤ **v** < 0,7	Harmful and toxic chemical agents
	3	**v** ≥ 0,7	Highly toxic chemical agents

*Each class is associated with a group belonging to the chemicals that can be used according to the risk phrases (**"R"**), as shown below:*

***In class 1 fume hoods, ONLY** substances of **"Group 1"** may be used, with the following risk phrases: **R36 – R37,** or hazard statements (according to the new CLP classification): **H319 – H335** (irritant compounds)*

***In class 2 fume hoods**, in addition to those of **"Group 1", ONLY** substances of **"Group 2"** may be used, with the following risk phrases: **R20 – R42,** or hazard statements (according to the new CLP classification): **H332 – H334** (harmful compounds)*

***In class 3 fume hoods,** all compounds may be used.*

At this point, a coloured symbol will be affixed to each hood, which will immediately identify its class.

*By measuring the speed with the protection screen positioned at 15 and 40 cm, two front speed values will be obtained, therefore two coloured symbols will be affixed on the hood, bearing the written (legible) height of the protection panel, which to refer to. For example, there may be the symbol bearing the writing "h15" and the symbol bearing the writing "h40". Obviously, the interpretation will be as follows: with the screen positioned at a height of 15 cm, all substances can be used; with the screen positioned at a height of 40 cm, only chemicals belonging to **Group 1** can be used.*

BIOLOGICAL CABINETS

Biological safety cabinets are a good primary prevention system as they prevent the spread of potentially dangerous biological material; they are equipped with HEPA **(High Efficiency Particulate Air)** filters, that prevent particle contamination, consisting of microfiber glass sheets, folded several times. Their filtering efficiency is represented by the ability to retain particles of 0.3 µ in diameter with an efficiency of between 99.97% and 99.99%. HEPA filters are grouped into 5 classes (from H10 to H14) with increasing performance characteristics.
At the time of installation, these cabinets must comply with the UNI EN 12469 standard, the CE marking, and the declaration of conformity. The cabinets are classified into three categories (Class I, Class II, Class III), according to the level of protection they guarantee to the operator, the surrounding environment and the product. Class II is further divided into 4 subtypes (A1, A2, B1, B2), according to the ratio between the percentage of expelled and recirculated air.
The choice of the biological safety cabinet is based on the potential risk of the agent used, on the possibility that laboratory operations may generate aerosols, and on the need to protect the operator, the environment or the product from airborne contaminants.

Class	Recirculated air	Expelled air	Biosafety level
I	0%	100%	1,2,3
II A1	70%	30%	1,2,3
II A2	70%	30%	1,2,3
II B1	30%	70%	1,2,3
II B2	0%	100%	1,2,3
III	0%	100%	1,2,3,4

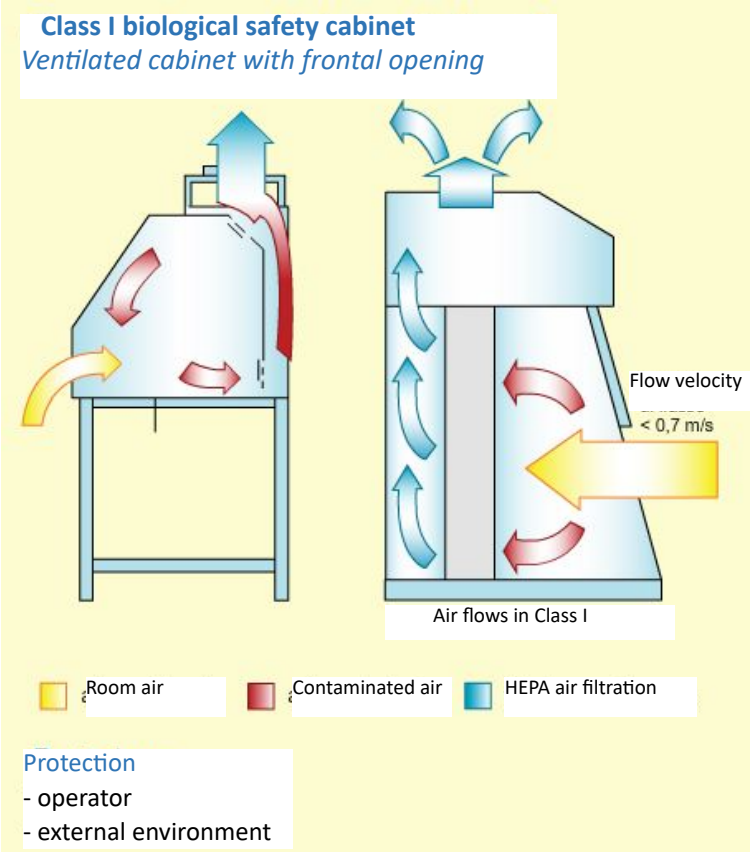
Use	Type of protection	Biological safety cabinet
Contained low-risk use	Operator and environment protection	Class I (0% recirculated air 100% expelled air)
Contained low-risk or moderate-risk use, small quantities of toxic chemical agents, trace radionuclides	Operator, environment, and product protection	Class II A1 and A2 (70% recirculated air 30% expelled air)
Larger quantities of volatile or radioactive toxic chemical agents	Operator, environment, and product protection	Class II B1 (30% recirculated air 70% expelled air) Class II B2 (0% recirculated air 100% expelled air
Contained high-risk use	Total barrier between the operator and the work area	Class III (glove-box) (0% recirculated air 100% expelled air)

Class I biological safety cabinet Horizontal laminar flow cabinet

Protection of the operator is ensured by the frontal flow of external air, conveyed as a laminar flow above the work surface, which is emitted from the cabinet through an extractor. In this way, the aerosol particles, if generated in the work area, are conveyed to the extractor and moved away from the operator and the environment. Protection of the environment is guaranteed by a HEPA filter in the exhaust system. Since the air that enters the worktop through the front opening is not sterile, this type of cabinets is not considered to be consistently reliable for the protection of the product.

Main use

Confinement of small instruments (centrifuges, small fermenters) and carrying out operations that can generate aerosols (homogenisation of tissues, aeration of crops).



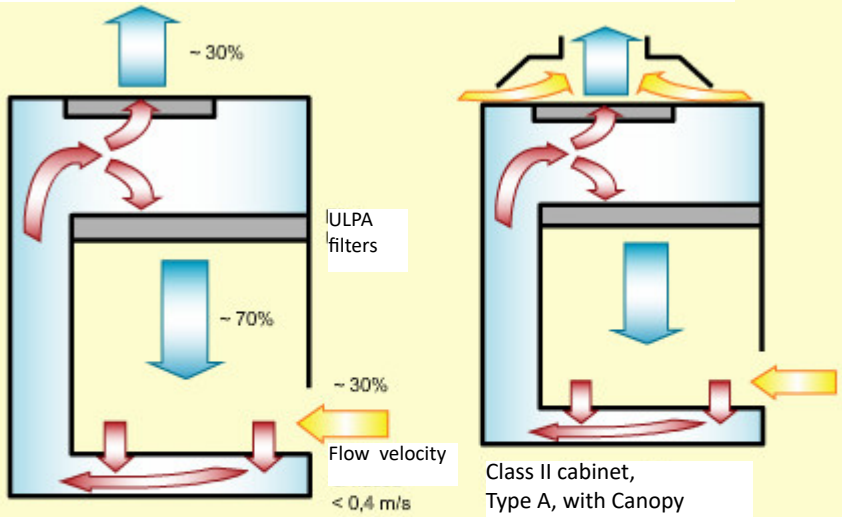
Class II biological safety cabinet Vertical laminar flow cabinet

There are 4 types of class II cabinets, distinguished according to the percentage of recycled air: Type A1, Type A2, Type B1, Type B2; they differ mainly in the ratio of volumes of recycled air in the work area, in the room, and/or sent outside, and for the air velocity:
Type A 70% recirculated air - 30% air expelled in the room. Frontal velocity = 0,38 m/sec
Type B1 30% recirculated air - 70% air expelled outwards. Frontal velocity = 0,5 m/sec
Type B2 100% air expelled outwards. Frontal velocity = 0,5 m/sec
In the type A cabinet, the air expelled is recirculated in the room, in the type B cabinet, the air is channelled outside the room. Compensation takes place thanks to the suction of room air through the front grid, thus creating an air barrier which prevents the escape of contaminated aerosols.
Protection of the operator the frontal flow of external air, conveyed as a laminar flow above the work surface, which is filtered through a HEPA filter, so as to minimise the possibility of cross-contamination for the product. The environment is protected by a HEPA filter that filters the air emitted by the cabinet (Types A1 and A2). Such air, free of particulates, can be introduced into the laboratory or released outside the building through the ventilation system.

Main use

Carrying out Class 2 and 3 contained uses. Contained uses that present a low and moderate risk, or operations for which a level 2 or 3 containment is adequate to protect human health and the environment. They can also be used for small quantities of non-volatile toxic chemicals and trace radionuclides (possibly present in cell cultures or microbial systems).

Class II biological safety cabinet, Type A



Class II Cabinet, Type A

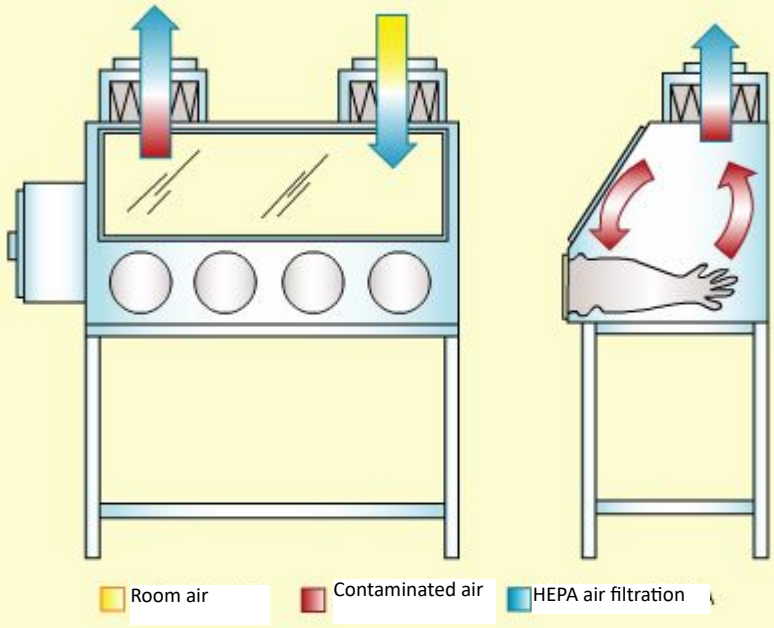
Class II cabinet, Type A, with Canopy connection

Protection
- operator
- external environment
- product

Class III biological safety cabinet (glove-box)

This type of glove-box cabinet is hermetically closed, the incoming air is filtered through HEPA filters and expelled after filtration through double HEPA filters in sequence. It operates under negative pressure and ensures total protection of the product / operator / environment.
This type of cabinet guarantees the highest level of personal protection and is used for pathogens belonging to group 4. The air flow is guaranteed by a specific suction system outside the cabinet, which maintains a negative pressure (about 124.5 Pa) within.
The gloves have a heavy rubber sleeve, positioned at the front, and allow access to the work surface. Class III cabinets must have an interlocking double door passage box that can be sterilised and equipped with a HEPA filter. The class III cabinet can be connected to a pass-through autoclave, and used to decontaminate all material that enters or leaves the cabinet. Several glove-boxes can be joined together to expand the work surface. The class III cabinets are suitable for working in the laboratory at containment level 3 and 4.

Class III biological safety cabinet "glove box"
(see the exclusive Insulator section)



Protection

- operator
- working environment outside the cabinet against biological agents.
- material being processed against external contamination

MAINTENANCE OF BIOLOGICAL CABINETS

Annually

- Checking and replacing the filters, as described in the Operation and Maintenance Manual.
- Checking and cleaning the drain pipes (if any).
- Checking the correct electrical and mechanical operation of the electric fan engine (if any).
- Checking the filters' hours-in-service (where possible).
- General check-up of the mechanical parts (e.g. the front panel, latches, etc.), structural parts (e.g. integrity of surfaces and pipes), indicators and alarms (if any), electrical system, taps, UV lamps (if any).
- Measuring the suction speed with anemometer, according to UNI EN 12469.
- Periodic verification of the presence of microorganisms in the filtered air by exposing, for 30 minutes, open Petri dishes containing culture media for the growth of heterotrophic bacteria and fungi, arranged at representative points on the work surface or, alternatively, using particle counters.

Class III biological safety cabinet (glove-box)

- Checking and replacing the filters, as described in the Operation and Maintenance Manual.
- Checking and cleaning the drain pipes (if any).
- Checking the correct electrical and mechanical operation of the electric fan engine (if any).
- Checking the filters' hours-in-service (where possible).
- General check-up of the structural parts (e.g. openings in which the gloves are applied, etc.), indicators and alarms (if any), electrical system, taps, UV lamps (if any).
- Checking of internal depression according to UNI EN 12469.
- Checking the velocity of air entering from each of the openings in which the gloves are applied, according to UNI EN 1246.
- Checking the air flow, according to UNI EN 12469.

Replaced filters must be disposed of as special waste using the EWC Code 15.02.02.

PRACTICAL INDICATIONS FOR CORRECT USE

Information on the appropriate use of biological safety cabinets must be provided to all users by the Head of the Laboratory or the Administrative executive in charge. Where indicated, specific written protocols or safety manuals relating to procedures must be provided to operators.

I In general, however, with each use of the cabinet, the following correct operating practices must be followed:

- Make sure that the cabinet is suitable for the biological agent used.
- Check that it works perfectly.
- Turn off UV lamps, if any.
- Before starting work, position the front glass shield, if of the sliding type, at the height set for greater operator protection (20 - 30 cm), or adjust the height of the chair so that the operator's face is above the opening of the front glass shield. The glass shield must not be opened when the cabinet is in use.
- Turn on the cabinet suction system at least 10 minutes before starting to work in order to stabilise the flow and allow the elimination of the particulates present inside of it.
- Clean the work surface, the internal walls and the internal surface of the glass shield with 70% ethanol (EtOH), or a solution (dilution 1:100) of 0.05% sodium hypochlorite, or other disinfectants (if hypochlorite is used, a second washing with sterile water is necessary to eliminate the residual chlorine, which can eventually corrode the stainless steel surfaces).
- Clean with 70% EtOH the surfaces of all materials and containers placed in the cabinet so as to reduce the release of microbial contaminants into the work area.
- Respect a "from clean to contaminated" flow during work activities, introduce materials in the cabinet by limiting the movement of "dirty" material towards "cleaner" areas or objects.
- Draw up, before starting to work, a list of materials to be placed in the cabinet, strictly necessary for the work activities, in order to avoid interrupting the flow of air several times with the introduction of new material.

- Reduce the material or equipment on the work surface to a minimum in order not to decrease the flow of air and avoid turbulence, possible cross contamination, and/or violations of the containment level.
- Start handling the materials after about one minute from placing the hands/arms inside the cabinet in order to stabilise the air flow in the cabinet, and perform the "air sweep" of the hands and arms to remove the microbial contaminants present on their surface. When the operator's arms are resting on the front of the cabinet grid, the room air flow could converge in the work area, instead of being sucked through the front grid. Raising your arms slightly may partially solve the problem.
- Do not block the front air grid with pipettes, sheets or other material, in order to avoid potential contamination of the material and not expose the operator to possible contamination.
- Avoid sudden movements of the forearms inside the cabinet so as not to alter the laminar flow of the air curtain, compromising the partial containment barrier provided. Moving the arms slowly and perpendicularly to the front opening of the cabinet will reduce this risk.
- Avoid the passage of people behind the operator, as well as the opening or closing of doors in the room so as not to alter the laminar flow.
- Carry out all the work operations in the middle and rear part of the work surface and in a way visible through the front glass. In addition, the equipment that generates aerosols (vortex mixer, table centrifuges) must be located in the rear part of the cabinet in order to exploit the "air split" advantage. Bulky items such as biohazard waste bags, used pipettes and liquid waste collection containers should be placed on the inside of the cabinet.
- Do not use bunsen or other types of burners under type II and III cabinets as the hot induced air can divert the regular internal flow of the air, and therefore cause contamination of the work area, the external environment and damage to the HEPA filters. It is advisable to keep an electric micro-incinerator, but the use of disposable sterile loops is preferable.
- Extract the potentially infected or contaminated material to closed and sealed containers, perfectly clean on the outside and labelled with the biohazard sign.
- Do not close the biohazard waste bag to be autoclaved outside the cabinet.
- Decontaminate the surfaces of all containers and equipment before removing them from the cabinet once all the operations have been completed.
- do not take potentially contaminated materials out of the cabinet before decontaminating their external surface; alternatively, the contaminated materials can also be placed in a sealed container and transferred to an incubator, autoclave or other device for decontamination.
- Leave the cabinet on for about 20 minutes after completing the work activities in order to eliminate any contamination.
- Clean and disinfect the cabinet at the end of each operation with suitable products. The work surface, the internal walls and the internal surface of the glass must be cleaned with 70% ethanol (EtOH), or a solution (dilution 1:100) of 0.05% sodium hypochlorite, or other disinfectants. When hypochlorite is used, it is necessary to carry out a second washing with sterile water in order to eliminate the residual chlorine, which can corrode the stainless steel surfaces. If necessary, the cabinet should be monitored for radioactivity and decontamination.
- Close the front opening when the biological safety cabinet is not being used, and turn on the UV lamp, if any.
- Immediately remove any small spills of the contaminated material in the cabinet with absorbent paper soaked in a decontamination solution (change the gloves after

decontamination and put them, together with the paper used for cleaning, in the material to be autoclaved); in case of larger spills (liquids that pass through the front or rear part of the grids), all the elements inside the cabinet must be removed and decontaminated, and the decontaminant solution must be poured on the work surface and through the grid into the tray.

7.2 PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) is equipment intended to be worn and held by an operator/ employee in order to protect them against one or more risks that threaten their safety or health during work, as well as any other supplement or accessory intended for this purpose.

Personal Protective Equipment is divided into three categories, according to the type of risk:

- Category I - There is a slight risk; the equipment is self-certified by the manufacturer;
- Category II - The risk is significant, such as damage to the eyes, hands, arms, face. A prototype of the device has been certified by an authorised inspection body;
- Category III - Includes all PPE for the respiratory tract and protection from aggressive chemical agents. A prototype of the device has been certified by an authorised inspection body, in addition there is production control.

The PPE **specific for the for the various types of risk present in the Unicam laboratories are identified in the Risk Assessment Document** (**RAD**), and are provided to users by the employer through the Head of the Laboratory, who draws up and signs a special delivery report.

The PPE delivered constitute **personal equipment,** with the exception of the more complex and exceptionally used ones (e.g. self-contained breathing apparatus). They must be worn **at all times**, like in the case of safety spectacles, or kept in the laboratory in a special cabinet at hand for a ready and convenient use when needed.

The **employee is obliged to use these devices correctly,** to take care of them and **not to make changes to them**, reporting any defects or inconveniences that they may encounter**.**

EYE AND FACE PROTECTION: SPECTACLES, GOGGLES AND E FACE SHIELDS

Eye and face protection equipment should be chosen based on the physical state, operations and toxicity level of the products..

Safety spectacles Safety spectacles with side shields are required for anyone working in the laboratory. This type of safety spectacles protect the eyes from solid materials (splinters) and from small splashes such as those that can originate from the opening of a test tube but do not provide adequate protection in case of significant chemical spillage, in fact they do not adhere to the face and therefore can allow the chemical to percolate on the sides and reach the skin.

Safety goggles Safety goggles s are used when there is a possibility of significant splashes, or if you are wearing eyeglasses. They must have openings to prevent the fogging.

Face shields Visors, face shields or protective masks are required when pouring or transferring corrosive materials or dangerous liquids, especially if in large quantities. Face shields are not a substitute for ocular protectors, both protections must be used.

Use of CONTACT LENSES

Contact lenses are increasingly used and can represent an additional risk factor for those who work in laboratories. In fact, the risks are the following:

1. They might absorb chemical vapours which can then condense between the lens and the eye;
2. They might facilitate a long and direct contact between toxic substances and the eyes;
3. They might capture substances and particles in the space between the lens and the eye;
4. They can be difficult to remove in an emergency due to the muscle spasms of the eye;
5. Some types of solvents “dissolve” the polymer lenses;
6. Even rinsing the eye with significant quantities of water may not help to wash it of contaminants if the lenses have remained in place.

Advice

Employees who wear contact lenses and who work in laboratories **MUST** obligatorily wear eye protection (safety spectacles, face shields).

At the end of activities in which chemicals are used, always wash your hands thoroughly with soap and water and rinse before handling the lenses. Apply this procedure even if you have worn gloves because they can become porous or have small cuts not visible to the naked eye due to possible contamination of the skin with dangerous agents.

NEVER leave lenses in rooms where volatile chemicals are present.

PROTECTION OF THE UPPER LIMBS: GLOVES

Gloves play a very important role in hand protection as long as they are used and stored properly. The main types of gloves used in the laboratories are the following:

- ❖ gloves for chemical or biological risks, made of material suitable for specific substances;
- ❖ heat protection gloves (for the use of furnaces, mitts, or the like);
- ❖ cold protection gloves (e.g. for the use or handling of liquefied cryogenic gases);
- ❖ cut resistant gloves for handling glass;
- ❖ Inner cotton gloves, useful in case of allergies.

The type of gloves to be worn must be the one specifically provided for in the risk assessment for the operation being carried out.

You should always keep in mind the following:

- ❖ gloves only protect the operator but do not remove the contaminant from the workplace;
- ❖ some types of gloves are uncomfortable and can interfere with the working method;
- ❖ wearing gloves interferes with the sense of touch and therefore more caution than usual is needed when grasping things;
- ❖ good protection depends a lot on the way the gloves are worn and on the attention given to the instructions for use;
- ❖ incorrect use or poor maintenance may neutralise the protection.

When using gloves, adopt the following general rules:

1. Wear gloves of the appropriate size;
2. Check the gloves before each use in order to detect damage or contamination (cuts, stings, discoloured spots), in case of anomalies replace them immediately.
3. Take the gloves off before touching surfaces that are not to be contaminated (handles, telephone etc.);
4. Disposable gloves must never be reused, they must be taken off taking care to turn them upside down, and then be placed among the hazardous waste.
5. Reusable gloves must however be replaced periodically according to the frequency of use and their resistance to the substances used. Washings and the use of non-polar solvents remove plastic agents, rapidly degrading the glove.
6. If case of spillage on the gloves, you must take them off and wash your hands immediately.
7. Always wash your hands after taking off the gloves.
8. **It is absolutely forbidden to keep gloves on outside the laboratories.**

BODY PROTECTION: LABORATORY LAB COATS AND APRONS

The handling of chemicals implies the possibility of contamination of clothing; therefore, for hygiene reasons, that is, in order to preserve your clothes from this contamination, it is always necessary to wear a lab coat when you are inside a chemical laboratory. The lab coat must be comfortable so that it can be worn throughout the working day, it is usually made of cotton or the cotton/polyester blend.

When using the lab coat, respect the following rules:

- wear the lab coat every time you enter the laboratory or when handling chemical agents;
- keep the lab coat in the laboratory and do not wear it outside the laboratory area;
- clean the lab coat regularly by washing it separately from normal clothing; if the lab coat or personal clothing is significantly contaminated they must be decontaminated before the next use.

It should be noted that the normal laboratory lab coat is a part of work clothes that must be worn for hygiene reasons; since it does not perform an effective protective function from chemical agents, it is not a part of Personal Protection Equipment. However, if protection of the body from a specific risk is required, for example, if carrying out operations in which large quantities of dangerous substances/mixtures are handled, protective clothing (gowns, aprons or overalls) made of special materials resistant to the chemical agent in question, must be worn; in this case, such clothes are to be considered Personal Protective Equipment.

PROTECTION OF THE LOWER LIMBS: SAFETY SHOES AND SHOE-COVERS

Typical laboratory activity can rarely require protection of the lower limbs, but it might be required while performing ancillary activities, such as:

- handling of cylinders, dewars, and other heavy objects;
- transfer of significant quantities of acids, solvents, cryogenic liquefied gases.;
- frequenting slippery places.

In these cases, and others, specific types of shoes or shoe-covers to be used to protect the lower limbs are identified in the RAD.

As with any other PPE, it is mandatory to always and in a correct way wear safety shoes or shoe-covers, if the use of the same is envisaged for work activities.

In the event that the use of such PPE is not prescribed, it is however always mandatory to **avoid the use of sandals, open shoes or, in any case, material easily permeable to dangerous substances that might accidentally spill during the laboratory activity**.

RESPIRATORY TRACT PROTECTION: MASKS AND RESPIRATORS

Respiratory PPE are devices intended to protect against vapours, gases and respirable particles that can be sources of danger, using filtration mechanisms. These devices, also called Respiratory Protection Equipment - RPE are used when operators are exposed for short periods and/or to low concentrations of pollutants. They can be divided into two categories:

Filtrating equipment, operating by removing contaminants from the ambient air before it is inspired by the operator.

Isolating equipment, equipped with an air source independent of the air present in the environment (for example a cylinder).

FINE PARTICLE FILTER RESPIRATORS

They protect from fine particles (dust, fibres, fumes, mists). The inspired air is filtered by mechanical and electrostatic action. The two main types of devices are the following:

Filtering facepiece It consists of a single element of filtering material indicated by the abbreviation FFP. It can be equipped with an exhalation valve; it must be replaced at the end of each working shift.	
Mask (half mask or full face mask) The half mask only covers the nose and mouth. White filters are mounted interchangeably, and indicated with letter "P". The full face mask, on the other hand, covers the entire face. There can be one or two filters. Filtering facepieces, and the filters are divided into 3 efficiency categories: ● FFP1/P1 against *irritating* particles (TLV ≥ 10 mg/m3) ● FFP2/P2 against *harmful* particles (TLV between 0.1 e 10 mg/ m3) ● FFP3/P3 against *toxic* particles (TLV ≤ 0.1 mg/m3). There is also the following distinction: ● S for water based solids and mists ● SL for organic based mists (not foreseen for FFP1).	 

In addition to filtering facepieces and masks, there are also helmets and hoods with filters. A typical example are *ventilated welding helmets*, which protect both the respiratory tract against metal fumes and the eyes against IR/UV radiation.

GAS FILTER RESPIRATORS

They protect against gases and vapours, which are retained by activated carbon filters with chemical or physical absorption. Filters are divided into Types, based on the substance or classes of substances they absorb.

Gas filter respirators also include filtering facepieces, masks, helmets or hoods. For A/B/E/K filters, there are 3 capacity classes, based on their duration:

- ❖ Class 1 *Low* capacity
- ❖ Class 2 *Medium* capacity
- ❖ Class 3 *High* capacity

RESPIRATORS WITH COMBINED FILTERS

They simultaneously protect from particles and gases/vapours. They are equipped with a fine-particles filter (P or FFP), and one or more gas filters, to be selected separately. EN 14387 provides for the following types of combined filters:

TYPE	COLOUR	PROTECTION AGAINST
A	Brown	Organic gases and vapours with boiling point > 65°C
AX disposable	Brown	Organic gases and vapours with boiling point < 65°C
B	Grey	Inorganic gases and vapours, excluding CO
E	Yellow	Sulphur dioxide and other acid gases
K	Green	Ammonia and its organic derivatives
SX disposable	Purple	Compounds specified by the manufacturer

ISOLATING EQUIPMENT (BREATHING APPARATUS)

Unlike filter respirators, breathing apparatus are independent of the ambient atmosphere. Fresh air, supplied to the user from alternative sources (e.g. compressed air cylinders), is conveyed to the facepiece (or helmet/hood) through a fitting. They are necessary in the following cases:

- the atmosphere is deficient in oxygen (concentration < 17%);
- contaminants are present in concentrations above the limits of use of filter respirators;
- gaseous contaminants have an olfactory threshold greater than TLV-TWA;
- the nature and/or concentration of the contaminants are not known;
- work is performed in confined spaces.

The correct type of equipment to be worn is indicated in the Risk Assessment Document for the specific activity being performed; it is forbidden to use devices other than those prescribed, as they may not be suitable to provide the necessary protection.

Disposable filtering facepieces must not be reused and must be disposed of if damaged, dirty or contaminated by blood or other biological fluids; while the reusable ones must be sanitised before being used again.

8. STORAGE OF DANGEROUS SUBSTANCES

The mere presence of dangerous substances/mixtures in the laboratory is a source of chemical risk; for this reason, it is necessary to take some precautions regarding their storage, which may

require the use of particular safety cabinets, or, in cases where storage must take place at low temperatures, laboratory refrigerators. Below are some general recommendations and indications on safety cabinets and laboratory refrigerators.

Carcinogenic and/or mutagenic agents

Carcinogenic and/or mutagenic substances/mixtures of category 1A and 1B, according to the CLP regulation, must always be kept under a key, and access to these substances/mixtures must be granted only to expressly authorized personnel.

8.1 REAGENT CONTROL

In the management of dangerous substances, it is necessary to have precise control of the quantities in storage, to indicate their danger, and to prepare interventions to be performed in the event of accidental spills or releases. We therefore recommend following the instructions below:

1. Maintain an updated register for each deposit/cabinet containing the substances/mixtures, and the quantities in storage.
2. Perform a periodic check (at least once a year) of the stored chemical products: those that cannot be identified, are deteriorated or very old, must be eliminated.
3. Reduce the quantities of hazardous chemicals to the necessary minimum, and replace, where possible, hazardous products with other products that are not hazardous, or are less hazardous.
4. Keep the updated safety data sheet for each substance / mixture present in the laboratory and comply with any special indications contained in the data sheet (item Handling and Storage).
5. Place the necessary warning signs (e.g. Flammable materials) and prohibition signs (e.g. No open flame) clearly visible on each deposit/cabinet.
6. Make sure that all containers are labelled so that their contents can be recognised at any time.
7. Prepare emergency procedures to be performed in case of accidental product dispersion. In particular, make the material for the absorption and neutralisation of any spills available near cabinets containing liquid chemical products. For the choice of the most suitable material, refer to what is indicated in the safety data sheets.

SAFEGUARDING AND ARRANGEMENT OF CONTAINERS

In order to reduce the possibility of an accidental breakage of a container, the following precautions are recommended:

- Avoid overfilling the shelves (respect the maximum expected load);
- Avoid accumulating the containers one on top of the other;
- Preferably place the containers of larger dimensions and weight, and those with the most dangerous substances/mixtures, at the bottom;
- Avoid placing the containers on high shelves; arrange the corrosive, caustic or irritating substances/mixtures at a height lower than eye-height;
- If there are no tray shelves, use shelves with the outer edge raised so as to avoid accidental sliding of the containers;

- Make sure that the substances/mixtures are not placed near heat sources or in direct sunlight.

COMPATIBILITY AND CONTAINMENT

When it comes to storage, it is always necessary to consider the possibility of accidental breakage of the containers. To limit the damage, it is advisable to follow the following precautions:

- Place chemically incompatible substances/mixtures, i.e. capable of reacting chemically with each other, in separate compartments. This condition implies, for example, that the acids are separated from the bases and that the combustible/flammable materials are separated from the oxidizers (oxidants);
- Keep containers with solid materials in compartments separate from containers containing liquids. Solid materials are usually not very reactive, but they can significantly increase their reactivity if placed in contact with a liquid;
- Store the containers with liquids in collection trays that can contain an accidental spill. If necessary, also place a collection tank on the bottom of the cabinets.

8.2 SAFETY STORAGE CABINETS

Some particularly dangerous substances/mixtures **must** be stored in suitable safety storage cabinets; it is the case of **flammable materials which must be placed in fire safety storage cabinets** and **corrosives to be stored in acid/base safety storage cabinets.** In the case of **volatile non-flammable and non-corrosive liquids, the vapours of which may contaminate the environment, solvent safety storage cabinets are used.**
Safety storage cabinets are normally delivered already equipped with a danger signage. For example, fire safety storage cabinets have a warning sign informing about the presence of flammable materials and a prohibition of the use of open flames, while safety storage cabinets for acids or bases have signs indicating the presence of corrosive materials. However, if the substances/mixtures contained within a cabinet may result in an additional, unreported hazard, it is necessary to place additional signs on the cabinet. For example, if a fire safety storage cabinet contains materials which, in addition to being flammable, are also toxic, it is necessary to affix the toxic materials sign on the outer side of the cabinet.

FIRE SAFETY STORAGE CABINETS

Flammable liquids must be stored in fire safety storage cabinets. The EN 4470-1 standard classifies safety cabinets according to the time required, in specified heating conditions, to raise their internal temperature by 180 K, without this entailing the risk of causing or fuelling a fire. In these standard tests, the cabinet, introduced into an oven, is heated according to a specific temperature-time curve which simulates the evolution of a fire. The number that identifies the type of cabinet therefore gives an idea of the time that the cabinet can withstand if subjected to a fire.

Classification of types of cabinets for flammable materials

Type	Time needed to raise the temperature by 18 K (min)

15	≥ 15
30	≥ 30
60	≥ 60
90	≥ 90

The choice of the type of cabinet must consider the time of evacuation of the staff and the time of intervention of the emergency teams to extinguish a fire. In any case, the placement of a fire safety storage cabinet inside a chemical laboratory requires a type 90 cabinet.

Main features

The EN 4470-1 standard requires that the cabinets, regardless of the type, meet a series of specifications; the main ones are shown below:

- The cabinets must be designed to be ventilated. Forced ventilation is recommended in the presence of non-hermetically sealed containers, in particular in the presence of volatile substances/mixtures; in this case, to reduce the odour, change of air at least 10 times per hour is required (the pressure drop must not exceed 150 Pa). The ventilation system must keep the cabinet in depression;
- The cabinet doors must be equipped with a device that makes them close automatically when the ambient temperature reaches 50°C;
- The ventilation opening and the exhaust air expulsion opening must close automatically when the temperature reaches 70°C. The seals and valves in the ventilation openings must therefore close automatically at this temperature. The gaskets are normally heat-expanding so that if heated they turn into a foam with high insulating power;
- The height of the highest shelve must not exceed 1.75 m;
- Shelves must be tray-shaped in order to contain any liquid leaks from accidental damage or breakage of the containers;
- A bottom tank must always be present to collect any liquid leaks that have not been completely retained by the tray shelves. The capacity of the bottom tray must be at least 10% of the volume of all the containers stored in the cabinet, or at least 110% of the volume of the largest container;
- In order to prevent electrostatic discharge, the cabinets are provided with a grounding which must be connected to the grounding of electrical installations, if any.

ACID/BASE SAFETY STORAGE CABINETS

Liquid corrosive substances/mixtures must be stored in special ventilated cabinets. The materials used to make these cabinets are particularly resistant to corrosion. Like with all cabinets for liquids, it is desirable that the shelves are tray-shaped, and that there is a bottom tank. It is important to note that acids and bases are incompatible and therefore must be placed in different compartments.

SOLVENT SAFETY STORAGE CABINETS

A solvent safety storage cabinet is a ventilated cabinet with tray-shaped shelves and a containment tank on the bottom, suitable for the storage of volatile non-flammable and non-corrosive solvents. The air flow must be at least equal to 10 air volume changes per hour. A suction system should be created, so that both the cabinet and the section of the expulsion piping present in the room are under vacuum.

A ventilated cabinet is necessary when there is a possibility that the release of non-negligible quantities of vapours from the containers with volatile liquids may contaminate the environment, exposing operators to concentrations higher than the threshold values allowed for hygiene reasons. If the liquids are flammable, it is necessary to ventilate the fire safety storage cabinet, and if they are corrosive, the appropriate safety cabinets are already ventilated. In other cases, it is necessary to provide a storage cabinet for solvents.

8.3 REFRIGERATORS

Refrigerators used in laboratories can be of both, domestic and laboratory type. To refrigerate volatile organic liquids, however, laboratory refrigerators must necessarily be used.

DOMESTIC REFRIGERATORS

Domestic refrigerators can **only** be used to refrigerate aqueous solutions or, in any case, non-hazardous materials. They are absolutely unsuitable for containing flammable liquids as they have the following drawbacks:

- The internal temperature of a refrigerator is normally higher than the flashpoint of the volatile liquids stored, so their vapours may cause combustion in the presence of a trigger;
- Inside a domestic refrigerator there are many ignition sources such as the thermostat and internal light;
- In domestic refrigerators, the compressor is normally placed at the bottom where cold vapours, if any, escaping from the internal compartment may accumulate.

LABORATORY REFRIGERATORS

Laboratory refrigerators are professional refrigerators equipped with an accurate temperature control and regulation system; they usually have an automatic door closing device, and a power failure indicator; they may be equipped with too-high/too-low temperature alarms, an open-door alarm and an internal temperature recording system; if they are intended for the storage of highly heat-sensitive and unstable substances/mixtures, they also have a buffer battery which intervenes in the event of a power failure. An important feature of these refrigerators is that, even in the case of a minimum configuration, they are made so as to avoid a possible ignition of flammable mixtures inside the storage compartment. The thermostat is external, the internal light is special, and the perimeter seals, usually magnetic, guarantee excellent sealing; finally, the compressor and its circuit are placed on top of the unit in order to reduce the possibility of triggering cold vapours layered at floor level.

In the case of highly flammable or explosive substances/mixtures, the use of special explosion-proof refrigerators is mandatory.

RECOMMENDATIONS FOR THE USE OF REFRIGERATORS

Position and power connection

- Place the refrigerator in a well-ventilated place, away from direct sunlight and other heat sources; avoid placing it in close contact with a wall;
- It is forbidden to use adapters and / or multiple sockets to connect the refrigerator to the power supply.

Requirements for dangerous material

- Use only explosion-proof refrigerators (ATEX) for the storage of flammable and/or explosive materials;
- In the presence of dangerous materials, due to their instability with the change in temperature, use a refrigerator equipped with a high-temperature optical and acoustic alarm, and a buffer battery that intervenes during a power outage.

Safety signs

- Indicate the danger from the stored substances/mixtures (flammability, explosiveness, toxicity, etc.) by placing all the safety signs on the refrigerator in a clearly visible position;
- Indicate the prohibition of placing flammable or explosive materials inside the refrigerators that are not suitable for the storage of these products, that is, that don't have an explosion-proof internal compartment.
- Indicate, in particular for domestic refrigerators, the prohibition of storing food and beverages intended for consumption.

Content management

- Keep an updated register with the substances/mixtures, and their quantities, in storage;
- Place all liquid substance/mixtures in well-sealed containers in order to minimise the release of vapours;
- Place the containers containing substances / mixtures in an unbreakable secondary container;
- Reduce the storage of dangerous substances/mixtures to the minimum quantity necessary for work;
- Avoid overloading the refrigerator with excessive quantities of products;
- Limit the door opening time to the minimum necessary in order to avoid deterioration of the material and possible dangerous reactions.

9. CRYOGENIC LIQUIDS

The use of cryogenic liquids in laboratories is widespread, both for the correct functioning of scientific instruments (magnetic resonances, cryostats, etc.), and for the storage of samples and substances, or to obtain low reaction temperatures. The cryogenic liquid most used for these purposes is liquid nitrogen, but liquid helium is also commonly used.

The main storage point for liquid nitrogen at UNICAM is a 3000 litre dewar located at the Department of Chemistry in Via S. Agostino 1, in Camerino. The liquid-phase nitrogen may be

taken from here and transported to the various points of use by using specially dedicated and compliant containers for mobile cryogenic liquids (dewars).

9.1 RISKS

The main risks involved in the handling of nitrogen are the following:
Contact burns Nitrogen is stored in a liquid form at a very low temperature (-196°C), therefore contact with the liquid can cause severe cold burns and, if prolonged, it can lead to the freezing of the affected part; moreover, in contact with very cold surfaces (uninsulated pipes or containers), the skin can adhere to it very firmly and tear when trying to detach it.

Eye injuries caused by splashes of liquid or puffs of cryogenic vapours.

Risk of asphyxiation Excessive gas concentrations reduce the percentage of oxygen in the environment creating a risk of epoxy, leading up to asphyxia in the most serious cases. This can occur following the evaporation of liquid nitrogen in closed environments (a phenomenon that cannot be avoided in any way in specific containers), a single litre of liquid nitrogen evaporating produces 704 litres of gaseous nitrogen.
ATTENTION: The mist that forms when a liquefied gas is exposed to the air is due to the humidity that condenses and not to the gas itself which, on the other hand, is transparent and colourless.

9.2 CRYOGENIC LIQUID CONTAINERS

To store or transport cryogenic liquids, it is essential to use special containers (dewars), in compliance with the law. It is absolutely forbidden to transport liquid nitrogen in makeshift containers such as polystyrene containers or food thermos as they are absolutely unsuitable and dangerous.
The standard cryogenic containers are made of materials capable of withstanding sudden and high temperature variations, they can be of the open type or equipped with a tapping device operating in slight overpressure. In this case there must be a safety system (automatic valves) that allows the discharge of the gas and prevents the formation of pressures too high.
If there is a tapping system (or dispenser) or a pouring spout, it is necessary to check, at regular intervals, that the vent is not obstructed by the ice formed due to solidification of the atmospheric humidity. An inadequate discharge may be the cause of an excessive pressure increase resulting in possible damage to the container or, in extreme cases, in bursts.
Keep an eye on the control pressure gauge: the pressure must not exceed 60% of the safety valve calibration value.
Even in the case of an open dewar, once the container is filled, it must always be closed with an appropriate cap or lid. Use only the cap or lid supplied together with the container.

9.3 STORAGE AND USE OF CRYOGENIC LIQUIDS

It is absolutely essential to provide for the storage of liquid nitrogen containers only outdoors or in well-ventilated rooms, equipped with a device for measuring the percentage concentration of

oxygen, connected to an automatic forced ventilation system and an audible alarm system that guarantee a fast and adequate change of air in case of spillage.
The use must be made in airy environments, always providing for the use of **Personal Protective Equipment (PPE),** such as: gloves for protection from cold burns, spectacles or goggles equipped with side protectors or visors, and protections of the lower limbs in order to avoid, especially when performing the transfer of liquids, the dripping of the material inside the shoes. The gloves must be large, in order to be easily removed in case drops or splashes enter them. In the event of accidental spillage or "leakage" from the containers, the **first thing** to pay attention to is avoiding contact with the liquid and the escaping steam, and therefore you must make sure to isolate the affected area from the leak until the leak is not under control.

9.4 GENERAL SAFETY INDICATIONS

In order to guarantee personnel safety, the following indications must be respected and enforced.

1. Avoid accidental contact with cryogenic liquid or evaporated gas, which is still at temperatures that cause cold burns that can be as severe as those caused by high temperatures. Particular attention must be paid to all operations involving the direct use of the liquid.
2. The most frequent risks occur in the **transfer operations** and in the **operations of immersion and extraction of objects from the liquid** due to the production of splashes caused by the variation of the temperature of the cryogenic liquid. These operations must be carried out very slowly in order to allow the objects to change temperature in a non-abrupt way.
3. To extract objects immersed in liquid always use pliers or pincers, handling both, these and the objects, with caution; in addition to the contact risks already mentioned, it must be remembered that many materials that are soft or flexible at room temperature become hard and fragile at low temperatures.
4. Store and use the cryogenic liquid in closed systems or in systems with positive pressure so as to prevent the infiltration and solidification of air or other gases, the consequence of which could be the obstruction of vent passages and safety valves.
5. Keep the surfaces on which the air condenses clean, as the condensed air is enriched with oxygen (nitrogen evaporates before oxygen), especially near the valves and vents, where lubricant may be present. A high concentration of oxygen can increase the risk of fire.
6. Check, according to the instructions of the supplier, the correct functioning of the safety valves of the cryogenic liquid containers, since the transfer of a small amount of heat to the liquid causes the expansion of the liquid.

9.5 TRANSPORT SAFETY INSTRUCTIONS

Personnel authorised for transport must be informed and trained on the risks and on the prevention and protection measures. Transport refers both to the movement of dewars within a single facility, and to the transport from one Unicam facility to another.
In the case of transfer between the different Unicam facilities, full dewars may only be transported using the appropriate vehicle prepared specifically for the purpose, booking it in advance

according to the established methods. **It is absolutely forbidden to transport containers of any type containing liquid nitrogen using normal vehicles.**
The specific transport rules that must be observed are those set in Point 14 of the product Safety Data Sheet. Special precautions to be taken for transportation are set below:

1. Make sure that the cap (if any) of the dewar is correctly assembled.
2. Move the nitrogen containers (whether full or empty) avoiding shocks that could cause incongruous evaporation and give rise to an increase in the flow of gas through the vent devices.
3. Carry the heaviest dewars using special trolleys and secure them in place.
4. If the delivery involves the use of an elevator, it must be used without accompanying personnel, or more precisely: an operator is positioned on the arrival floor, to collect the container, while a second operator sends it, without entering the elevator.

9.6 TRANSFER SAFETY INSTRUCTIONS

Liquid nitrogen transfer operations must be carried out by operators appropriately informed on the potential risks associated with the handling of compressed and/or cryogenic gases, and instructed on the prevention and protection measures and any internal procedures defined by The Head of the Laboratory.
The transfer must be carried out in a well-ventilated room **wearing the appropriate Personal Protective Equipment** (cold-resistant gloves, visor or goggles, apron, shoes).
Before proceeding with a transfer, make sure that the destination container is empty and does not contain water or other cryogenic liquids.
Unless the original container is small in size and easy to handle (so it may be sufficient to use a funnel), always use a special pressurized tapping system with flexible hose.

TRANSFER FROM ONE DEWAR TO ANOTHER AT ATMOSPHERIC PRESSURE

1. Place the container to be filled on a stable surface (preferably a laboratory worktop, with raised edges).
2. Hold the container to be filled with a long clamp, made of non-conductive material (wood, plastic) or block it to be sure that it does not spill.
3. Perform the lifting of the dewar and the transfer of the cryogenic liquid in two (two persons are needed).
4. During the transfer operations, check the level reached on the container, avoiding any direct contact with the cryogenic substance.
5. In the event that a person feels dizzy or loses consciousness, immediately transport them to a well-ventilated area and start first aid procedures.

TRANSFER FROM A TANK TO A DEWAR AT ATMOSPHERIC PRESSURE

1. Position the dewar near the transfer area so that you can easily lay the end of the flexible tube on the bottom.
2. Slowly open the tank withdrawal valve.

3. When the desired level has been nearly reached, close the valve on the liquid phase halfway.
4. At the desired level, completely close the valve on the liquid phase of the tank.

9.7 PERSONAL PROTECTIVE EQUIPMENT (PPE) FOR CRYOGENIC LIQUIDS

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Cryogenic liquids transport operations

- cold-resistant work gloves with the CE EN 511 marking
- footwear

Cryogenic liquids transfer operations
Cryogenic liquids withdrawal operations

- cold-resistant work gloves (with the CE EN 511 marking)
- visor or spectacles (with the CE EN 166 marking)
- apron
- footwear

10. COMPRESSED GAS CYLINDERS

Particular precautions should be used in all activities involving the use, transport and storage of cylinders containing compressed gas, even when the contained gas is a so-called “inert” gas.
The chemical and toxicological risk represented by the gas contained in the cylinder must in fact be considered independently of the risk represented by a container under pressure.

Inert gases can be dangerous as they can lead to the formation of an under-oxygenated atmosphere, performing an asphyxiating action; oxygen concentrations lower than 16-18% are already considered dangerous. In the case of escape of "inert" gases (for example, nitrogen, argon, helium), it is good practice to leave the laboratory and return to it only after having it aerated.

10.1 HANDLING OF CYLINDERS

- The containers must be handled with the utmost caution, slowly performing all the necessary manoeuvres, avoiding violent impacts, falls or other mechanical stresses that could compromise their integrity and resistance.
- The containers must not be lifted by the cap, nor dragged, rolled or slipped on the floor. The movement of the same, even for short distances, must take place using a hand trolley or other suitable means of transport.
- The containers must not be handled with hands or with gloves greased with oil or grease, first of all to avoid that the grip is not safe precisely because of these products. Moreover, this rule is particularly important when handling oxidizing gas containers.
- **If a cylinder is about to fall, do not try to stop it. Let it fall!**

10.2 STORAGE OF CYLINDERS IN THE LABORATORIES

Considering the potential risk of a cylinder containing any type of compressed, liquefied or dissolved gas, it is strongly advised against keeping cylinders inside the laboratories.
If, however, you decide to keep the cylinders in use, **never the reserve ones**, inside the laboratory, it is absolutely essential that the cylinders are placed in special safety cabinets, or that they are securely fixed to the wall by means of solid anchoring systems. ***In any case, they must be removed from the laboratory as soon as the need for their use ceases.***

10.3 USE OF CYLINDERS

A gas container must be put into use only if its contents are clearly identifiable. Content is identified in the following ways:

1. colouring of the spinner, according to the colour code prescribed by law;
2. commercial name of the gas stamped on the spinner in full or abbreviated, if it is very long;
3. indelible writings, self-adhesive labels, decals placed on the body of the container, or identification tags attached to the valve or the protective cap;

Before using a cylinder, **even for extemporaneous use**, it is necessary to secure it to the wall or to any solid support, using chains or other effective stops. Once the container is secured, the protective cap of the valve can be removed, and use can be initiated, keeping in mind the following general rules of conduct:

1. The containers must never be heated above 50°C. It is absolutely forbidden to bring a flame into direct contact with the container.
2. Containers must not be artificially cooled to very low temperatures. Many types of steel lose ductility and become brittle at low temperatures.
3. The containers must be protected against any type of tampering by unauthorised personnel.

4. The users must not erase or render illegible the writings, nor remove the labels, decals, or tags applied on the containers by the supplier to identify the gas contained.
5. The users must not change, modify, tamper with, or tap any safety devices present, or, in the event of gas leaks, carry out repairs on full containers and on valves.
6. Pressure reducers, pressure gauges, hoses or other equipment intended for a gas with different chemical properties, incompatible with that contained in the cylinder, must not be fitted (for this purpose, consult the tables).
7. It is necessary to make sure that the reducers are compliant and calibrated to withstand a pressure at least 20% higher than the maximum cylinder pressure (also indicated on the spinner stamping).
8. If the cylinder is not used, the valve must always be kept closed. The valves on containers under pressure must be opened gradually and slowly.
9. Never use wrenches or other tools to open or close valves equipped with a handwheel. Avoid force-opening hard valves or valves blocked for corrosion.
10. Lubrication of the valves is not necessary. It is absolutely forbidden to use oil, grease or other combustible lubricants on the valves of containers containing oxygen and other oxidizing gases.
11. Before returning an empty container, the user must make sure that the valve is properly closed and replace the protective cap. ***It is advisable to always leave a slight positive pressure inside the container***.

10.4 STORAGE AND DEPOSIT OF CYLINDERS

Storage and deposit of cylinders is managed by specially trained and appointed personnel, therefore in general, it does not interest the users of the laboratory. The following are general indications, which, however, are useful for those who, although not appointed for the storage, do use and handle the compressed gas cylinders.

- Containers containing gas must not be exposed to direct sunlight, nor kept near heat sources or, in any case, in environments where the temperature can reach or exceed 50°C.
- Containers must not be put in contact with corrosive chemical agents.
- Storage rooms must be cool, well-ventilated and free of heat sources, such as steam pipes, radiators, etc.
- The storage rooms must be identified with the name of the gas placed in storage. If different but compatible gases are present in the same deposit, the containers must be grouped according to the type of gas contained.
- To avoid, in the event of leaks, dangerous reactions, such as explosions or fires, it is forbidden to store in the same room containers containing incompatible gases (for example, flammable gases, such as methane, hydrogen, acetylene, or LPG, must be separated from gas oxidants, such as oxygen, nitrous oxide, air; ammonia from acid gases, such as hydrochloric acid, etc.). It is also forbidden to store containers in rooms where combustible materials or flammable substances are found.
- In storage rooms, full containers must be kept separate from the empty ones, using suitable signs to distinguish their respective deposits.
- In the storage rooms, the containers must be kept in a vertical position and secured to the walls with chains or other suitable means, to avoid overturning.

- Storage rooms for containers containing dangerous and harmful gases (flammable, toxic, corrosive) must be sufficiently isolated from other premises or places of work and passage, and adequately separated from each other.
- Storage rooms for containers containing dangerous and harmful gases must be equipped with adequate ventilation systems. In the absence of adequate ventilation, indicator devices and automatic warning devices must be installed to signal when dangerous concentrations or conditions have been reached. Where this is not possible, frequent checks and measurements should be performed.
- Signs must be posted in the storage rooms with containers containing dangerous and harmful gases, indicating the prohibitions, the collective and personal protective equipment to be used, the safety rules, and the emergency interventions to be adopted in the event of an accident.
- Premises for storing containers containing flammable gases must be equipped with “electrical safety systems”, and with fire safety systems.

APPENDIX A - HAZARD STATEMENTS AND ADDITIONAL HAZARD STATEMENTS

Hazard statements – Physical hazards	
H200	Unstable explosive
H201	Explosive; mass explosion hazard
H202	Explosive; severe projection hazard
H203	Explosive; fire, blast or projection hazard
H204	Fire or projection hazard
H205	May mass explode in fire
H220	Extremely flammable gas
H221	Flammable gas
H222	Extremely flammable aerosol
H223	Flammable aerosol
H224	Extremely flammable liquid and vapour
H225	Highly flammable liquid and vapour
H226	Flammable liquid and vapour
H228	Flammable solid
H240	Heating may cause an explosion
H241	Heating may cause a fire or explosion
H242	Heating may cause a fire
H250	Catches fire spontaneously if exposed to air
H251	Self-heating; may catch fire
H252	Self-heating in large quantities; may catch fire
H260	In contact with water releases flammable gases which may ignite spontaneously
H261	In contact with water releases flammable gas
H270	May cause or intensify fire; oxidizer
H271	May cause fire or explosion; strong oxidizer
H272	May intensify fire; oxidizer
H280	Contains gas under pressure; may explode if heated
H281	Contains refrigerated gas; may cause cryogenic burns or injury
H290	May be corrosive to metals

Hazard statements – Health hazards	
H300	Fatal if swallowed
H301	Toxic if swallowed
H302	Harmful if swallowed
H304	May be fatal if swallowed and enters airways
H310	Fatal in contact with skin
H311	Toxic in contact with skin
H312	Harmful in contact with skin
H314	Causes severe skin burns and eye damage
H315	Causes skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye damage
H319	Causes serious eye irritation
H330	Fatal if inhaled
H331	Toxic if inhaled
H332	Harmful if inhaled
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335	May cause respiratory irritation
H336	May cause drowsiness or dizziness
H340	May cause genetic defects *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H341	Suspected of causing genetic defects *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H350	May cause cancer *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H351	Suspected of causing cancer *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H360	May damage fertility or the unborn child *<state specific effect, if known> <state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H361	Suspected of damaging fertility or the unborn child *<state specific effect, if known> <state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*

H362	May cause harm to breast-fed children
H370	Causes damage to organs *<or state all organs affected, if known> <state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H371	May cause damage to organs *<or state all organs affected, if known> <state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H372	Causes damage to organs *<or state all organs affected, if known>* through prolonged or repeated exposure *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*
H373	May cause damage to organs *<or state all organs affected, if known>* through prolonged or repeated exposure *<state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard>*

Hazard statements – Environmental hazards	
H400	Very toxic to aquatic life
H410	Very toxic to aquatic life with long-lasting effects
H411	Toxic to aquatic life with long-lasting effects
H412	Harmful to aquatic life with long-lasting effects
H413	May cause long-lasting harmful effects to aquatic life

Additional hazard statements	
EUH001	Explosive when dry
EUH006	Explosive with or without contact with air
EUH014	Reacts violently with water
EUH018	In use may form flammable/explosive vapour-air mixture
EUH019	May form explosive peroxides
EUH044	Risk of explosion if heated under confinement
EUH029	Contact with water liberates toxic gas
EUH031	Contact with acids liberates toxic gas

EUH032	Contact with acids liberates very toxic gas
EUH066	Repeated exposure may cause skin dryness or cracking
EUH070	Toxic by eye contact
EUH071	Corrosive to the respiratory tract
EUH059	Hazardous to the ozone layer
EUH 201/201A	Contains lead. Should not be used on surfaces liable to be chewed or sucked by children. Warning! Contains lead.
EUH202	Cyanoacrylate. Danger. Bonds skin and eyes in seconds. Keep out of the reach of children.
EUH203	Contains chromium(VI). May produce an allergic reaction.
EUH204	Contains isocyanates. May produce an allergic reaction.
EUH205	Contains epoxy constituents. May produce an allergic reaction.
EUH206	Warning! Do not use together with other products. May release dangerous gases (chlorine).
EUH207	Warning! Contains cadmium. Dangerous fumes are formed during use. See information supplied by the manufacturer. Comply with the safety instructions.
EUH208	Contains <name of sensitising substance>. May produce an allergic reaction.
EUH209/209 A	Can become highly flammable in use. Can become flammable in use.
EUH210	Safety data sheet available on request.
EUH401	To avoid risks to human health and the environment, comply with the instructions for use.

Hazard statements with additional codes	
H350i	May cause cancer if inhaled.
H360F	May damage fertility.
H360D	May damage the unborn child.
H361f	Suspected of damaging fertility.
H361d	Suspected of damaging the unborn child.
H360FD	May damage fertility, may damage the unborn child.

H361fd	Suspected of damaging fertility, suspected of damaging the unborn child.
H360Fd	Suspected of damaging fertility, suspected of damaging the unborn child.
H360Df	May damage the unborn child, suspected of damaging fertility.

APPENDIX B – LIST OF PRECAUTIONARY STATEMENTS

General precautionary statements	
P101	If medical advice is needed, have product container or label at hand.
P102	Keep out of reach of children.
P103	Read label before use.

Prevention precautionary statements	
P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P211	Do not spray on an open flame or other ignition source.
P220	Keep/Store away from clothing/…/combustible materials.
P221	Take any precaution to avoid mixing with combustibles.
P222	Do not allow contact with air.
P223	Keep away from any possible contact with water, because of violent reaction and possible flash fire.
P230	Keep wetted with …
P231	Handle under inert gas.
P232	Protect from moisture.
P233	Keep container tightly closed.
P234	Keep only in original container.
P235	Keep cool.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ventilating/lighting/…/equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P244	Keep valves and fittings free from oil and grease.
P250	Do not subject to grinding/shock/…/friction.

P251	Pressurized container: Do not pierce or burn, even after use.
P260	Do not breathe dust/fume/gas/mist/vapours/spray.
P261	Avoid breathing dust/fume/gas/mist/vapours/spray.
P262	Do not get in eyes, on skin, or on clothing.
P263	Avoid contact during pregnancy/while nursing.
P264	Wash … thoroughly after handling.
P270	Do not eat, drink or smoke when using this product.
P271	Use only outdoors or in a well-ventilated area.
P272	Contaminated work clothing should not be allowed out of the workplace.
P273	Avoid release to the environment.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P281	Use personal protective equipment as required.
P282	Wear cold insulating gloves/face shield/eye protection.
P283	Wear fire/flame resistant/retardant clothing.
P284	Wear respiratory protection.
P285	In case of inadequate ventilation wear respiratory protection.
P231+P232	Handle under inert gas. Protect from moisture.
P235+P410	Keep cool. Protect from sunlight.

Response precautionary statements	
P301	IF SWALLOWED:
P302	IF ON SKIN:
P303	IF ON SKIN (or hair):
P304	IF INHALED:
P305	IF IN EYES:
P306	IF ON CLOTHING:
P307	IF exposed:
P308	IF exposed or concerned:
P309	IF exposed or if you feel unwell:
P310	Immediately call a POISON CENTRE or doctor/physician.
P311	Call a POISON CENTRE or doctor/physician.
P312	Call a POISON CENTRE or doctor/physician if you feel unwell.

P313	Get medical advice/attention.
P314	Get medical advice/attention if you feel unwell.
P315	Get immediate medical advice/attention.
P320	Specific treatment is urgent (see ... on this label).
P321	Specific treatment (see ... on this label).
P322	Specific measures (see ... on this label).
P330	Rinse mouth.
P331	Do NOT induce vomiting.
P332	If skin irritation occurs:
P333	If skin irritation or rash occurs:
P334	Immerse in cool water/wrap in wet bandages.
P335	Brush off loose particles from skin.
P336	Thaw frosted parts with lukewarm water. Do no rub affected area.
P337	If eye irritation persists:
P338	Remove contact lenses, if present and easy to do. Continue rinsing.
P340	Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P341	If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
P342	If experiencing respiratory symptoms:
P350	Gently wash with plenty of soap and water.
P351	Rinse cautiously with water for several minutes.
P352	Wash with plenty of soap and water.
P353	Rinse skin with water/shower.
P360	Rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P361	Remove/Take off immediately all contaminated clothing.
P362	Take off contaminated clothing and wash before reuse.
P363	Wash contaminated clothing before reuse.
P370	In case of fire:
P371	In case of major fire and large quantities:
P372	Explosion risk in case of fire.
P373	DO NOT fight fire when fire reaches explosives.
P374	Fight fire with normal precautions from a reasonable distance.

P375	Fight fire remotely due to the risk of explosion.
P376	Stop leak if safe to do so.
P377	Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P378	Use ... for extinction.
P380	Evacuate area.
P381	Eliminate all ignition sources if safe to do so.
P390	Absorb spillage to prevent material damage.
P391	Collect spillage.
P301+P310	IF SWALLOWED: Immediately call a POISON CENTRE or doctor/ physician.
P301+P312	IF SWALLOWED: Call a POISON CENTRE or doctor/physician if you feel unwell.
P301+P330+P331	IF SWALLOWED: rinse mouth. Do NOT induce vomiting.
P302+P334	IF ON SKIN: Immerse in cool water/wrap in wet bandages.
P302+P350	IF ON SKIN: Gently wash with plenty of soap and water.
P302+P352	IF ON SKIN: Wash with plenty of soap and water.
P303+P361+P353	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P304+P341	IF INHALED: If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P306+P360	IF ON CLOTHING: rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P307+P311	IF exposed: Call a POISON CENTRE or doctor/physician.
P308+P313	IF exposed or concerned: Get medical advice/attention.
P309+P311	IF exposed or if you feel unwell: Call a POISON CENTRE or doctor/physician.
P332+P313	If skin irritation occurs: Get medical advice/attention.
P333+P313	If skin irritation or rash occurs: Get medical advice/attention.
P335+P334	Brush off loose particles from skin. Immerse in cool water/wrap in wet bandages.
P337+P313	If eye irritation persists: Get medical advice/attention.

P342+P311	If experiencing respiratory symptoms: Call a POISON CENTRE or doctor/ physician.
P370+P376	In case of fire: Stop leak if safe to do so.
P370+P378	In case of fire: Use ... for extinction.
P370+P380	In case of fire: Evacuate area.
P370+P380+P375	In case of fire: Evacuate area. Fight fire remotely due to the risk of explosion.
P371+P380+P375	In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion.

Storage precautionary statements	
P401	Store…
P402	Store in a dry place.
P403	Store in a well-ventilated place.
P404	Store in a closed container.
P405	Store locked up.
P406	Store in corrosive resistant/... container with a resistant inner liner.
P407	Maintain air gap between stacks/pallets.
P410	Protect from sunlight.
P411	Store at temperatures not exceeding …°C/…°F.
P412	Do not expose to temperatures exceeding 50°C/122°F.
P413	Store bulk masses greater than …kg/…lb at temperatures not exceeding…°C/ °F.
P420	Store away from other materials.
P422	Store contents under...
P402+P404	Store in a dry place. Store in a closed container.
P403+P233	Store in a well-ventilated place. Keep container tightly closed.
P403+P235	Store in a well-ventilated place. Keep cool.
P410+P403	Protect from sunlight. Store in a well-ventilated place.
P410+P412	Protect from sunlight. Do no expose to temperatures exceeding 50°C/122°F.
P411+P235	Store at temperatures not exceeding ... °C/°F . Keep cool.

Disposal precautionary statements	
P501	Dispose of contents/container to...

APPENDIX C – UN CLASSIFICATION AND LABELS FOR TRANSPORTATION OF DANGEROUS GOODS

Class	Name	Division	Specimen labels	Description
1	Explosives	1.1		Substances and articles which have a mass explosion hazard
		1.2		Substances and articles which have a projection hazard
		1.3		Substances and articles which have a fire hazard
		1.4		Substances and articles which present no significant hazard
		1.5		Very insensitive substances
		1.6		Extremely insensitive articles
2	Gases	2.1		Flammable gases
		2.2		Substances and articles which have a fire hazard
		2.3		Toxic gases
3	Flammable liquids			

4	Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases	4.1		Flammable solids; self-reactive substances and solid desensitized explosives
		4.2		Substances liable to spontaneous combustion
		4.3		Substances which, in contact with water, emit flammable gases
5	Oxidizing substances and organic peroxides	5.1		Oxidizing substances
		5.2		Organic peroxides
6	Toxic and infectious substances	6.1		Toxic substances
		6.2		Infectious substances
7	Radioactive material			
	Fissile material			
8	Corrosive substances			
9	Miscellaneous dangerous substances and articles			

Minimum Information included on the Safety Data Sheet		
1	Identification of the substance/preparation, and of the company/ undertaking	• Identification of the substance or preparation • Identified uses of the substance/preparation • Identification of the company/undertaking • Emergency telephone number
2	Hazard identification	• Classification of the substance or mixture • Brief hazard identification • Label elements, including the Precautionary statements
3	Composition/information on ingredients	Substance • Chemical identity of the substance • Common name(s), synonym(s) of the substance • CAS number and other unique identifiers for the substance • Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance Mixture • Chemical identity of the mixture and concentration ranges for all hazardous ingredients, within the meaning of the GHS, and which are present above their cut-off levels
4	First aid measures	• Description of necessary first-aid measures by relevant routes of exposure: inhalation, contact with skin or eye, ingestion • Expected immediate and delayed symptoms • Advice whether immediate medical attention is required or any special treatment, if necessary
5	Fire-fighting measures	• Suitable extinguishing media • Extinguishing media not to be used for safety reasons • Specific hazards arising from exposure to the substance or the preparation, to combustion products, to gases produced • Special protective equipment for fire-fighters

6	Accidental release measures	• Personal precautions, protective equipment and emergency procedures (for non-emergency personnel and for emergency responders) • Environmental precautions • Methods and materials for containment and cleaning up • References to other sections
7	Handling and Storage	• Precautions for safe handling • Conditions for safe storage, including any incompatibilities • Specific final uses
8	Exposure controls/ Personal protection	• Control parameters (e.g. Occupational exposure limits or biological limit values • Appropriate engineering controls • Individual and collective protection measures
9	Physical and chemical properties	• Appearance: physical state (solid, liquid, gas), colour e odour (if noticeable) • pH • Boiling point/range • Flash point • Flammability (solid, gas) • Explosive properties • Oxidizing properties • Vapour pressure • Relative density • Solubility • Water solubility • Partition coefficient: n-octanol/water • Viscosity • Vapour density • Evaporation rate
10	Stability and reactivity	• Chemical stability and possibility of hazardous reactions • Conditions to avoid • Incompatible materials • Hazardous decomposition products

11	Toxicological information	• A concise but complete and comprehensible description of the various toxicological (health) effects that may arise if the user comes into contact with the substance or mixture. • Information on the likely routes of exposure • Symptoms related to the physical, chemical and toxicological characteristics • Delayed and immediate effects, and also chronic effects from short and long term exposure • Numerical measures of toxicity (such as acute toxicity estimates)
12	Ecological information	• Description of the possible effects, behaviour and environmental fate of the substance or preparation in air, water and/or soil • Ecotoxicity • Mobility (potential to move if released to the environment) • Persistence and degradability • Bioaccumulative potential • Results of PBT / vPvB assessments • Other harmful effects
13	Disposal considerations	• Description of the residues and information related to their handling in terms of safety • Proper disposal methods for the substance or mixture, and for the contaminated packaging (incineration, recycling, landfilling, etc.)
14	Transport information	• Special precautions which a user must be aware of and which he must comply with as regards transport or handling inside or outside the company. • If necessary, information on the transport classification for each of the modal regulations: IMDG (sea), ADR (road), RID (railway), ICAO/ IATA (air), in particular: • - UN number, - Class, - UN proper shipping name, - Packaging group, - Marine pollutant, - Other useful information

15	Regulatory information	• Safety, health and environmental regulations reported on the label • Specific EU provisions in relation to the protection of humans or the environment. • List of the national laws implementing the provisions and any other relevant national measures
16	Other information	• Any other information that the supplier considers relevant for the safety and health of the user and for the protection of the environment. • When a safety data sheet has been modified, the information added, deleted or modified (if not indicated elsewhere) is included

APPENDIX E – LIST OF SOME INCOMPATIBLE CHEMICAL SUBSTANCES

Many chemical substances react dangerously if they come into contact with other substances or with certain materials. **Some** of these incompatibilities are listed below (the substances and materials from the first column and those from the second column react dangerously when in contact with each other; **the list is to be considered indicative** and not exhaustive: always consult the safety data sheets)

INCOMPATIBLE CHEMICAL SUBSTANCES WITH RISK OF VIOLENT REACTIONS

Substance	Incompatible with
ACETYLENE	Chlorine, bromine, copper, fluorine, silver, mercury
ACETONE	Concentrated nitric and sulfuric acid mixtures
ACETIC ACID	Chromic acid, Nitric acid, peroxides, permanganates
HYDROCYANIC ACID	Nitric acid, alkali
CHROMIC ACID & CHROMIUM TRIOXIDE	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol, flammable liquids
CONCENTRATED NITRIC ACID	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases, copper, brass, any heavy metals
OXALIC ACID	Silver, mercury
PERCHLORIC ACID	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
SULPHURIC ACID	Chlorate, perchlorates, permanganates
ANHYDROUS AMMONIA	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
ANILINE	Nitric acid, hydrogen peroxide
SILVER	Acetylene, oxalic acid, tartaric acid, fulminic acid

BROMINE	Ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, benzene, turpentine
ACTIVATED CARBON	Calcium hypochlorite, all oxidizing agents
CHLORATES	Ammonium salts, acids, powdered metals, sulphur
CHLORINE	See Bromine
CHLORINE DIOXIDE	Ammonia, methane, phosphine, hydrogen sulphide
FLUORINE	All other chemicals
HYDROFLUORIC ACID	Aqueous or anhydrous ammonia
PHOSPHOROUS (WHITE)	Air and oxygen
HYDRAZINE	Hydrogen peroxide, nitric acid, any oxidizing agent
HYDROCARBONS (BENZENE, BUTANE, PROPANE, PETROL)	Fluorine, chlorine, chromic acid, peroxides
IODINE	Acetylene, aqueous or anhydrous ammonia
MERCURY	Acetylene, fulminic acid, ammonia
ALKALI & ALKALINE EARTH METALS	Carbon dioxide, carbon tetrachloride or other chlorinated hydrocarbons
AMMONIUM NITRATE	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulphur, finely divided organic combustible materials
NITROPARAFFINS	Inorganic bases, amines
CALCIUM OXIDE	Water
OXYGEN	Oils, grease, hydrogen, flammable liquids, solids, or gases
POTASSIUM PERMANGANATE	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
HYDROGEN PEROXIDE	Copper, chromium, iron, most metals or their salts, flammable liquids, combustible materials

ARSENICAL MATERIALS + any reducing agent	generates **ARSINE**
NITRIC ACID + copper, brass, any heavy metal	generates **NITROGEN DIOXIDE**
CYANIDES + acids	generates **HYDROCYANIC ACID**
PHOSPHORUS + caustic alkali or reducing agents	generates **PHOSPHINE**
HYPOCHLORITE + acids	generates **CHLORINE, HYPOCHLOROUS ACID**
NITRATES + sulphuric acid	generates **NITROGEN DIOXIDE**
SULPHIDES + acids	generates **HYDROGEN SULPHIDE**

APPENDIX F – SOME CHEMICAL SPILL CLEAN-UP PROCEDURES

Type of spill	Recommended clean-up
Organic acids	Apply sodium bicarbonate (baking soda). Absorb with granules or vermiculite.
Inorganic acids	Apply sodium bicarbonate / calcium oxide or sodium carbonate / calcium oxide. Absorb with granules or vermiculite. NOTE: Hydrofluoric acid is an exception (see below).
Hydrochloric acid	Do not use water. Absorb with sand or sodium bicarbonate.
Aldehydes	Absorb with granules or vermiculite.
Aliphatic amines	Apply sodium bisulphate. Absorb with granules or vermiculite.
Aromatic amines	Absorb with granules or vermiculite. Avoid contact with skin and inhalation.
Halogenated aromatic amines	Absorb with granules or vermiculite. Avoid contact with skin and inhalation.
Azides (potentially explosive)	Absorb with granules or vermiculite. Decontaminate with a 10% solution of ceric ammonium nitrate.
Bases (caustic alkalis)	Neutralise with acid or other commercially available chemical neutralisers and absorb with granules or vermiculite.
Carbon sulphide	Absorb with granules or vermiculite.
Chlorohydrin	Absorb with granules or vermiculite. Avoid contact with skin and inhalation.
Cyanides	Wet or moisten the solids before sweeping or use an aspirator with a HEPA filter. Absorb the liquids with granules or vermiculite.
Halides, organic or inorganic	Apply sodium bicarbonate.
Halogenated hydrocarbons	Absorb with granules or vermiculite.
Hydrazine	Absorb with granules or vermiculite. Avoid organic materials.

Hydrofluoric acid	Absorb with calcium carbonate (or calcium oxide) rather than sodium bicarbonate which can lead to the formation of sodium fluoride considered more toxic than calcium fluoride. Pay close attention to the choice of granules for the absorption of acid, those which contain silicates are incompatible with hydrofluoric acid.
Inorganic salts solutions	Apply soda.
Mercaptans/organic sulphides	Neutralise with a calcium hypochlorite solution. Absorb with granules or vermiculite.
Nitriles	Sweep away the solids. Absorb the liquids with granules or vermiculite.
Organic nitro compounds	Absorb with granules or vermiculite. Avoid contact with skin and inhalation.
Oxidizing agents	Apply sodium bisulphite.
Peroxides (violent reactions with water)	Absorb with granules or vermiculite.
Organic phosphates	Absorb with granules or vermiculite.
Reducing agents	Apply soda or sodium bicarbonate.

Mandatory signs

WASH YOUR HANDS AT THE END OF EACH OPERATION

PROTECTIVE CLOTHING MUST BE WORN

EAR PROTECTION MUST BE WORN

PROTECTIVE GLOVES MUST BE WORN

PROTECTIVE FOOTWEAR MUST BE WORN

SAFETY HELMETS MUST BE WORN

EYE PROTECTION MUST BE WORN

FACE PROTECTION MUST BE WORN

RESPIRATORY PROTECTION MUST BE WORN

Prohibition signs

NO ENTRY UNLESS AUTHORISED

NO PEDESTRIAN CROSSING

DO NOT TOUCH

NO SMOKING

NO OPEN FLAMES

NO ENTRY UNLESS AUTHORISED

NOT DRINKING WATER

NO WATER ON FIRE

DO NOT USE FIRE EXTINGUISHERS

First aid and rescue signs

FIRST AID

EMERGENCY EYEWASH

EMERGENCY SHOWER

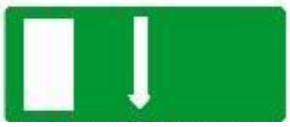
EMERGENCY EXIT ROUTE

DIRECTION TO ESCAPE ROUTE (sign to be added to the previous ones)

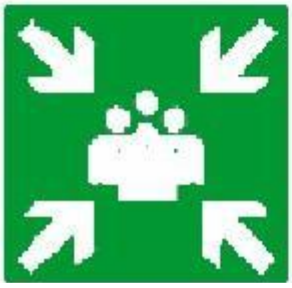
DIRECTION TO ESCAPE ROUTE (sign to be added to the previous ones)

EMERGENCY EXIT ROUTE

EMERGENCY EXIT ROUTE



EMERGENCY EXIT ROUTE



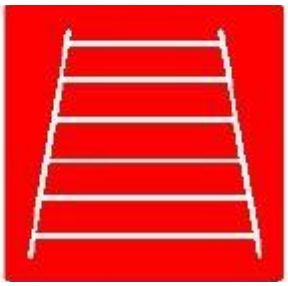
ASSEMBLY POINT

Fire safety signs

FIRE HYDRANT

FIRE ALARM PUSH BUTTON

FIRE EXTINGUISHER



FIRE LADDER

FIRE PUMP CONNECTION

FIRE EMERGENCY TELEPHONE

FIRE ALARM