Polytechnic University of Turin
Department of Applied Science and Technology

Guide to Safety in Chemical Laboratories

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Summary

1 Purpose

This guide provides general guidance on safety in chemical and chemical engineering laboratories. It is addressed to all personnel working in the department's laboratories (students, fellows, PhD students, technicians and faculty).

2 General standards of behavior

In order to behave properly in the laboratory, the operator (thesis student, research scientist, doctoral student, etc.) must be able to interpret the safety signs and labeling of chemicals; he/she must also be informed about the rules defined by the Laboratory Manager, the procedures to be adopted in emergency situations, where the safety data sheets of the materials used and the manuals of the equipment he/she will have to use are available. Adequate training and specific training should be provided for each task to be performed. The operator must then be trained on how to properly use the instrumentation and equipment that he is expected to have to employ.

2.1 First access to the laboratory

Only personnel authorized by the Laboratory Manager are allowed to enter a laboratory.

When entering a laboratory for the first time, one must:

- Read the sign at the entrance listing the Lab Manager and emergency phone numbers (manager, infirmary, fire department, concierge, etc.);
- Reading safety signs;
- Inquire about the presence and location of laboratory safety equipment (first aid kit, fire extinguishers, eye showers, exit routes, emergency stairs etc.);
- Find out how to access available documentation (MSDSs, manuals, disposal procedures, laboratory regulations, etc.).

2.2 General modes of operation

Comply with all rules defined by the Laboratory Manager (safety rules, waste disposal, instrument reservation, etc.).

Before using any equipment, it is necessary to be trained on how to use it properly, especially how to take action in case of an emergency (equipment manual, operating procedure, instruction by personnel etc.).

Use only compliant electrical equipment by connecting it to the power grid properly, without losing protection against direct contact, maintaining the connection with the grounding system and the appropriate IP rating.

All operations carried out during laboratory activities should be planned by estimating the possible sources of accidents.

Never leave dangerous equipment running unsupervised.

Report any failures, malfunctions, or safety problems to the Laboratory Manager.

Report any incident, even a minor one, to the Laboratory Manager.

Avoid excess of crowding in laboratories.

2.3 Hygiene and cleanliness

Wash in case of contact with any chemical agent. Wash hands, face and any other part of the body that has come in contact with chemicals thoroughly with soap and water.

Always wear a lab coat and keep it clean. The lab coat and other clothing worn can retain discrete amounts of toxic substances and transmit them through inhalation or skin absorption. Therefore, it is recommended that you wash your lab coat frequently and avoid wearing the shoes and clothes used in the lab at home.

Keep your workstation clean and tidy. Cleanliness reduces the possible contact with hazardous substances; tidiness reduces the possibility of causing accidents such as spilling containers or glassware, or swapping in the use of substances; and finally,an orderly workstation makes it easier to intervene in the event of an accident.

Avoid bringing food or drink into a chemical laboratory. Do not consume food or beverages in chemical laboratories and avoid, even for a short time, storing in the laboratory any foodstuff intended for consumption. The risk of contamination also concerns candy, chewing gum, cigarettes present in lab coat pockets. Do not use laboratory containers as food containers.

2.4Precautions in the use of chemicals.

Before handling any chemical product, it is necessary to learn about its chemical and physical properties and its hazardousness so as to take all useful precautions in order to operate safely. In particular, it is necessary to:

- Carefully consult the safety data sheets of the chemicals used and the labels on their containers so as to follow the directions given for handling, storage and disposal. Additional information can be obtained by consulting paper or computerized databases.
- Check the chemical compatibility between the substances used.
- Adopt, if possible, methods to reduce the presence of concentrations of hazardous products; in particular, flammable, toxic or chemically unstable substances/mixtures.

In the use and handling you must follow the operating procedure and, in case of an accident, the emergency procedures established by the person in charge of the research activity, adopting all the prescribed Individual Protection Devices (gloves, filtering facepieces, etc.) and Collective (chemical hood). It therefore turns out to be necessary before starting the activity:

- To have been trained in the proper execution of the necessary operational and emergency procedures and, in particular, in the use of the Protective Equipment required by the procedures.
- Check the laboratory for the availability and efficiency of Protective Equipment and any other equipment or materials needed for normal operations and in case of emergency (e.g., fire extinguishers, adsorbent material to be used in case of accidental spillage of a liquid).

In general, the following rules should be followed:

- Do not leave chemicals in the laboratory or inside a fume hood that are not clearly identifiable.

- Store all chemicals in the appropriate cabinets at the end of the activity; in particular, flammables, toxicants and corrosives (acids and bases).
- Properly collect, separate and dispose of chemical wastes, solid and liquid, produced in the laboratory; it is forbidden to dump them into the sewer or abandon them in the environment; in particular,do not throw flammable materials into waste bins.
- Never leave chemical reactions running unsupervised by an operator.
- Avoid sources of ignition that could result in fire and explosion (e.g., the use of Bunsen burners or any other open flame is prohibited in the presence of flammable substances and outside a chemical fume hood. Never heat flammable solvents using "open flames" but employ electric heaters.
- In case it is necessary to transport dangerous liquids (flammable, corrosive, toxic etc.)contained in glass containers for long distances, place them in buckets. This operation facilitates their transportation and in case the container breaks provides containment.

2.5 Protection

Eye protection. Always wear goggles when working with chemicals. Contact lens wearers should always wear protective goggles, however. Contact lenses may hinder washing operations, so it is best to remove contact lenses before entering the laboratory. In case of contact of a substance with the eyes, perform, while waiting for medical attention, continuous flushing for about ten minutes by eye shower or with the faucet barrel facing upward.

Protect hands with suitable gloves. Latex gloves or other suitable material in chemical-type operations. Work gloves in the case of special operations such as threading a glass tube into a rubber tube or cap.

Wear Personal Protective Equipment (goggles, face shields, masks, etc.) as required by the substance's MSDS or any other supplemental information sources.

All operations involving volatile, toxic-harmful, flammable or explosive products must be carried out under a chemical fume hood (the suction efficiency of which must be assured following periodic inspections). Chemical fume hoods have the primary purpose of eliminating the risk of exposure to hazardous chemicalagents. Conducting an operation inside a chemical fume hood eliminates the risk of exposure to hazardous substances and reduces the risks of ignition, fire development and explosion. A chemical fume hood should be used for the transfer or withdrawal of solvents (especially if they are volatile),for chemical reactions with the development of hazardous gases or vapors, for the use of equipment that can release fumes, gases or vapors into the environment (for example, a rotary evaporator without a solvent recovery syst em).

2.6 Handling of liquids

Never use the mouth to aspirate a liquid. In particular, do not use pipettes by aspirating directly with the mouth, but always use propipettes (piglets).

Always add the reagents very slowly and stirring continuously in a way to avoid violent and uncontrolled reaction.

In dilutions, gradually pour the concentrated solution into the solvent or the more dilute solution while continuously stirring the mixture. Never perform the operation by pouring the dilute solution (or the solvent) into the concentrated solution.

2.7 Prevention of fire hazards

Comply with the ban on smoking on the premises. Avoid smoking in risky areas or not using the ashtray.

Comply with the ban on open flames.

Use protected electrical panels, *avoiding or minimizing the use of power strips, adapters and extension cords.*

Avoid overloading in electric utilities.

Do not obstruct the ventilation of electrical equipment or heating appliances.

Do not use non-standard electrical equipment and do not keep it on when not in use.

Avoid dangerous proximity between combustible or flammable materials (paper, wood, flammable liquids) and possible *ignition sources* (electrical equipment, heating equipment, etc.).

Reduce the amount of flammable chemicals to the necessary minimum.

Avoid the accumulation of garbage, paper or other combustible material that can be easily ignited.

Keep escape routes and emergency exits clear of all obstacles.

3 Safety signs and signage

The purpose of safety signs is to quickly and easily draw attention to objects and situations that may cause certain dangers, in particular: to prohibit dangerous behavior; to warn exposed persons of a risk or danger; to prescribe safe behavior for the purpose of safety; to provide directions related to emergency exits and means of rescue or relief; and to indicate additional prevention and safety elements.

3.1 Dimensions

The area of the sign must be appropriately sized in relation to the distance from which the sign is to be recognizable. According to current regulations, the size of a sign must comply with the following formula:

$$A \geq L^2/2000$$

where A *is the area of* the signal surface expressed in m^2 and L *is* the distance in meters at which the signal should be recognizable.

The following table shows the minimum allowable area for some distances.

Distance in meters	5	10	15	20	25	30
Sign area in cm^2	125	500	1125	2000	3125	4500

3.2 Shape and color

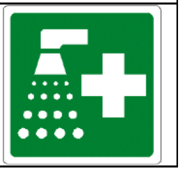
The regulations define the shape of the sign, the colors of the border, background and pictogram according to the type of sign. Indeed, one has that signs must have the following characteristics:

- Prohibition signs are round in shape, have red border and crossbar and black pictogram on a white background. In these signs, red must cover at least 35 percent of the surface.
- Warning signs are triangular in shape with a black pictogram on a yellow background. In these signs, yellow must cover at least 50 percent of the sign's surface area.
- Prescription signs have a round shape with a white pictogram on a light blue background. In these signs, light blue must cover at least 50 percent of the sign's surface area.
- Rescue or relief signs are square or rectangular in shape with a white pictogram on a green background. In these signs, green must cover at least 50 percent of the sign's surface area
- Firefighting equipment signs are square or rectangular in shape with a white pictogram on a red background.
- Information signs are square or rectangular in shape with a white pictogram on a blue background.

Table 3.1 - Shapes and colors of signals

	○	△	▭▭
🟥	Prohibition		Firefighting
🟨		Attention Danger	
🟩			Rescue Rescue
🟦	Prescriptions		Information Instructions

Table 3.2 Examples of safety signals

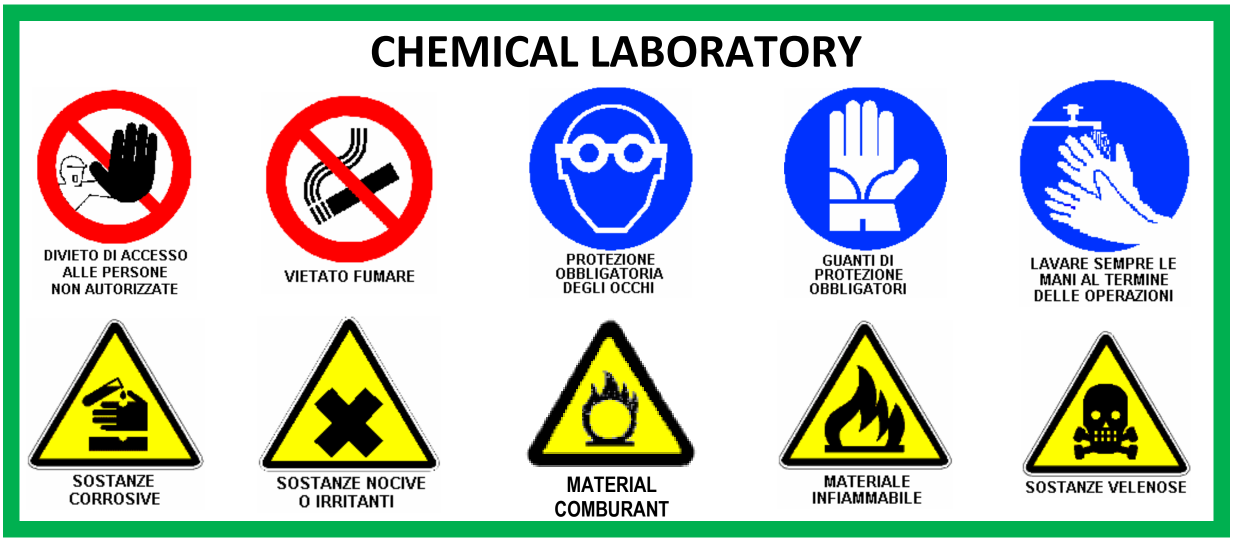
Meaning or purpose	Directions and clarifications	Examples
Prohibition signs	Dangerous attitudes	
Firefighting materials and equipment	Identification and location	
Warning signs	Attention, caution, verification	
Prescription signs	Specific behavior or action, requirement to carry a means of personal safety.	
Signs of rescue or relief	Doors, exits, routes, materials, locations, rooms	
Security situation		

3.3Disposition of signs

In the arrangement of signs with safety signs in chemical laboratories, follow the following directions:

- Post a sign at the entrance of the laboratory with the main prohibitions, requirements and warnings (an example is shown in the figure).
- Post necessary warning and hazard signs in every cabinet, refrigerator or other structure containing chemicals.
- Post signs inside the room with the main prohibitions, dangers, warnings, etc. in the laboratory.

Figure 3.1 - Example of a sign at the entrance of a chemical laboratory.



3.4Signage of pipelines containing fluids

Pipes that contain or are used to transport fluids have distinctive colors that identify the category of fluid present.

Table 3.4 Signal colors of pipes containing fluids

Red	Firefighting
Green	Water
Gray or Silver	Steam and superheated water
Brown	Mineral oils, vegetable oils and animal oils, liquid fuels
Yellow ochre	Liquefied gas or fluid (excluding air)
Orange	Acids
Yellow	Hazardous fluids
Light blue	Air
Black	Other liquids

4 Classification and Labeling of Chemicals

Chemicals are generally distinguished into substances and mixtures (or preparations). A *substance* consists of a chemical element or its compounds in their natural state or obtained by means of a production process. Substance usually includes additives necessary to maintain its stability and impurities resulting 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 chemical structure unaltered.

Substances and mixtures can be divided into four hazard groups:

- Non-hazardous (e.g., drinking water and atmospheric air under normal conditions). No special precautions are to be taken in these cases.
- Non-hazardous but used under conditions that may pose a hazard (e.g., high temperature water, compressed air). In these cases, the hazard is not chemical in nature but arises primarily from the alteration of physical variables such as temperature, pressure, concentration, or from the particular conditions of use.
- Hazardous but not classified by the regulations on classification, labeling and packaging of hazardous chemicals (e.g., malodorous or infected degraded organic materials, wastewater with biohazard, or materials and products excluded from the regulations such as drugs, waste etc.). Not all hazardous substances are regulated by the same regulations as "traditional" chemicals.
- Hazardous as defined by the regulations on classification, labeling and packaging of hazardous chemicals (most chemical substances and preparations normally found in workplaces belong to this group).

4.1 Classification systems

Hazardous chemical classification systems change depending on whether they are designed to apply to the transportation or use of hazardous chemicals. This distinction is due to the different effects resulting from exposure to hazardous products: occasional for transport and prolonged over time in the areas of use, consumption and distribution. Some systems are based on risk others on the nature of the hazard due to the substances or mixtures. In general, hazard refers to a source of possible injury or damage to health, while risk refers to a combination of probability and severity of possible injury or damage to health in a hazardous situation.

4.2 UN recommendations the transport of dangerous goods

The UN has issued a Model Regulation called "Recommendations on the Transport of Dangerous Goods" also called the "Orange Book "which specifies the criteria for classification, labeling and packaging of dangerous goods. Based on the UN Recommendations, a series of international regulations covering different modes of transport (modal regulations) have been established, namely: the ADR for road transport in Europe; the RID for rail transport 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 on UN hazard labels for the transport of dangerous goods are given in Table X.1. *Since they also appear on the outer packaging of packages, it is good to make them known to users receiving the goods*.

Table 4.1- UN hazard classes and labels for the transport of dangerous goods.

Class	Name	Division	Label templates	Name
1	Explosives	1.1		Substances and objects with mass explosion hazards
		1.2		Substances and objects with risk of producing projectiles
		1.3		Substances and objects with risk of fire production
		1.4		Substances and objects with lower risk
		1.5		Insensitive substances
		1.6		Very insensitive objects
2	Gas	2.1		Flammable gases
		2.2		Non-flammable and non-toxic gases
		2.3		Toxic gases
3	Flammable liquids			

4	Flammable solids; self-combusting substances; substances that, in contact with water, emit flammable gases	4.1		Flammable solids, self-reactive substances and desensitizing explosives
		4.2		Substances subject to spontaneous ignition
		4.3		Substances that, in contact with water, emit flammable gases
5	Organic oxidants and peroxides	5.1		Oxidants
		5.2		Organic peroxides
6	Toxic and infectious substances	6.1		Toxic substances
		6.2		Infectious substances
7	Radioactive materials			
	Fissile materials			
8	Corrosive substances			
9	Miscellaneous hazardous substances and articles			

4.3 Classification, labeling and packaging systems

The classification, labeling and packaging of hazardous substances and mixtures within the European Union is governed by the European Regulation EC No. 1272/2008(called CLP Regulation, Classification, Labelling and Packaging of substances and mixtures), which transposes the *classification criteria* and *labeling rules of the Globally Harmonized System (GHS)*of the United Nations Organization. The CLP regulation is legally binding in all member states of the European Union, it replacedthe pre-existing regulation based on Directive 67/548/EEC (DSP - Dangerous Substances Directive) and Directive 1999/45/EC (DPP - Dangerous Preparations Directive).

4.4 The EC Regulation No. 1272/2008 (CLP Regulation).

The classification governed by the CLP regulation is based on a hierarchical structure consisting of hazard classes and categories. Classes identify the nature of the hazard, and 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 hazard. There is in some cases further subdivision into distinct subcategories by 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 hazard from the intrinsic properties of the material.

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

Table 4.3 Classes, divisions, types, groups and categories of the CLP regulation

PHYSICAL DANGERS
Explosives (Unstable Explosives, Divisions 1.1,1.2,1.3,1.4,1.5 and 1.6)
Flammable gases (Categories 1 and 2)
Flammable aerosols (Categories 1 and 2)
Oxidizing gases (Category 1)
Gases under pressure (four groups: compressed, liquefied, refrigerated liquefied, dissolved gases)
Flammable liquids (Categories 1, 2 and 3)
Flammable Solids (Categories 1 and 2)
Self-reactive substances and mixtures (Type A, B, C, D, E, F and G)
Pyrophoric liquids (Category 1)
Pyrophoric Solids (Category 1)
Self-heating substances and mixtures (Categories 1 and 2)
Substances and mixtures that, in contact with water, emit flammable gases (Categories 1, 2 and 3)
Oxidizing Liquids (Categories 1, 2 and 3)
Oxidizing solids (Categories 1, 2 and 3)
Organic peroxides (Type A, B, C, D, E, F and G)

Metal Corrosives (Category 1)

HEALTH HAZARDS

Acute toxicity (Categories 1, 2,3 and 4)
Skin corrosion/irritation (Categories 1A, 1B, 1C and 2)
Severe eye injury/eye irritation (Categories 1 and 2)
Respiratory or skin sensitization (Categories 1 and 2)
Germ cell mutagenicity (Categories 1A, 1B and 2)
Carcinogenicity (Categories 1A, 1B and 2)

Reproductive toxicity (Categories 1A, 1B and 2 plus an additional category for effects on lactation)
Specific Target Organ Toxicity - Single Exposure (Categories 1, 2 and Category 3 for narcotic effects and respiratory irritation only)
Specific Target Organ Toxicity - Repeated Exposure (Categories 1 and 2)
Aspiration hazard (Category 1)

ENVIRONMENTAL AND OZONE LAYER HAZARDS.

Hazardous to the Aquatic Environment - Acute Toxicity (Category 1)
Hazardous to the Aquatic Environment - Chronic Toxicity (Categories 1, 2, 3, and 4)
Hazardous to the ozone layer (additional class)

In the label, in addition to the identification of the product, the manufacturer, and the quantity packed, there are standardized elements that are easy to understand and point out hazards and precautions to be followed when handling the product; however, it should be noted that the labeling of packages that do not contain ***a quantity greater than 125 ml*** may be incomplete as the size of the container is too small to allow for a label with all the elements of hazard communication (the minimum label size is standardized).

According to the CLP regulation, a substance or mixture classified as hazardous contained in a package has a label that includes the following:

- Name, address and telephone number of the supplier(s);
- the nominal quantity of the substance or mixture contained in the package made available to the public, if this quantity is not indicated elsewhere in the package;
- product identifiers;
- hazard pictograms (if required);
- warnings (if needed);
- hazard statements (if required);
- cautionary advice (if needed);
- A section for additional information (if needed).

Product identifiers are the information that allows the substance or mixture to be identified. In the European Union, if a substance appears in the '*classification and labeling inventory*, the *identification number* and *name* assigned to it are reported. Otherwise, the *CAS number* (if available) and the *IUPAC* or other internationally recognized name are reported. In the case of a mixture, the *trade name* or *designation of the mixture* and the *identity of all constituents of the mixture* that contribute to its classification with respect to acute toxicity, skin corrosion or serious eye injury, germ cell mutagenicity, carcinogenicity, reproductive toxicity, respiratory or skin sensitization, specific target organ toxicity, or aspiration hazard shall be reported. We may limit ourselves to a *maximum of four designations*, unless a larger number is necessary because of the nature and severity of the hazards.

A ***pictogram*** is a graphic composition comprising a symbol and other graphic elements (border, pattern or background color, etc.) intended to communicate specific information about the hazard in question. In the case of CLP/GHS, the symbols and shape of the pictograms (rotated square) on the labels have been taken, whenever possible, from those in the UN Recommendations for the Transport of Dangerous Goods. All symbols are black, the frame color is red, and the background color is white.

Table 4.4 shows the pictograms, with corresponding codes, used to signal danger in the use of substances/mixtures or articles.

Table 4.4 - Pictograms adopted by the GHS system.

Pictogram	Code	Description	Symbol
	GHS01	Explosiveness	Bomb going off
	GHS02	Flammability	Flame
	GHS03	Combustion power	Circle on flame
	GHS04	Gas under pressure	Gas cylinder
	GHS05	Corrosiveness	Liquid that corrodes hand and material
	GHS06	Acute toxicity	Skull with crossed tibiae
	GHS07	Miscellaneous	Exclamation point
	GHS08	Health hazards	Man with damage
	GHS09	Environmental hazards	Dead tree and fish

In the case of ***a single label with both the labeling for use and the labeling for transport on it,*** i.e., when you have a single package, then you do not carry the GHS hazard pictograms if the hazards have already been signaled by a similar pictogram from the UN Recommendations 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 that indicates the relative degree of severity of a hazard; two degrees of hazard are distinguished in the GHS:

- Danger: warning for the most serious hazard categories;
- caution: warning for less severe hazard categories.

When the "Danger" warning is on the label, there is no "Caution" warning.

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

The European classification system prior to CLP signaled the nature of the hazard through standard phrases called *risk phrases*. Since some of these phrases do not have equivalents in the hazard statements of the GHS system, in order not to lose this information, the CLP regulation added *additional hazard statements*. The code for these indications consists of the letters EUH followed by the code number of the risk phrase from which they are derived preceded by zeros until there are three digits. For example, the risk phrase *Dry State Explosive* corresponding to code R1was included in CLP as an additional hazard statement with code EUH001.

There are CLP/GHS hazard statements that can be supplemented with specific information. In such cases, the hazard statements with the supplementary information are coded by adding letters to the three numerical digits. For example, the hazard statement "May cause cancer" (H350) may be supplemented with an indication of a route of exposure if it is determined that no other route of exposure poses the same hazard; in the case of inhalation it becomes "May cause cancer if inhaled," the supplemental code for which is H350i.

A *precautionary* statement is a standard phrase that describes the measure or measures recommended to minimize or prevent the harmful effects of exposure to a hazardous substance or mixture resulting from its use or disposal. Obviously redundant or superfluous precautionary statements shall not appear on the label so that more than six precautionary statements are avoided unless a greater number is necessary because of the severity of the hazards. To reduce the number of cautionary statements, they may be combined to form a single statement.

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

Table 4.5 - Codes for hazard statements and cautionary statements.

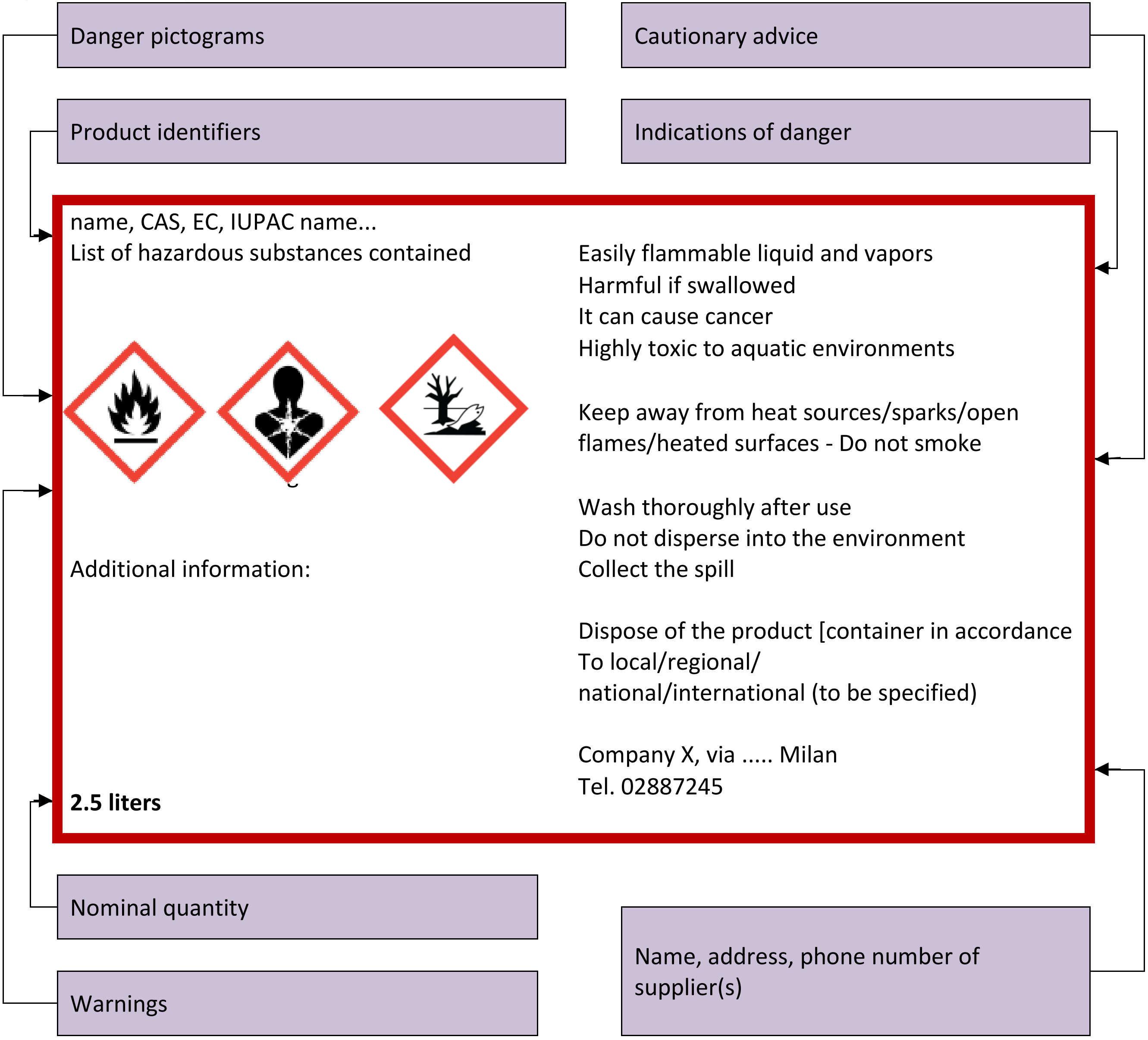
Indications of danger	Cautionary advice
	P101-P103 General

H200-H290 Physical Hazards
H300-H373 Health Hazards
H400-H413 Environmental Hazards

P201-P285 Prevention
P301-P391 Reaction
P401-P422 Conservation
P501 Disposal

Examples of labels are shown in the following figures.

Figure 4.2 - Example of a label



Danger pictograms

Cautionary advice

Product identifiers

Indications of danger

name, CAS, EC, IUPAC name...
List of hazardous substances contained

Easily flammable liquid and vapors
Harmful if swallowed
It can cause cancer
Highly toxic to aquatic environments

Keep away from heat sources/sparks/open flames/heated surfaces - Do not smoke

Wash thoroughly after use
Do not disperse into the environment
Collect the spill

Additional information:

Dispose of the product [container in accordance To local/regional/ national/international (to be specified)

Company X, via ..... Milan
Tel. 02887245

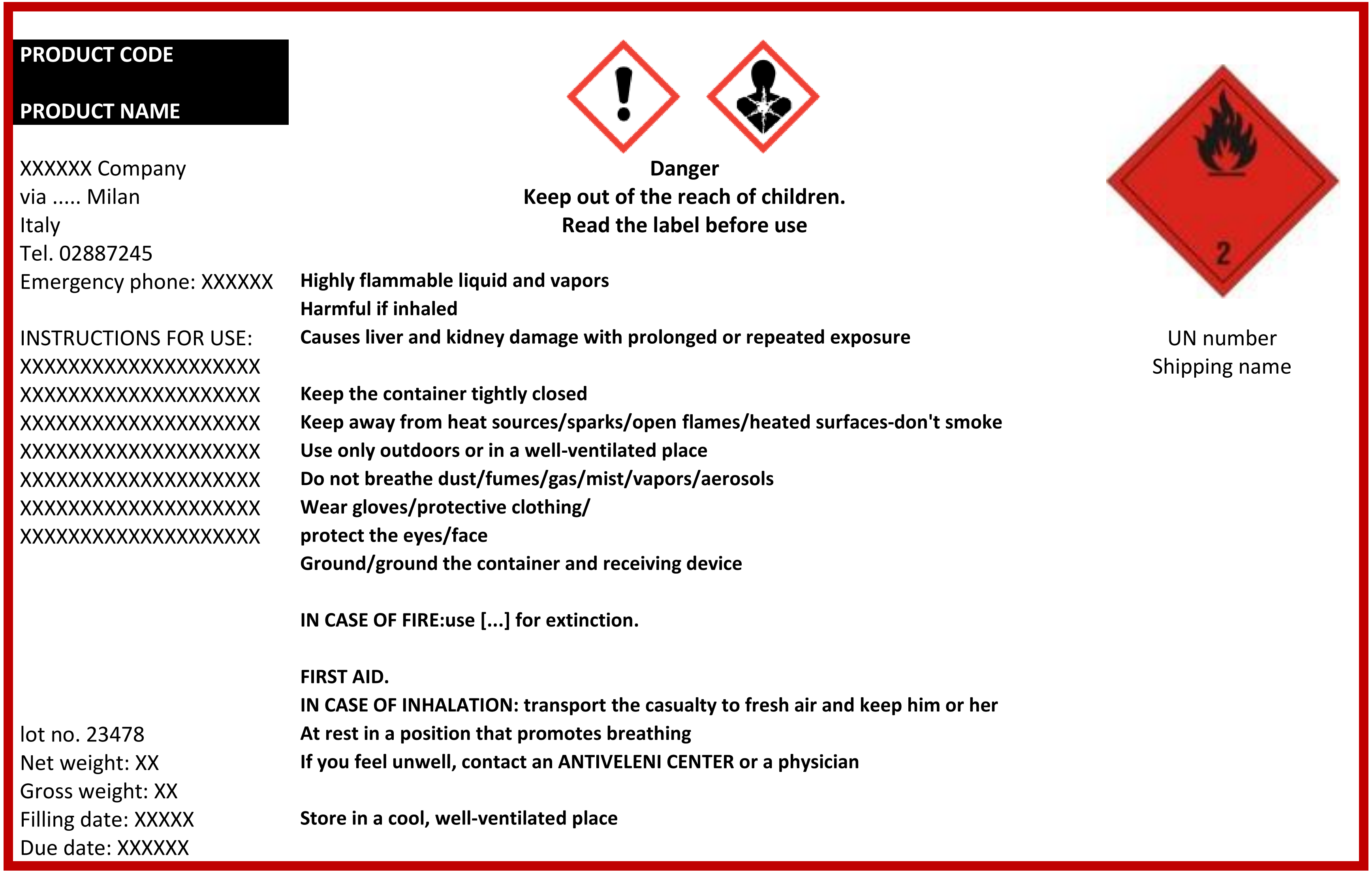
2.5 liters

Nominal quantity

Warnings

Name, address, phone number of supplier(s)

Figure 4.3 - Example of a label in the case of a single package



PRODUCT CODE

PRODUCT NAME

XXXXXX Company
via ..... Milan
Italy
Tel. 02887245
Emergency phone: XXXXXX

INSTRUCTIONS FOR USE:
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX

lot no. 23478
Net weight: XX
Gross weight: XX
Filling date: XXXXX
Due date: XXXXXX

Danger
Keep out of the reach of children.
Read the label before use

Highly flammable liquid and vapors
Harmful if inhaled
Causes liver and kidney damage with prolonged or repeated exposure

Keep the container tightly closed
Keep away from heat sources/sparks/open flames/heated surfaces-don't smoke
Use only outdoors or in a well-ventilated place
Do not breathe dust/fumes/gas/mist/vapors/aerosols
Wear gloves/protective clothing/
protect the eyes/face
Ground/ground the container and receiving device

IN CASE OF FIRE:use [...] for extinction.

FIRST AID.
IN CASE OF INHALATION: transport the casualty to fresh air and keep him or her
At rest in a position that promotes breathing
If you feel unwell, contact an ANTIVELENI CENTER or a physician

Store in a cool, well-ventilated place

UN number
Shipping name

4.5 Regulations on carcinogens and/or mutagens

Italian legislation regarding protection from carcinogens and/or mutagens is contained in Legislative Decree 81/08 (Title IX, Chapter 2). The decree refers to the classification system defined by Directives 67/548/EEC and 1999/45/EC, that is, the classification system used in the EU before the adoption of the CLP regulation. In these directives, potentially carcinogenic and/or mutagenic agents were divided into three hazard categories; in categories 1 and 2, carcinogenic or mutagenic effects were known (cat. 1) or probable (cat. 2), while category 3 was assigned when harmfulness was suspected but not proven (possible effects). The Legislative Decree, in its definitions (Art. 234) ***considers carcinogens or mutagens to be category 1 or 2 carcinogenic or mutagenic substances and preparations,*** thus excluding category 3 substances and preparations. This distinction is important because for agents considered carcinogens and/or mutagens, the legislative decree requires a ***specific assessment of the operator's risk of exposure*** and, if a health risk is revealed, the establishment of an appropriate ***exposure register*** and appropriate ***health surveillance*** defined by the competent physician.

To apply Legislative Decree 81/08 with the classification system introduced in the EU by the CLP regulation, it is necessary to keep in mind that ***categories 1 and 2 of the old classification correspond to category 1 (subcategories 1A and 1B) of the CLP regulation, while category 3 corresponds to category 2 of the CLP.***

Cautionary statements are given in Table 4.6, while Tables 4.7, 4.8, 4.9 and 4.10 contain the hazard communication elements of the label required by the CLP regulation.

Table 4.6- Cautionary statements for carcinogens or mutagens.

Cautionary Advice - Prevention	
P201	Obtain specific instructions before use.
P202	Do not handle before reading and understanding all warnings.
P281	Use the required personal protective equipment.
Cautionary Advice - Reaction	
P308+P313	IF exposed or possibly exposed, seek medical attention.
Cautionary Advice - Storage	
P405	Store under lock and key.
Cautionary Advice - Disposal	
P501	Dispose of the product/recipient in ...

Table 4.7-Carcinogenic agents (known or probable effects)

Classification system	CLP Regulation (GHS)
Category	1A or 1B
Pictogram	 Danger
Indications of danger	H350: May cause cancer (state route of exposure if it is determined that no other route of exposure poses the same hazard)
Cautionary Council Prevention	P201 P202 P281
Cautionary Council Reaction	P308 + P313
Cautionary Council Conservation	P405
Cautionary Council Disposal	P501

Table 4.8- Suspected carcinogens (possible effects)

Classification system	CLP Regulation (GHS)
Category	2
Pictogram	 Attention
Indications of danger	H351: Suspected of causing cancer (state route of exposure if it is determined that no other route of exposure poses the same hazard)
Cautionary Council Prevention	P201 P202 P281
Cautionary Council Reaction	P308 + P313
Cautionary Council Conservation	P405
Cautionary Council Disposal	P501

Table 4.9-Mutagenic agents (known or probable effects)

Classification system	CLP Regulation (GHS)
Category	1A or 1B
Pictogram	 Danger
Indications of danger	H340: May cause genetic alteration (state route of exposure if it is determined that no other route of exposure poses the same hazard)
Cautionary Council Prevention	P201 P202 P281
Cautionary Council Reaction	P308 + P313
Cautionary Council Conservation	P405
Cautionary Council Disposal	P501

Table 4.10 -Suspected mutagens (possible effects).

Classification system	CLP Regulation (GHS)
Category	2
Pictogram	 Attention
Indications of danger	H341: Suspected of causing genetic alteration (state route of exposure if it is determined that no other route of exposure poses the same hazard)
Cautionary Council Prevention	P201 P202 P281
Cautionary Council Reaction	P308 + P313
Cautionary Council Conservation	P405
Cautionary Council Disposal	P501

5 Safety Data Sheet

All hazardous substances or mixtures placed on the market in Europe must be accompanied by a safety data sheet (SDS). It is a detailed information document whose purpose is to *enable professional users to take the necessary measures to protect the environment as well as health and safety in the workplace*. The sheet, prepared by and under the responsibility of the person who places the product on the market (manufacturer, importer, distributor), must be updated on the basis of the most recent technical and scientific knowledge, must be drawn up in the Italian language, and must bear the date of preparation and that of the last revision, if any. The form currently adopted in Europe is structured to comply with the GHS system; the minimum information to be reported is shown in Table 5.1.

The safety data sheet to be consulted should always be exactly that of the product to be used. Substances or mixtures that look the same can present completely different hazards. For example, the presence of a minute amount of a carcinogen (0.1 percent) is sufficient for a non-hazardous substance/mixture to be classified as a carcinogen, or a monomer that is stable in the presence of a polarization inhibitor can become dangerously unstable in its absence. The physical characteristics of a substance/mixture are also important, e.g., a solid material can be stable or give rise to self-ignition phenomena depending on its particle size; if it is very fine, it is easier to have locally high temperatures because of less heat dissipation.

Table 5.1 - Minimum information to be reported on the safety data sheet.

1	Identification of the substance/preparation and the company/enterprise	• Identification of the substance or preparation • Use of the substance/preparation • Identification of the company/enterprise • Urgent call telephone number
2	Hazard identification	• Classification of the substance or mixture. • Brief indication of hazards. • Label elements including Cautionary Advice.
3	Composition/ingredient information	<u>Substance</u> • Chemical identity. • Common name, synonyms, etc. • CAS number and other identifiers. • Impurities and stabilizing additives classified and contributing to the classification of the substance. <u>Blend</u> • The chemical identity and concentration limits of all components that are defined as hazardous and present in amounts above their threshold value.
4	First aid measures	• Describe first aid measures broken down according to exposure routes: inhalation, skin and eye contact, ingestion. • Most important acute and delayed symptoms/effects. • Indication of the need for immediate medical intervention or special treatment, if needed.
5	Firefighting measures	• Suitable extinguishing media. • Extinguishing media not to be used for safety reasons.

		• Special hazards resulting from exposure to the substance or preparation, products of combustion, gases produced. • Special protective equipment for firefighters.
6	Measures in case of accidental release	• Personal precautions, protective equipment and emergency procedures (for non-direct responders and direct responders). • Environment-related precautions. • Methods and materials for containment and cleaning. • References to other sections.
7	Handling and storage	• Precautions for safe handling. • Conditions for safe storage, including possible incompatibilities. • Specific end uses.
8	Exposure controls/ personal protection	• Control parameters (e.g., exposure limit values or biological limit values). • Appropriate engineering controls. • Individual and collective protection measures.
9	Physical and chemical properties	• Appearance: physical state (solid, liquid, gaseous), color and odor (if perceptible). • pH • Boiling point/interval • Flash point • Flammability (solids, gases) • Explosive properties • Oxidizing properties • Vapor pressure • Relative density • Solubility • Water solubility • Partition coefficient n-octanol/water • Viscosity • Vapor density • Evaporation rate
10	Stability and responsiveness	• Chemical stability and the possibility of hazardous reactions. • Conditions to avoid. • Materials to avoid. • Hazardous decomposition products.
11	Toxicological information	• Concise but complete and understandable description of the various toxicological (health) effects that may arise if the user comes into contact with the substance or mixture. • Information on likely routes of exposure. • Symptoms related to physical, chemical, and toxicological characteristics. • Delayed, immediate, and chronic effects following short-term or long-term exposure.

		• Numerical toxicity values (e.g., acute toxicity estimates).
12	Ecological information	• Description of the possible effects, behavior, and environmental fate of the substance or preparation in air, water, and/or soil. • Ecotoxicity • Mobility (transport in case of release to the environment) • Persistence and degradability • Bioaccumulation potential • Results of PBT/vPvB assessment • Other harmful effects
13	Disposal considerations	• Description of residues and information regarding their handling from a safety perspective. • Suitable disposal methods of the substance or mixture and contaminated packaging (incineration, recycling, landfilling, etc.).
14	Transportation information	• Special precautions that a user should be aware of and adhere to regarding transportation or handling within or outside the company. • If necessary, information on the transport classification for each of the modal regulations: IMDG (sea), ADR (road), RID (rail), ICAO/IATA (air), specifically: -UN number, - class, - appropriate shipping name, - packing group, - marine pollutant, -Other useful information.
15	Regulatory information	• Health, safety and environmental protection information appearing on the label. • Specific community provisions in relation to the protection of man or the environment. • Mention of national laws implementing the provisions and any other relevant national measures.
16	More information	• Any other information that the supplier considers relevant to the safety and health of the user and the protection of the environment. • When a safety data sheet has been modified, the added, deleted, or changed information is indicated (if not indicated elsewhere).

6 Exposure to toxic agents

Activities carried out in a laboratory involve the use of chemical agents capable of exerting a toxic action in the human body. The main routes of entry into the human body are inhalation, dermal absorption (through the skin, eyes and mucous membranes) and ingestion. Inhalation is the most likely route, as breathing makes assimilation of airborne chemicals unavoidable when one is without appropriate protective equipment (e.g., gas masks). If absorption of gases or vapors is excluded, however, dermal absorption is less likely because it requires physical contact between the liquid or solid agent and the skin (e.g., contact with a contaminated surface). Finally, unintentional ingestion is rare although it is still possible; it may be due, for example, to poor personal hygiene or subconscious hand-to-mouth contact. In conclusion, it can be said that the toxicological risk to which one is subjected in an occupational setting is largely an inhalation risk and to a lesser extent a dermal absorption risk.

Environmental monitoring of airborne toxic agents is the most frequently adopted form of control because it is the quickest and simplest method of controlling exposure. The aim is to limit the maximum dose of toxic agent by placing limits on the exposure time and the attainable environmental concentration (occupational exposure limit value). However, this method has the drawback of not referring to the actual dose absorbed by individuals, which also depends on unconsidered factors such as lung ventilation and the physical activity being performed. This drawback can be overcome by supplementing environmental monitoring with biological monitoring, that is, by monitoring not only the work environment but also the exposed individuals.

Biological monitoring consists of the measurement of one or more indicators of a chemical nature (e.g., a toxic agent or its metabolite) in a biological medium (blood, urine, etc.) taken from exposed persons. Biological monitoring of exposure, biological monitoring of effects, and biological monitoring of susceptibility can be distinguished. Biological exposure monitoring determines the level of internal exposure by measuring biological indicators of dose or exposure and compares them, when known, with biological limit or reference values. Measurement of biological indicators of effect assesses the presence of early symptoms or dysfunctional situations that are reversible as exposure situations improve. In contrast, biological indicators of susceptibility signal interindividual differences in toxic response caused by genetic differences. Biological monitoring is often recommended for skin-absorbable toxic agents that may produce systemic effects for the prevention of which environmental monitoring alone is inadequate.

The discipline concerned with identifying, assessing, and controlling harmful factors in the workplace is industrial hygiene. Their associations and other national and international organizations concerned with occupational health provide occupational and biological exposure limit values for the most common chemical agents. These limit values, established on the basis of available scientific knowledge and updated periodically, are often incorporated into national regulations.

The European Union has mandated a Scientific Committee on Occupational Exposure Limit Values (SCOEL) to define exposure thresholds (Occupational Exposure Limits- OELs), which should represent a low level of risk for most workers, below which no harmful consequences are expected for exposed people.

Regarding Italy, Legislative Decree No. 81/2008 (Consolidated Safety Act) transposed the mandatory occupational and biological exposure values prepared by the European Commission and established national limit values. The values are listed in Annexes XXXVIII, XXXIX, XL and XLI of the legislative decree. A special scientific committee is in charge of updating them in accordance with technical and scientific progress, evolving regulations and EU or international specifications.

Occupational and biological exposure limit values can be found, when available, in Section 8 (Exposure controls/personal protection) of the chemical agent's safety data sheet.

Since in the absence of specific European or Italian limit values, exposure values published by the ACGIH are usually used, a brief description of them is given in the following section.

6.1 ACGIH Threshold Limit Values.

The most widely used occupational exposure values are those published annually by the American Conference of Governmental Industrial Hygienists (ACGIH). It should be noted that these values, referred to as Threshold Limit Values (TLVs) and denoted by the acronym TLVs, do not constitute a clear dividing line between hazardous and nonhazardous concentrations, nor a relative index of toxicity; moreover, since they are designed to be used in the occupational setting, they refer only to healthy adults: values applicable to the entire population are normally much higher.Regarding carcinogens, these may appear on the list published by the ACGIH with an indication to avoid all exposure (there is no threshold value) or, in some cases, conservative TLV values are given.

Threshold limit values, reported in ppm (by volume) or mg/m^3 ,are divided into TLV-TWA, TLV-STEL and TLV-C.

The TLV-TWA (Threshold Limit Value-Time Weighted Average) or threshold limit value is the time-weighted average concentration to which it is considered that all workers may be repeatedly exposed during a normal work week (8-hour daily shift, 40-hour weekly). Excursion above the TLV-TWA value is allowed if this is compensated for during the working day by an excursion below it.

The TLV-STEL (Threshold Limit Value - Short-Term Exposure Limit) or Threshold Limit Value with Short-Term Exposure Limit is the concentration to which workers are believed to be able to be exposed for a continuous period of 15 min without suffering irritation, chronic or irreversible tissue alteration, or narcosis of sufficient intensity to increase the likelihood of injury, or limited the ability to get to safety in the event of an accident, or reduced work efficiency, provided that the average daily limit imposed by the TWA is met. A STEL is a TWA of 15 min of exposure that must never be exceeded during processing even if the TWA is met. The TWA must not be exceeded more than four times a day and at least one hour must elapse between two successive exposures.

7Classification of protective equipment

The activities carried out in a laboratory, and in particular the use of chemicals, pose an exposure hazard to operators. The methods and procedures adopted must be designed so must eliminate or minimize these hazards. To this end, means of protection are used, which can be divided into two groups: means that exert a protective action on all personnel present (Collective Protection Devices-PCDs) and means that, worn by operators, exert an individual protective action (Individual Protection Devices-DPIs). When choosing means of protection, the adoption of Collective Protective Devices is preferable; only when Collective Protective Devices are inadequate is it appropriate to equip individual operators with Individual Protective Devices.

7.1 Personal Protective Equipment

Personal protective equipment (PPE) is equipment intended to be worn and held by an operator/worker for the purpose of protecting him or her against one or more hazards that may threaten his or her safety or health while at work, as well as any other complement or accessory intended for that purpose.

Personal protective equipment is divided into three categories, depending on the type of risk:

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

Personal protective equipment must by law bear the CE mark indicating compliance with essential health and safety requirements. In addition, the safety device must contain an instruction manual for use, storage, cleaning, maintenance, expiration date, category and limits of use possibly written in official languages.

7.2 Collective Protection Devices

The most common Collective Protection Devices (CPDs) in laboratories are systems that, by acting directly on the pollutant source, reduce or eliminate the risk of operator exposure and contamination of the work environment. Examples of Collective Protection Devices are conventional full exhaust chemical fume hoods, molecular filtration chemical fume hoods, ventilated and safety cabinets for flammable materials, BioHazard fume hoods *(microbiological safety cabinets)*, and glove boxes. Collective Protection Devices not having a product directive to refer to are without CE marking.

8 Clothing and body protection

8.1 Lab coat

Handling chemicals involves the possibility of contamination of clothing; therefore, one has that for reasons of hygiene, that is, to preserve one's clothing from this contamination, it is necessary to wear a lab coat at all times when 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 cotton and polyester.

Observe the following rules when wearing the gown:

- Wear a lab coat every time you enter the laboratory or handle chemical agents;
- Keep the lab coat in the lab and do not wear it outside the lab area;
- clean the gown regularly; if the gown or personal clothing becomes significantly contaminated it must be decontaminated before its next use.

It should be noted that the normal lab coat is a garment from work that must be worn for reasons of hygiene; since it does not perform an effective protective function from chemical agents, it is not Personal Protective Equipment. However, in cases where protection of the body from a specific hazard is required, for example, if operations are carried out in which large quantities of hazardous substances/mixtures are handled, protective garments (lab coats, aprons or coveralls) made of special materials resistant to the chemical agent in question must be worn; in this case, these garments are to be considered Personal Protective Equipment.

8.2Glasses, goggles and visors

Eye protection should be chosen according to the physical state, operations and toxicity level of the products.

Safety glasses

Safety glasses with side shields are required for anyone working in the laboratory. Safety glassesprotect the *eyes from solid materials* (shrapnel) but are *less effective in protecting against splashes.*

Goggles

Masks or goggles are used when splashing is possible or if you are *forced to wear prescription glasses*. They must have openings to prevent fogging.

Visors

Visors, face shields or protective masks are required when *pouring or decanting corrosive* materials *or hazardous liquids especially if in large quantities*. Shields *are not a substitute for eye protectors*; both should be used.

Contact lens wearers *should be informed of the special risks* involved (e.g., absorption of chemicals from the air), especially if they are of the gas permeable type. Gases and vapors can condense between the lens and the eye causing permanent damage to the eye itself. Splashes that get behind the lens would be difficult to remove with eye washes. In addition, some types of solvents "dissolve" polymeric lenses.

Inspect glasses and screens for damage or deterioration before wearing them.

8.3G Chemical gloves

Gloves have the task of protecting the hands from contact with harmful substances/mixtures; they must therefore be worn whenever this danger exists. In their use, it should always be kept in mind that they protect only for a limited period of time; in fact, they always allow slight permeation to an extent inversely proportional to their thickness. Selection of the type of gloves (material and thickness) should be made on the basis of the safety data sheet and any other information that can be found (chemical resistance of the material, penetration and permeation indices). The most commonly used materials are latex, nitrile, neoprene, PVC etc.; for those without textile support inside, a knitted underglove can be used to avoid direct contact with the skin. In the case of latex gloves, allergic reactions are possible. Finally, chemical gloves are not suitable for working with hot or abrasive materials; in these cases, special gloves are required.

Adopt the following rules when using gloves:

- Inspect gloves before each use for damage or contamination (cuts, punctures, discolored spots).
- Remove gloves before touching surfaces that should not be contaminated (handles, telephone, etc.).
- Gloves should be removed, taking care to turn them over, and then placed in hazardous waste.
- Disposable gloves should never be reused.
- However, nondisposable gloves should be replaced periodically depending on the frequency of use and their resistance to the substances used. Washings and the use of nonpolar solvents remove plastic agents by rapidly degrading the glove.
- In case of spillage on gloves, it is necessary to remove them and wash hands immediately.
- Always wash your hands after removing your gloves.

8.3.1 Characteristics and marking of gloves

The two main characteristics that determine the behavior of gloves relative to chemical protection are penetration and permeation resistance. The term penetration refers to the passage of a chemical or microorganism through material porosity, seams, any micro-holes or other imperfections in the protective glove material, while permeation refers to the passage of the chemical through the glove by diffusion.

Penetration

Penetration resistance is evaluated by subjecting the glove to standardized leakage tests with air and/or water. The result to be checked in accordance with the average quality level (AQL) is quantified by in three-level performance index.

Penetration index	Average level of quality
Level 3	< 0.65
Level 2	<1.5
Level 1	<4.0

Level 2 in the penetration test performed with water is considered sufficient to be an effective barrier against microorganisms. In this case, the following pictogram is affixed.

Permeation

Permeation resistance is expressed by an index that is a function of the time it takes for a particular liquid substance to fully impregnate the thickness of the glove. Glove manufacturers normally make available to customers the permeation indices of their products for a large number of substances in order to facilitate the selection of the most suitable glove.

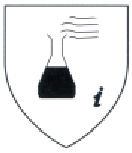
Permeation index	Permeation time (min)
0	<10
1	>10
2	>30
3	>60
4	>120
5	>240
6	>480

The standard has defined a list of twelve characteristic chemicals to be used for performing permeation tests. For a glove to be considered chemical resistant, it must have a permeation time of more than 30 min (permeation index 2)for at least three of these standard substances. The standard substances were coded by letters as shown in the following table.

Letter Code	Substance	Class

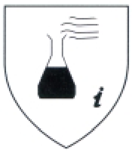
A	Methanol	Primary alcohol
B	Acetone	Ketone
C	Acetonitrile	Nitrile
D	Dichloromethane	Chlorinated alkane
E	Carbon disulfide	Organic sulfide
F	Toluene	Aromatic hydrocarbon
G	Diethylamine 1	Amine
H	Tetrahydrofuran	Ether and heterocyclic
I	Ethyl acetate	Foreign
J	n-heptane	Alcano
K	Sodium hydroxide 40%	Inorganic base
L	Sulfuric acid 96%.	Inorganic mineral acid

The "Chemical Resistance" pictogram is followed by at least three letters referring to standard chemicals that have a permeation index of at least 2, for example:



ACK

In cases where the permeation indices are greater than two their values may be given before the letter sequence.



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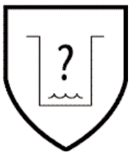
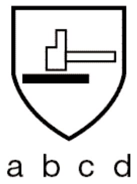
The "Low Chemical Resistance" pictogram is applied to gloves that do not achieve a permeation time of at least 30 minutes for at least three chemicals out of the twelve reference substances, but comply with the penetration test (penetration index 2).



However, chemical gloves must have adequate protection from mechanical hazards, it is represented by the pictogram "mechanical hazard" followed by four digits (performance indices), each of which indicates the level of performance of the glove detected by the test for a given hazard.



The performance indexes represented in the figure with letters are as follows:

a. Abrasion resistance indicated by the number of cycles required to completely scrape the test glove;

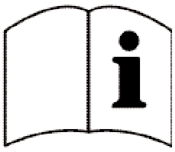
b. shear strength (from blade) indicated by a factor calculated on the number of passes required to cut the test glove at a constant speed;

c. Tear strength indicates the force required to tear the specimen;

d. Puncture resistance means the force required to pierce the specimen with a standard-sized drill bit.

Evidence	Performance index					
	0	1	2	3	4	5
a. Abrasion resistance (cycles)	<100	100	500	2000	8000	
b. Shear strength (factor)	<1,2	1,2	2,5	5,0	10,0	20,0
c. Tear resistance (newton)	<10	10	10	25	50	75
d. Puncture resistance (newton)	<20	20	20	60	100	150

Finally, the following pictogram indicates that the gloves come with instructions for use.



8.3.2 Selection of gloves

In selecting gloves, it is first necessary to identify the most suitable material, i.e., one that has adequate chemical resistance to the substance/mixture from which they are to protect the operator's hands. This first selection can be based on tables provided by the manufacturer; a rough indication can be obtained from the following table.

Substances	Latex	Nitrile	Neoprene	PVC
Acids	x	x	x	x
Bases	x	x	x	x
Hydrocarbons		x	x	
Ketones	x		x	
Organic solvents		x	x	
Oils		x	x	x
Fats		x	x	x

Once the material is chosen, the glove is selected on the basis of its *permeation index*. In fact, its value must be *sufficient to protect the operator for as long as there is contact between the gloves and the chemical*. Usually 30 minutes (index 2) is more than enough, but if it is necessary to protect the operator for an entire working day (eight hours of continuous contact a the substance) then a glove with permeation index 6 is required. In case the permeation indexes of the chemical are not available it is convenient to use as a reference those of the chemically most similar substance for which they are available.

8.4Anti-accident footwear.

Work footwear can be:

- safety footwear, marked with the letter "S" (safety);
- Protective footwear, marked with the letter "P" (protective);
- Professional footwear, marked with the letter "O" (occupational).

8.4.1 Safety footwear

Safety footwear is divided into seven categories: SB, S1, S1P, S2, S3, S4 and S5. The basic category, denoted SB (B=base), corresponds to the following minimum requirements:

- Tip with height and load-bearing base capable of absorbing 200 J;
- Closed heel area;
- Base height sufficient for the purpose of the shoe;
- upper (in the low type it can also be open);
- front lining;

- insole;
- Sole made of any kind of material (can be smooth).

Subsequent categories S1, S1P, S2, S3, S4 and S5 must have additional requirements identified in the marking by the symbols:A, E, WRU, P, HI, CI, HRO.

Symbol	Requirement
A	antistatic properties
E	energy absorption in the heel area
WRU	water penetration and absorption - upper
P	puncture resistance
HI	insulation from heat
CI	insulation from the cold
HRO	resistance to contact heat

Category	Additional requirements to the minimum requirements						
	A	E	WRU	P	HI	CI	HRO
S1	X	X					
S1P	X	X		X			
S2	X	X	X				
S3	X	X	X	X	(*)	(*)	(*)

(*) requirement not mandatory, indicated on footwear if present.

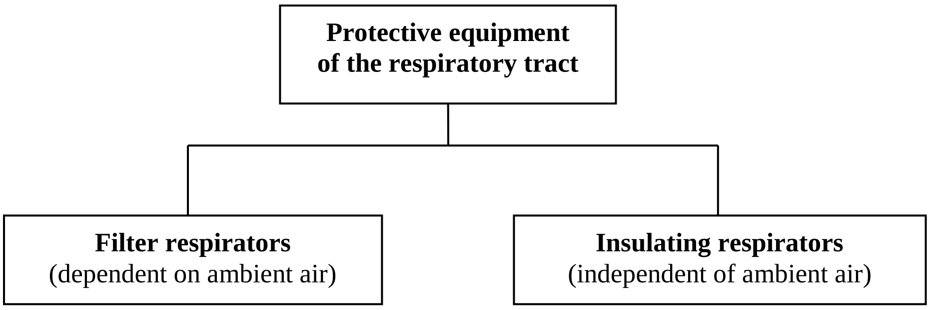
The S4 and S5 categories are boots suitable in environments with heavy liquid presence. They have antistatic and energy-absorbing properties in the heel area. S5 has puncture resistance as an additional requirement.

8.4.2 Protective and professional footwear

These shoes are similar to safety shoes, the only difference being the protective toe cap. In protective footwear it has an absorption energy of 100 J, in professional footwear it is absent.

8.5Respiratory protection.

Chemical laboratories may work with volatile substances, gases or dusts that can be assimilated through inhalation and cause toxic effects. If the use of a chemical fume hood with adequate ventilation is not sufficient to ensure the safety of operators, then it is necessary to protect the respiratory tract with Personal Protective Equipment called respirators. These devices, also referred to as Respiratory Protective Devices - APVRs, can be divided into two categories: filter respirators, which work by removing contaminants from the ambient air before it is inhaled by the operator, and isolation respirators, which are equipped with an air source independent of the air in the environment (such as a cylinder).



Filter respirators are the most commonly used; however, there are situations in which their use is not possible;for example, they cannot make up for the possible lack of oxygen needed for breathing (a fact that can occur during a fire in a poorly ventilated environment) or when the concentration of the contaminant is high or unknown.

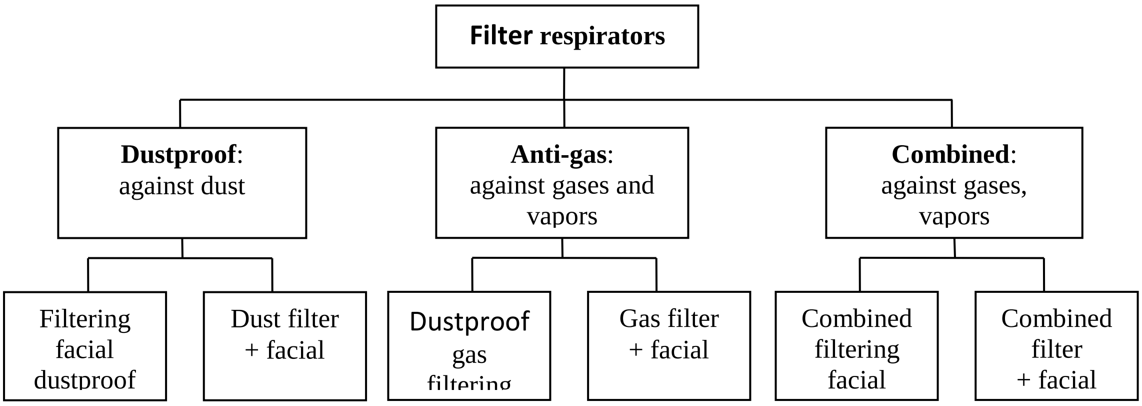
8.5.1 Filter respirators

Filter respirators can be distinguished on the basis of the harmful substances to be removed into the following three categories:

- Dustproof for dust, fibers, fumes (particles less than 4 microns) and mists (liquid droplets on an aqueous or organic basis).
- Anti-gas for gases and vapors.
- Combined against particles, gases and vapors.

Because filters have a limited operating time, respirators normally consist of two separable elements: a facepiece and a replaceable filter. However, there are also disposable respirators called filtering facepieces in which the facepiece and filter form a single element.

The following diagram represents the possible facepiece/filter combinations for the three categories of respirators.



In the case of dust, the resistance to airflow caused by the filter can make breathing so difficult that it requires the use of electrorespirators in which ventilation is assisted by an electric fan. In these respirators, the air drawn in by an electric fan is filtered and conveyed to the facepiece (full mask, half-mask, hood or full helmet) while maintaining some overpressure to prevent the entry of contaminated outside air.

Based on ventilation, three types of respirators can be distinguished:

- Unassisted breathing, where ventilation is due only to the breathing act of the operator.
- Ventilation-assisted respirators that are designed to provide some protection even if the electric fan is blocked
- Forced-ventilation respirators that do not provide protection without the contribution of the electric fan.

8.5.1.1Facials of filter respirators.

Filtering facepieces

Filtering facemasks consist of a mask covering the nose and mouth made entirely or mostly of filter material through which inhaled air passes. Exhaled air can be exhausted through the filter material or through an exhalation valve. Many filtering facepieces, in order to fit the face better, have a moldable adapter around the nose (nose clip). Filtering facepieces are mainly used to hold corpuscles however some types also hold vapors (organic or acidic). These respirators are disposable, meaning they can be used for only one work shift (eight hours).

Filtering facial without exhalation valve

Detail of the inside of
the faceplate

Filtering facial with exhalation valve

Detail of the inside of
the faceplate

Masks or semi-masks

Filter masks consist of a full face element (full-face masks, full-face masks) that also protects the eyes or a half-mask that covers only the nose and mouth coupled with one or more filter elements. Each mask is equipped with both inhalation and exhalation valves.

Full-face masks have a better seal than half-masks.

Double filter element semi-mask

Single filter element and double filter element integral mask

8.5.1.2 Unassisted dust filter respirators.

Unassisted dust respirators filter inhaled air by mechanical action combined generally with electrostatic action. They are generally distinguished by white coloration and consist of either filtering facepieces or half-masks with filters.

European standards define 3 classes of protection with increasing total filtering efficiency. Filtering facepieces are indicated by the acronym FFP (Filtering Anti-Dust Facepieces) followed by the protection class number, while the acronym P followed by the class number indicates a dust filter for use with a half-mask. It is noted that for the same dust class, the filtering facepiece and the half-mask with filter provide the same level of protection.

Protection classes	Minimum total filter efficiency
FFP1/P1	78%
FFP2/P2	92%
FFP3/P3	98%

There is a further subdivision based on the type of pollutant. We have, in fact, the following two classes:

- **S** for water-based solids and mists;
- **SL** for organic-based mists (class not provided for FFP1).

In this regard, it is important to note that dust filters P2 and P3 without an indication of the type of pollutant are intended to be class SL.

8.5.1.3 Dust filter electrorespirators.

These are electro-ventilated respirators equipped with dust filters. Compared with unassisted filter respirators, these respirators provide greater comfort, as the lower breathing resistance allows them to be used for longer periods. These systems can be equipped with alarms to signal any abnormalities, insufficient battery charge, or filter exhaustion. If they are to be used in an explosive or flammable atmosphere, intrinsically safe systems must be used to prevent sparking of the electrical part.

The degree of protection provided by the respirator changes depending on whether it is equipped with a mask (full or half mask) or a hood/helmet (full helmet).

Dust filter electrorespirators with mask

These are ventilator-assisted respirators that therefore provide some degree of protection when the electroventilator is off even if and this situation is to be considered abnormal (electroventilator failure). The protection classes have been defined considering both operating conditions (electroventilator on or off): there are therefore two efficiency values for each class. The protection class of the device coincides with the filter marking. This type of respirator is identified by the abbreviation TM (Turbo Mask) followed by a P (anti-dust) and the protection class.

Protection classes and marking	Minimum total filter efficiency
	Electric fan

	Accessed	Off
TMP1	95%	90%
TMP2	99%	90%
TMP3	99.95%	90%

Dust filter electrorespirator with hood/helmet

These are forced-ventilation respirators i.e., they do not provide any protection if the electric fan is blocked. They are identified by the abbreviation TH (Turbo Hood/Helmet) followed by a P (anti-dust) and the protection class. Again, the classification of the unit coincides with the marking on the filter.

Protection classes	**Minimum total filter efficiency**
THP1	90%
THP2	95%
THP3	99.8%

8.5.1.4 Selection criteria for dust filter respirators.

The choice of respirator depends on the concentration of the harmful substance in the air of the work environment (C_{est}) and the maximum contaminant concentration the air must have to be considered breathable without being harmful to the operator (C_{int}). The ratio between these two concentrations measured in the laboratory under appropriate conditions set by current regulations is called the Nominal Protection Factor (NPF). Since the operating conditions are the same as those used to determine total filter efficiency, the two quantities are related by the following relationship:

$$FPN = \frac{C_{est}}{C_{int}} = \frac{100}{100 - efficienzafiltrante\%}$$

The Nominal Protection Factor calculated by the above equation is conservatively rounded down.

If the operating conditions are assumed to be similar to standard laboratory conditions, then knowing the maximum concentration of the harmful substance respirable by the operator (e.g., by placing it equal to the TLV of the contaminant) one can estimate for each respirator the maximum external concentration for which it is usable. This method has the drawback that actual operating conditions may differ significantly from the laboratory conditions in which the FPN was measured especially in the case of high filter efficiencies. The calculation was then made more realistic by introducing a new, more conservative quantity called the Operational Protection Factor (FPO) to be used in place of the Nominal Protection Factor.

The table below shows the Operational Protection Factor values corresponding to different types of unassisted particulate filter respirators.

Nominal Operating Factors defined by the UNI 10720 noma

Dust filter respirators	FPO	$\max C_{est}$
Unassisted breathing		
FFP1/semask + P1	4	4×TLV-TWA
FFP2/semask + P2	10	10×TLV-TWA
FFP3/semask + P3	30	30×TLV-TWA
Full facial + P1	4	4×TLV-TWA
Full facial + P2	15	15×TLV-TWA
Full facial + P3	400	400×TLV-TWA
Electrorespirators with full mask (ventilator-assisted)		
TMP1	10	10×TLV-TWA
TMP2	100	100×TLV-TWA
TMP3	400	400×TLV-TWA
Electrorespirators with hood/helmet (forced ventilation)		
THP1	5	5×TLV-TWA
THP2	20	20×TLV-TWA
THP3	100	100×TLV-TWA

By comparing the maximum external contaminant concentration thus calculated (FPOxTLV-TWA) with that actually present, a suitable respirator for the work environment can then be selected. This procedure makes it necessary to measure the contaminate concentration present in the work environment.

In the exceptional and temporary case where the concentration of the contaminant is not known, the minimum level of protection can be estimated based solely on the toxicity of the substance (TLV-TWA) using the values in the following table as a reference:

Toxicity of the substance	Minimum level of protection

TLV-TWA≈ 10 mg/m^3	FFP1/P1
10 mg/m^3 >TLV-TWA>0.1 mg/m^3	FFP2/P2
TLV-TWA<0.1 mg/m^3	FFP3/P3

8.5.1.5 Duration of dust filters

Dust filters should be replaced when a noticeable increase in respiratory resistance is felt.

Dust filtering facepieces can only be used for a limited number of hours (technical standards require replacement of the facepiece after each work shift) because over time there is a loss of seal edge. Where they have a sealing edge they can be used for the equivalent of three work shifts.

8.5.1.6Gas filter respirators.

Gas-filtering respirators protect the respiratory tract by purifying the inhaled air of harmful gases or vapors; because the resistance to breathing due to the filter element is not high, these respirators are unassisted; they usually consist of a mask and filter; however, there are also filtering facepieces that retain gases and vapors.

The material in the filter can adsorb the contaminant, react chemically with it, or exert a catalytic action. The most commonly used adsorbent material is activated carbon. If the action of activated carbon is insufficient, solid reagents in granular form (alkalis, metal oxides, etc.) or chemical compounds supported by various materials (activated carbon, pumice and silica gel or impregnated activated carbon) are used. The reaction can be a neutralization that locks the acidic or basic contaminant into the filter or if the component is neutral a conversion to gaseous products that are nontoxic or at least tolerable by the human body. Catalytic filters are available for the removal of carbon monoxide: they catalyze its oxidation to dioxide.

Filters can consist of several filter materials so as to protect against different types of substances. Thus we have that gas filters can be monovalent (when they protect against only one harmful gas/vapor) or polyvalent (when they protect against more than one harmful gas/vapor). In the case where aerosol (dust) protection is also present, we speak of combined filters.

Filters A,B,E and K

European standards have defined a series of types of filters identified by the letters A, B, E and K and by a color (A-brown, B-grey, E-yellow and K-green) shown on the filter container or filter face piece. Each type of filter is distinguished into three classes characterized by a different removal capacity (amount of contaminant the filter is able to remove) and thus duration of filtration. Although all filters have the same filtering efficiency (unit efficiency), there are, for each class, limiting concentrations of use.

The classes of type A, B, E and K filters and the corresponding maximum concentrations are given in the following table.

Class	**Capacity**	**Maximum use concentration** (C_{maxF})

1	low	0.1% by volume- 1000 ml/m^3
2	media	0.5% by volume - 5000 ml/m^3
3	high	1% by volume - 10000 ml/m^3

AX Filters

Filters for vapors with boiling temperature less than 65°C, unlike organic vapors removed by Type A filters, cannot be characterized through the previous classes. The regulations require the same coloring as A filters but limits on contaminant concentration and time of use dependent on filter capacity (1 or 2 g of substance removed).

SX Filters

The regulations require the use initials SX (violet color) to refer to a filter to be used for a particular compound that the supplier must specify (e.g., dichloromethane).

Special filters

Nitrogen fumes or mercury vapors are always accompanied by aerosol that requires a dust filter of protection class 3. The mark on these filters includes the dust filter symbol P3 and white coloring to indicate the presence of the dust filter. Thus, we have that nitrogen fumes are identified by the abbreviation NO-P3 and the colors blue and white, while mercury vapor filters have the symbol Hg-P3 and the colors red and white.

Other special filters

European regulations recommend the use of insulating respirators in the case of particularly hazardous gases such as carbon monoxide and radioactive gases. There are commercially available filters for these and other hazardous gases that refer, for example, to the German standard (DIN 3181).

Main types of filters defined by European regulations

Color	Type	Protection	Class	Limitations of use	Norma
🟫	A	Organic gases and vapors with boiling points above 65°C as specified by the manufacturer.	1 2 3	1000 ml/m^3 5000 ml/m^3 10000 ml/m^3	EN141
▨	B	Inorganic gases and vapors (except CO) as specified by the manufacturer.	1 2 3	1000 ml/m^3 5000 ml/m^3 10000 ml/m^3	EN141
🟨	E	Sulfur dioxide, acid gases and vapors as specified by the manufacturer.	1 2 3	1000 ml/m^3 5000 ml/m^3 10000 ml/m^3	EN141
🟩	K	Ammonia and its derivatives as specified by the manufacturer.	1 2 3	1000 ml/m^3 5000 ml/m^3 10000 ml/m^3	EN141
🟫	AX	Organic gases and vapors with boiling points below 65°C as specified by the manufacturer.	-	1 g 100 ml/m^3 max 40min 1 g 500 ml/m^3 max 20min 2 g 1000 ml/m^3 max60min 2 g 5000 ml/m^3 max20min	EN371
🟪	SX	Specific compounds	-	to be specified	EN372

Special filters defined by European regulations

Color	Type	Protection	class	Limitations of use	Norma
🟦 ⬜	NO-P3	Nitrogen fumes (NO, NO$_2$, NO$_X$ and aerosols)	-	maximum 20 min	EN141
🟥 ⬜	Hg-P3	Mercury vapors and aerosols	-	maximum 50 hours	EN141

Color	Type	Protection	Notes	Norma
⬛	CO	Carbon monoxide	Disposable filter.	DIN 3181
🟧 ⬜	Reaktor-P3	Radioactive iodine and anti-dust	Disposable filter.	DIN 3181

Filter marking

The abbreviation for a monovalent filter consists of the literal symbol of the filter type followed by its class if it exists.

For example.

E2
🟨

indicates a class 2 sulfur dioxide filter.

In the case of filtering facepieces, the symbol is preceded by FF, so it becomes FFE2.

In combination filters, there is also filter material to abate aerosols. In this case, in addition to the coloring indicating the type of gas/vapor removed, the white coloring (aerosol removal, mist removal,...) is also shown, and the initials of the gas filter are added to the initials of the dust filter.

For example.

K2-P3
🟩⬜

indicates a combination filter with class 2 filter material to remove ammonia and its derivatives and class 3 filter material to remove aerosols.

In the case of multipurpose filters, which provide protection for more than one type of substance, the colors of each type of filter are shown on the container. Similarly, the abbreviation shown on the label is obtained by sequentially indicating symbol and class (if any) of each type of filter.

For example:

A2B2E2K1
🟫▒🟨🟩

and in the case of a **combined filter**

A2B2E2K1-P3
🟫▒🟨🟩⬜

8.5.1.7 Gas filter selection criteria.

When selecting the filter, it is important to have the manufacturer's indications about the suitability of the filter against the harmful substance for which it is to be used. If substances of more than one type were present, it is necessary to use combination filters already prepared by the manufacturer.

Knowledge of the concentration of the harmful substance present in the environment in which one is to work (C_{est}) is crucial to the choice of respirator type. First, it is necessary to check whether it is low enough to operate with a filter respirator. If the answer is positive, a filter capacity class should be chosen such that the concentration of the harmful substance is less than or equal to the maximum allowable concentration of the class (C_{maxF}):

$$C_{est} \leq C_{maxF}$$

Next, the mask type is selected based on the operational protection factor needed to satisfy the following inequality:

$$C_{est} \leq FPO \times TLV$$

In this case, we have in fact that the respirator's level of protection expressed by the operational protection factor does not depend on the efficiency of the filter, which is always unitary, but on the tightness of the mask: a full-face mask has a better tightness than a half-mask.

Operational protection factors (UNI 10720)

Gas respirators	FPO	Limitations of use
Half mask + class 1 gas filters Class 1 gas filtering facial	30	1000 ml/m^3
Half mask + class 2 gas filters Class 2 gas filtering facepiece	30	5000 ml/m^3
Semi-mask + class 3 gas filters Class 3 gas filtering facepiece	30	10000 ml/m^3
Full face mask + class 1 gas filters	400	1000 ml/m^3
Full face mask + class 2 gas filters	400	5000 ml/m^3
Full face mask + class 3 gas filters	400	10000 ml/m^3

In conclusion, selected a class of capabilities for which:

$$C_{est} \leq C_{maxF}$$

using the protection factors given in the table above we have that if $C_{est} \leq 30 \times TLV$ one can operate with a half-mask or a filtering face mask, while if $400 \times TLV \geq C_{est} \geq 30 \times TLV$ one must operate with a full-face mask.

8.5.1.8 Combined filter selection criteria

In the case of combined filters, the selection criteria for dust filters and those for gas filters must be applied separately.

8.5.1.9 Duration of gas filters.

Filter life depends on the nature and concentration of the contaminant, humidity, temperature, respiratory rate and lung capacity. Therefore, filter life cannot be determined a priori. The filter should be replaced when there is a smell or taste of the substance. This means that the filter is saturated and no longer absorbing. Some filters have an olfactory detector that produces a characteristic odor just before the filter is exhausted.

8.5.1.10 Storage of filters

Filters should be stored in a cool, dry place, unopened as received from the supplier. In this way they will retain their efficiency characteristics for the period of time specified by the manufacturer. They may suffer a considerable or total decrease in their efficiency if they have been used even once or if they have otherwise been unsealed and opened.

8.5.1.11How to wear a gas mask

The mask should be worn without the filter already screwed onto the face piece so that the operation is easier.

To put on the mask and check the tightness, the following steps should be taken:

- Lean the chin rest against the chin;
- Wear the facepiece so that it fits snugly over the face;
- Stretch the upper tie-rods, passing them over the head, and place them on the nape of the neck;
- Act immediately on all straps;
- Close the screwing seat for the filter tightly with the palm of your hand;
- Inhale deeply: no air infiltration should be felt.

Once the filter is removed from the bag-case, check that the rubber plug at the bottom and the metal cover at the nozzle are engaged in their seats.

Remove the caps and apply the filter to the nozzle, screwing it on tightly. After this operation, the operator is ready to take action.

8.5.2 Insulating respirators

Insulating respirators have an air source independent of the air in the environment, thus providing a high degree of protection. They are often used in emergency situations when the conditions under which one must operate are not known.

The following conditions necessarily require the use of insulating respirators:

- percentage of oxygen less than 17 percent;
- Contaminant concentration above the limit for filter respirator use;

- presence of gases/vapors that are odorless or have an odor threshold above the limits for safe operation (e.g., TLV-TWA);
- Unknown nature and/or concentration of contaminants.

In all other cases, filter respirators can be used.

Insulating respirators can be:

- Self-contained open- or closed-circuit breathing apparatus;
- Fresh air intake respirators with mask;
- Semi-mask/air supply respirators.

In open-circuit rebreathers, air from the cylinder is expelled after breathing from the mask. They consist of compressed air cylinders, usually 200 bar, pressure-reducing system, a regulator, mask, support backpack, accompanying devices (control pressure gauge and an end-of-charge sound alarm.

These respirators can be:

- Negative pressure where during inhalation a negative pressure is created in the mask that draws air out of the cylinder
- positive pressure (overpressure), in which case a positive pressure is maintained inside the mask that absolutely prevents the passage of contaminants and generally offers less resistance to inhalation.

Closed-circuit self-contained breathing apparatus are devices in which air is not expelled after breathing but is recirculated after purification from carbon dioxide and oxygen enrichment. These are complex self-contained breathing apparatuses with large autonomies but high costs and considerable difficulty in use and maintenance.

Fresh air intake respirators with a mask are devices consisting of a mask and an external air intake system, either unassisted or assisted with manual or powered ventilation systems.

Compressed air networked respirators are protective systems that take advantage of the compressed air network to feed masks, helmets, and hoods. It is important that the air supplied is definitely free of CO, dust, organic vapors, and moisture. Compressed air filters consist of multiple stages that remove contaminants, but not carbon monoxide. There are devices that have an alarm signal of the presence of carbon monoxide.

Operational Protection Factors (FPOs)

Insulating respirator	FPO
Open-circuit negative-pressure compressed air self-respirator.	400
Open-circuit positive-pressure compressed air self-respirator	1000
Closed-circuit self-respirator - enriched compressed air	400
Respirator with semi-mask/mask with continuous flow compressed air supply.	30/400
Half-mask/mask supplied-air respirator with demand-driven dispenser	30/400
Half-mask/mask supplied-air respirator with positive-pressure (overpressure) demand-response nozzle	1000

9 Suction systems

One means used in laboratories to limit the dispersion of contaminants into the work environment is the use of aspirate systems. The selection of the most suitable device is facilitated by the use of a classification of contaminants based primarily on their hazard by inhalation; therefore, first a classification system of chemical agents suitable for this purpose will be set forth, and then the most commonly used suction devices will be discussed: chemical fume hoods, canopy hoods, and suction nozzles.

9.1 Classification of chemical agents for the selection of a vacuum system

When assessing the hazardousness of a chemical agent in order to select a suitable extraction device, it is recommended to refer to the classification used by the Health and Safety Executive (HSE-UK) under the COSHH (Control of Substances Hazardous to Health), which has the advantage of providing concentration ranges where the chemical hazard is considered low. Under this approach, substances/mixtures are divided into five groups of increasing hazard on the basis of risk phrases (SDRs) or, similarly, hazard indices (CLP regulation). The table below assigns hazard indices H and a separate concentration range for dusts and vapors to each group. Groups A, B, C and D cover a logarithmic concentration range for dusts and vapors. The upper end of group A represents the level that should not normally be exceeded in accordance with what is considered good risk control practice: 500 ppm for vapors and 10 mg/m^3 for dusts. H statements have been assigned to groups A through D only when it has been possible to identify an airborne concentration range in which there is adequate control of chemical risk;in cases a where this is not possible, such as for carcinogens, group E has been assigned.

Table 9.1 Classification into hazard groups of COSHH

Group	Concentration range			Danger index
A	Powder	>1 to 10	mg/m^3	H303, H304, H305, H313, H315, H316, H318, H319, H320, H333, H336 and all H-numbers not otherwise listed
	Steam	>50 to 500	ppm	
B	Powder	>0.1 to 1	mg/m^3	H302, H312, H332, H371
	Steam	>5 to 50	ppm	
C	Powder	>0.01 to 0.1	mg/m^3	H301, H311, H314, H317, H318, H331, H335, H370, H373
	Steam	>0.5 to 5	ppm	
D	Powder	<0,01	mg/m^3	H300, H310, H330, H351, H360, H361, H362, H372
	Steam	<0,5	ppm	
E	Powder	-	mg/m^3	H334, H340, H341, H350
	Steam	-	ppm	

9.2 Chemical hood

Chemical fume hoods are localized extraction devices used to remove hazardous emissions (gases, vapors, fumes, aerosols) thereby preventing their dispersion into the work environment. Emissions may originate from equipment such as distillation units, bench reactors or pilot plants, or they may have occurred during normal handling of hazardous substances/mixtures. Fume hood extraction exerts a containment action, which prevents contamination of the environment, and a dilution action of vapors (or airborne particulates), which reduces the likelihood of the formation of flammable or explosive atmospheres; finally, the presence of a protective shield protects the operator from splashes and explosions.

Chemical fume hoods consist of a cabin connected at the top to an extraction system. Air intake occurs frontally through an opening, the width of which can be varied by sliding a glazed panel (up-and-down or up-and-down screen) on vertical guides. Air is generally drawn in from intakes located in the hood compartment either at the top or at the bottom: intakes located at the top generate an upward flow within the cabin, while those located at the bottom induce a horizontal flow, parallel to the work surface/base of the cabin, so that the upward flow intercepts less dense air contaminants, while the horizontal flow captures more dense air contaminants. Air intakes located at the bottom, arranged along the base of the inner back panel (counter-back panel), introduce the air flow into a vertical ductwork (rear intake plenum) made inside a double wall (double bottom consisting of a back panel and a counter-back panel) closed by side panels (inner side shoulders). In order to improve the containment action, the inner compartment of a hood is designed to minimize the presence of vortices.

Chemical fume hoods can be exhaust or recirculating. In expulsion *chemical fume hoods*, the exhausted airflow is completely discharged to the outdoor environment through a special ductwork, while in *recirculating fume hoods* the airflow is first purified by filtration and then reintroduced into the working environment. In exhaust hoods, the electric fans are placed near the exhaust so as to keep the exhaust line under pressure, thus avoiding contaminant leakage along the ductwork; in recirculating hoods, on the other hand, the electric fans are placed near the filtration unit located at the top of the hood. Exhaust hoods are usually without a purification system; however, when dealing with highly toxic agents, it may be necessary to install a filter assembly in this type of hood as well. The filter assembly of a fume hood, when present, usually consists of an electrostatic prefilter capable of retaining dust and one or more activated carbon filters that neutralize and adsorb contaminants.

Chemical fume hoods can be distinguished on the basis of their intended use into benchtop chemical fume hoods, distillation chemical fume hoods, and technological chemical fume hoods. Benchtop *chemical fume hoods* have placed within the enclosure a work surface arranged at the height of an ordinary laboratory bench.These fume hoods are designed to allow operators to handle hazardous chemical agents. To use them properly, the operator must stand in front of them and introduce only his hands (protected by gloves) and forearms into the ventilation opening so as to avoid inhalation of toxic agents and be protected, via the up-and-down screen, from any splashes or explosions (the up-and-down is equipped with laminated safety glass). *Distillation chemical fume hoods* have a lowered work surface suitable for housing a distillation unit or other equipment of similar size, while *technological chemical fume hoods (walk-in*) have no work surface, so that a usable hood compartment is available from the floor; the latter fume hoods are those capable of housing larger equipment.

9.2.1 Main construction characteristics

Being places subject to fire and explosion hazards,and being subjected to aggressive chemical agents such as acid or bases,fume hoods are made of materials with good fire and corrosion resistance.The paints used must also be fireproof and corrosion-resistant. Electrical outlets and switches, as possible sources of ignition, are usually located outside the hood (on the side uprights or under the outer edge of the worktop); service controls (e.g., dispensing valves) are also best located externally so that they can be safely operated by operators. The upper part of the hood compartment (ceiling), in addition to air intakes, is often equipped with anti-explosion devices that in the event of a deflagration allow the shock wave to be vented upward when the upstand is fully down. Internal lighting is usually achieved by a fluorescent tube mounted in an insulated transparent compartment with an electrical protection rating of IP65. The work surface, with a raised front edge, should be as seamless as possible so as to make it easier to clean; the material of which it is made should have good chemical resistance, monolithic stoneware is often used; isotactic propylene (moplen), which does not have good temperature resistance, is used when high resistance to acids or alkalis is desired.

When purchasing a new hood, it is advisable to require compliance with the European standards contained in the technical standard UNI EN 14175 parts 2 and 3; if a variable airflow system is desired, it is also necessary to require compliance with part 6; if on-site performance verification is desired, also require compliance with part 4. Other standards of interest are ANSI ASHRAE 110:1995 (US), BS 7258 (UK) AFNOR XP X15-203 (France) and DIN 12924 (Germany).

9.2.2 Incoming airflow control

The effectiveness of the capturing action exerted by a fume hood is strongly conditioned by the velocity of the air in the inlet section (front velocity) the ways in which this is controlled are therefore important. Two types of control can be distinguished: constant airflow and variable airflow. In constant air volume (CAV) fume ***hoods, there*** is a by-pass in addition to the air flowing through the inlet section regulated by the up and down, usually this is accomplished by a large louvered slot on the upper front panel through which additional air is made to flow. The lowering of the upslope screen gradually closes the area of the inlet section to the work surface and at the same time increases the area available for the flow of supplementary air by the same amount, so it is the case that the device allows, with the same expelled air flow rate, to keep the frontal velocity constant as the position of the upslope screen changes. ***Variable*** air volume (VAV) ***hoods,*** on the other hand, are equipped with an electronic regulation system designed to control the frontal velocity according to the position of the up-and-down screen, that is, the variation in the area of the inlet section. These fume hoods have an indicator that reports the air velocity measured by the control system's detection probe, which is equipped with an audible and/or visual alarm that is activated if the air flow falls. The control system allows the operator to set the airflow to the desired value; in the absence of operations, the hood can be adjusted to minimum flow, so that electrical and thermal energy can be saved.

9.2.3 Performance of a fume hood

A chemical fume hood must contain and remove contaminants released or generated within it, protect the operator against splashing liquids and against explosions. The performance of a fume hood is therefore evaluated on the basis of the following properties:

- Ability to contain contaminants within the fume hood compartment. Ability of the incoming airflow to minimize, in the ideal case prevent, the dispersion of contaminants in the fume hood compartment into the work environment.
- Ability to remove contaminant from the interior of the hood compartment. Ability of the fume hood to expel,along with the outgoing airflow, contaminants in the interior compartment.
- Robustness to containment. Ability of the fume hood to maintain or vary little in its containment capacity under the effect of external perturbations such as air currents in the work environment, movements of the fume hood operator, or movements of personnel present in the laboratory.
- Level of protection from liquid splashing or contact with particulate matter.
- Explosion protection level.

Containment, removal and robustness capabilities are determined using a gas as a tracer. The measurement methods are standardized by UNI EN 14175, which also gives safety requirements regarding the up-and-down screen, electrical components and explosion-proof devices.

9.2.4 Placement in the laboratory

In the placement of a fume hood, it is first necessary to keep in mind the possibility that it may explode or ignite and, in the case of vented fume hoods, to assess the need for adequate make-up of the expelled air so as to prevent the room from becoming depressed. In addition, it is important to consider that the performance of a fume hood in terms of containment and removal of pollutants depends not only on how it is constructed, but also on its location in the laboratory; in fact, effects of any external perturbations on the airflows entering the fume hood are always present despite having been minimized during design. Fundamental therefore to good performance is the absence in the hood's surroundings of external elements (obstacles, people, doors, etc.) that disturb the path of incoming air flows.

In order to identify the most suitable location of a chemical fume hood, it is recommended to follow the following recommendations, which are mainly based on the European standard UNI EN 14175:

- Fume hoods should preferably be placed in rooms that are 3 m high (the minimum height is 2.7 m).
- The distance to the up-and-down screen of any part of the laboratory frequently used by personnel as a place of passage should be at least 1 meter.
- The distance between the rising screen and any workbench opposite it should be at least 1.4 meters.
- The distance between the rising screen and a wall opposite it should be at least 2 meters.
- The possible interaction between two frontally arranged chemical fume hoods (or rows of hoods) should be carefully considered. In the absence of measurements made on site, it is recommended that a distance of at least 3 m be maintained between the up and down screens of two opposing fume hoods.
- The effect of air flows in the room on the performance of the chemical fume hood must be carefully considered. The air velocity in the room should not exceed 0.2 m/s in the area 40 cm from the rising screen.
- The presence near the hood of large isolated obstacles such as structural pillars can significantly affect its performance. In the absence of measurements taken on site, it is recommended that the

distance between the ideal plane passing through the side shoulder of the hood and the corresponding parallel plane passing through the end of the obstacle closest to the hood be at least 30 cm.

- No frequently used door should be within 1 meter of the up-and-down screen or 30 cm from the side shoulder of the hood. This recommendation does not apply for doors used exclusively as emergency exits.

9.2.5 Maintenance

Maintenance should be carried out according to the maintenance manual provided by the manufacturer; a list of required periodic checks with how to perform them is given in EN14175 parts 4,5 and 6. It is advisable to keep a special record where maintenance and efficiency check data should be noted, including the date of the check and the signature of the person who performed the operation.

In periodic inspections, it is recommended to pay special attention to the vacuum system, the operation of the rising screen and the filter unit (if any); in addition, regularly check the cleanliness condition of the work surface, the absence of corrosion phenomena, the mechanical integrity of the structure, the state of the electrical insulations, the lighting, the operation of the dispensers, the efficiency of the alarms present, and the state of the explosion suppression device.

Frontal speed

Frontal velocity should be periodically checked using an anemometer. It is advisable to have the measurement performed by qualified personnel in the manner described in EN14175. In short, the probe should always be positioned to measure the velocity component normal to the sliding plane of the upslope. The velocity should be measured at the intersection points of an ideal grid arranged on the inner slide plane; the measurement grid is obtained by drawing the following lines:

a) A series of at least three horizontal lines equidistant with the two outermost lines at $100 \pm 5\ mm$ from the upper (up and down) and lower (work surface) edge of the opening. The lines must be less than or equal to 400 mm apart.

b) A series of at least three vertical lines equidistant with the two outermost lines a $100 \pm 5\ mm$ from the side edges (left and right posts) of the opening. The lines must be less than or equal to 400 mm apart.

The frontal velocity is the arithmetic mean of the measured point velocities (also calculate its standard deviation).

Screen scrolling up and down

The slider must smoothly reach the positions corresponding to maximum and minimum opening with smooth and effortless sliding in the guides. Often, poor maintenance of the slide rail can lead to unpleasant injuries (e.g., injury from glass shattering or guillotine effect) or ineffective use of the hood itself (e.g., front panel locked at maximum opening).

Filter unit

The periodicity of filter replacement is a function of several factors (electric fan flow rate, type of contaminant, etc.); in any case, in the absence of more specific guidance, replacement should be expected at least every 12 months, regardless of hood use.

9.2.6 Criteria for assessing the suitability of a fume hood for the use of a toxic agent

In evaluating the performance of a fume hood in order to determine whether it is suitable for a specific toxic agent it is convenient to adopt two distinct criteria depending on whether or not the hoods meet the latest European or American standards. Indeed, hoods should be evaluated on the basis of their containment capacity, information that is actually available only for recently constructed hoods. In cases where the containment capacity is not known, the average frontal velocity is used to estimate their efficiency: that is, it is assumed that an increase in this magnitude corresponds to an increase in the hood's containment capacity; this assumption is approximately true for these hoods since, being older, they do not have the internal compartment optimized so as to minimize vortices for a given velocity range.

9.2.6.1 Hoods with known containment capacity

Fume hoods possessing a declaration of compliance with recent European (EN 14175, BS 7258, AFNOR XP X15-203 and DIN 12924) or American (ANSI ASHRAE 110) standards have a known containment capacity, which has been measured under the standard conditions defined by the relevant technical regulations. They guarantee, when properly installed,high containment of pollutants. In these cases, it is recommended to operate with the frontal velocities recommended by the supplier, higher velocities could in fact lead, due to increased turbulence, to a worsening of the containment capacity of the hood.

Classification

The suitability of these fume hoods for use in toxic agent operations can be assessed by taking as a reference their containment capacity measured in certification tests. The Natural Environment Research Council (UK) has proposed the classification shown in Table X.2, where tracer (sulfur hexafloride) concentrations refer to the internal measurement plan (EN 14175-3, sect. 5.3.3) and chemical agent toxicity is expressed using the COSHH hazard groups. Hoods complying with EN 14175 normally have containment indices of class 1 or 2.

Table 9.2 - Classification of hoods according to containment

Class NERC	Group COSHH	Concentration average of SF6 (ppm)	Concentration maximum of SF6 (ppm)	Remarks
1	D, E(*)	<0.005 to 0.020	from<0.010 to 0.040	
2	C	> 0.020 to 0.10	from > 0.040to 0.20	
3	B	from > 0.10to 0.20	from > 0.20to 0.40	Very poor performance. Possible improvement interventions.
4	-	> 0,20	> 0,40	Unsuitable for the use of toxic agents

(*) Additional investigations may be required to assess the suitability for use of Group E chemical agents.

Estimation of exposure to a specific chemical agent

In the case of chemical agents with a low occupational exposure value, it may be appropriate to perform a specific calculation; therefore, an exposure estimate can be performed by adopting as a reference the tracer concentration in the containment test reported in the certificate of compliance. The operator exposure value can be conservatively assumed to be equal to the concentration of the tracer used in the containment test multiplied by an appropriate safety factor (f_S);to be acceptable, the value so calculated must be less than the occupational exposure limit value of the toxic agent:

$$C_{valore\ limite\ di\ esposizione} \le f_S \cdot C_{tracciante}$$

The value of the safety factor must necessarily be high as it must include the different behavior of the toxic agent compared to that of the tracer and the different operating conditions (emission rate, direction of emission flow etc.). Table 9.3 shows the recommended factors of safety when threshold limit values (TLVs) are used.

Carcinogens and/or mutagens

In the case of Group E chemical agents, and in particular category 1A and 1B carcinogens and/or mutagens according to the CLP regulation (category 1 and 2 according to the SDR), it may be necessary to perform environmental sampling measures in order to assess the actual containment capacity of the fume hood in the room where it is installed. In any case, the characteristics of the fume hood (including certifications, containment capacity, and location in the laboratory) should be reported in detail in the description of the operating procedure to be attached to the permit application to be submitted in the manner defined by the Polytechnic.

Fume hoods using Group E chemical agents must always be full-ejection and equipped with a suitable filter unit that is regularly maintained.

Table 9.3 - Safety coefficients

Threshold limit value	Mode of use and operating conditions	Safety factor
TLV-TWA(allowable value for prolonged exposure)	• Periodic use • Prudent practices • Low emission (<4 liters/min)	10-20
	• Continuous use • Non-ideal practices • Low emission (4-8 liters/min) • Use of synergistic agents	20-40
TLV-STEL(short exposures, max 15 min,and occasional, max 4 times a day)	• Periodic use • Prudent practices • Low emission (<1 liter/min)	20-40
	• Continuous use • Non-ideal practices • Low emission (4-8 liters/min) • Use of synergistic agents	40-80
TLV-C (limit value not to be exceeded under any circumstances)	• Prudent practices • Low emission (<1 liter/min)	40-80
	• Non-ideal practices • Low emission (4-8 liters/min) • Use of synergistic agents	80-160

9.2.6.2 Hoods with unknown containment capacity

In the case of not recently constructed hoods, as mentioned above, it is assumed that the containment capacity is an increasing function of the frontal velocity. Some studies question this assumption; the two quantities are statistically correlated with an increasing trend, but the standard deviation is very high; therefore, when considering a single hood it may be the case that at very high velocities there is a deterioration in performance. The criteria commonly adopted to classify this fume hood are those given in the Scientific Apparatus Manufacturer Association (SAMA) Standards LF-10-1981. It is recommended that the classification given in Table 9.4, which is based on LF-10 standards and UNICHIM recommendations, be adopted to define the suitability of a fume hood for the use of toxic agents.

Table 9.4 Classification of hoods with unknown containment capacity

Class	Use	Group COSHH	Average frontal speed(*)
Grade A	High toxicity	D	$0{,}70\, m/s \leq v < 0{,}85\, m/s$
Grade B	Medium toxicity	C	$0{,}50\, m/s \leq v < 0{,}70\, m/s$
Grade C	Low toxicity	B	$0{,}40\, m/s \leq v < 0{,}50\, m/s$
Unclassifiable	Not usable	-	$v < 0{,}40\, m/s$

(*) Height of the slide rail relative to the work surface equal to 400 mm.

Given the uncertainty of performance, these fume hoods should be considered unsuitable for the use of very hazardous agents (Group E) in the absence of on-site measurements to determine actual containment capacity.

9.2.7 Method of use of a chemical fume hood

Chemical fume hoods are areas of potential danger because extremely flammable, explosive or toxic atmospheres can develop inside them. For this reason, the fume hood must be used properly and maintained in perfect working order at all times, and the operator must know the emergency procedures to be carried out in the event of an explosion or fire in the fume hood.

When using a chemical fume hood, follow the following directions:

- Before starting the activities, check that the up-and-down screen runs without any particular resistance, that any electrical equipment you intend to use has a safe electrical system, and finally make sure that the fume hood is sucking properly; this can be done by using the appropriate instrumentation (if available) or by other less accurate methods (e.g., with a sheet of paper placed on the fume hood work surface). If there is any doubt about the operation or performance of the checks, contact the laboratory manager.
- Avoid creating drafts near a running fume hood (opening doors or windows, frequent transit of people).
- Keep under the hood only the material strictly necessary for the activity (do not use the hood for storage).
- The work area and all material should be kept, as far as possible, away from the front edge of the work surface without necessitating the need to raise the upslope screen higher. Chemical agent containers should be at least 15 cm and heating units at least 30 cm away from the vertical sliding plane of the upslope screen.
- Do not obstruct the passage of air along the work surface, and if it is necessary to use equipment that clutters the surface, lift it off the surface by at least 2 inches using a stand and keep it away from the interior walls so as not to obstruct the intake vents.
- Perform the operations and slide the up and down screen slowly.

- Lower the up-and-down screen by maintaining a maximum opening of 40 cm while working (the lower the up-and-down screen is, the less the interior compartment is affected by spurious currents in the room); do not get inside the hood (e.g., with your head) for any reason.
- Keep the work surface clean and tidy. Perform thorough cleaning after each activity.
- When the hood is not in use, turn off the suction and lower the up-and-down screen.
- Do not use the fume hood as a means of reagent disposal by forced evaporation.
- Do not place multiple electrical outlets or extension cords inside a hood.
- Do not use the hoods as a permanent storage facility used to store hazardous substances/mixtures.

9.3 Canopy hoods

Canopy hoods are hoods without a cabin. This type of hood, being open, has a containment capacity that can be greatly affected by air currents; this interference can be reduced by shielding it on several sides. A canopy hood is advisable only in low-risk situations; in practice, it can be used to cover equipment subject to modest emissions of contaminants that are not particularly hazardous when updrafts are present, such as those resulting from thermal gradients, for example. To have effective extraction, the hood must have a projection from the bench top on which the equipment is placed equal to at least 0.4 times the vertical distance between the work surface and the hood edge plane (D). Given the required air velocity between to have effective suction, a velocity measured in the area between the hood edge and that of the countertop below, the required suction rate can be calculated by means of the following equation:

$$Q = 1{,}4\,PDv$$

Q: portata volumetrica di aspirazione della cappa
P: perimetro del banco
D: distanza verticale tra il piano bordo cappa e il piano di lavoro
v: velocità dell$'$aria
conQ, P, Devin unità coerenti

Table 9.5 shows the recommended velocities for canopy hoods depending on the cross currents that may be present and the contaminant hazard. The velocities given are valid in the absence of side screens. Where there are two opposing screens, the velocity is reducible by 0.12 m/s, while with screens placed on two adjacent sides, the velocity is reducible by 0.24 m/s. However, the air velocity must always be at least 0.25 m/s, even if applying the reduction results in a lower value.

Table 9.5 Reports the recommended air velocities in the absence of side screens

Toxicity	**Danger group COSHH**	**Air velocity in m/s with cross currents:**		
		absent	**slight**	**moderate**
Mild	B	0,38	0,63	0,87
Moderate	C	0,63	0,87	1,12
High	D	0,87	1,12	1,37

9.4 Suction nozzles

Suction vents are the simplest and also the least effective means of sucking up contaminants. They are systems designed to exert a highly localized suction action, so they are suitable for removing contaminates from a virtually point sources of emission. The shape of the nozzle can be circular, square, or rectangular in cross-section (with a ratio of smaller to larger side >0.3). Suction efficiency can be improved by adding a flange around the edge of the nozzle. In the presence of significant cross currents of air, appropriate shielding is essential. Knowing the air velocity at the emission point, the required suction flow rate can be calculated using the following equation:

$$Q = (10D^2 + A)v$$

Q: portata volumetrica di aspirazione
D: distanza lungo l'asse di simmetria della bocchetta tra il punto di emissione e il bordo bocchetta
A: area della superficie della faccia della bocchetta, area definita dal bordo della bocchetta
v: velocità dell'aria nel punto di emissione
con$Q, D, A e v$in unità coerenti

Table 9.6 shows the air velocities required for effective aspiration considering any ascending effects present and the hazardousness of the contaminant.

Table 9.6 Reports the recommended air velocities for inlet vents

Toxicity	**Danger group COSHH**	**Air velocity in m/s**			
		Absence of effects ascending	**Moderate upward effect**	**Active generation**	**Generation violent (*)**
Mild	B	0,25	0,38	0,63	2,53
Moderate	C	0,50	0,75	1,27	5,08
High	D	0,75	1,13	2,03	7,62

(*) Not recommended to use localized suction, use a chemical fume hood or otherwise a suction box

10 Chemical storage

The mere presence of hazardous substances/mixtures in the laboratory is a source of chemical risk; for this reason, certain precautions must be taken in their storage which may require special cabinets called safety cabinets. In some cases, storage must be at a low temperature for which refrigerators must be used. Some general recommendations are given below, while the following sections provide a brief description of some safety cabinets and laboratory refrigerators.

Carcinogens and/or mutagens

Category 1A and 1B carcinogenic and/or mutagenic substances/mixtures according to the CLP regulation should always be kept under lock and key, and access to these substances/mixtures should be granted only to expressly authorized personnel.

Reagent management

In the management of chemical products, it is necessary to have control over the quantities in storage, report their hazardousness, and arrange for actions to be taken in case of accidental spills. It is therefore advisable to comply with the following guidelines:

- Maintain for each storage room/cabinet an up-to-date register showing the substances/mixtures present and quantities in storage.
- Perform a periodic (at least once a year) check of stored chemicals: those that are unidentifiable, deteriorated or very old should be discarded.
- Reduce the amounts of hazardous chemicals to the minimum necessary and replace hazardous products with non-hazardous or less hazardous products whenever possible.
- Keep for each substance/mixture in the laboratory the updated safety data sheet and comply with any special instructions given in the sheet (Handling and Storage item).
- Post the necessary warning (e.g., flammable materials) and prohibition (e.g., no open flames) signs prominently on each storage room/cabinet.
- Make sure that all containers are labeled so that their contents can be recognized at any time.
- Set up emergency procedures to be carried out in case of accidental product spills. In particular, make material available near cabinets containing liquid chemicals to absorb and neutralize any spills. Refer to the safety data sheets when choosing the most suitable material.

Safeguarding of vessels and their arrangement

To reduce the possibility of an accidental rupture of a vessel, the following precautions are recommended:

- Avoid overloading the shelves (comply with the maximum expected load).
- Avoid piling containers on top of each other.
- Preferably place larger containers and those with the most hazardous substances/mixtures at the bottom.
- Avoid placing containers in shelves arranged too high; arrange corrosive, caustic or irritating substances/mixtures at a height below eye level.
- Use, in the absence of tray shelves, shelves with a raised outer edge so as to prevent accidental sliding of containers.
- Ensure that substances/mixtures are not placed near heat sources or direct sunlight.

Compatibility and containment

When storing, it is necessary to always consider the possibility of accidental breakage of the containers; the following precautions should be followed to limit damage:

- Place chemically incompatible substances/mixtures, i.e., capable of chemically reacting with each other, in separate compartments. This condition implies, for example, that acids are separated from bases and combustible/inflammable materials are separated from oxidizers (oxidizers).
- Keep containers with solids in separate compartments from containers containing liquids. Solid materials are usually unreactive, but can greatly increase their reactivity when placed in contact with a liquid.
- Store liquid containers inside drip pans capable of containing an accidental spillage. If necessary, also arrange a drip tray at the bottom of the cabinet.

10.1 Safety cabinets

Some particularly hazardous substances/mixtures must be stored in appropriate safety cabinets; these are the flammable materials to be placed in fire cabinets and corrosives to be stored in acid/base cabinets. In the case of nonflammable, non-corrosive volatile liquids whose vapors may contaminate the environment, solvent cabinets are used.

Safety cabinets are normally supplied already equipped with warning signs. For example, fire cabinets have a warning sign informing of the presence of flammable materials and a prohibition regarding the use of open flames, while acid or base cabinets have warning of the presence of corrosive materials. However, it is important to note that the substances/mixtures contained may result in the presence of additional hazards that are not signaled. In such cases, it is necessary to supplement the signage affixed to the cabinet. For example, if a fire-fighting cabinet contains materials that, in addition to being flammable, are toxic, it is also necessary to affix the toxic materials sign on the outside of the cabinet.

10.1.1 Fire safety cabinets.

Flammable liquids must be stored in fireproof cabinets. EN 4470-1 specifies performance requirements for flammable cabinets with an internal volume greater than 1 m^3 .

EN 4470-1 classifies safety cabinets according to the time required, under specified heating conditions, to raise their internal temperature by 180 K without posing a risk of causing or fueling a fire. In these standard tests, the cabinet, introduced into an oven, is heated according to a specified temperature-time curve that simulates the evolution of a fire. The number identifying the type of cabinet thus gives an idea of the time the cabinet can withstand if subjected to a fire.

Table 10.1 - Classification into types of flammable cabinets.

Type	Time to raise the temperature by 180 K (min)
15	≥ 15
30	≥ 30

60	≥ 60
90	≥ 90

The choice of cabinet type must consider the time for personnel to evacuate and the time for emergency teams to extinguish a fire. In any case, the placement of a fire safety cabinet within a chemical laboratory requires a type 90 cabinet.

Key Features

EN 4470-1 requires that cabinets, regardless of type, meet a number of specifications, the main ones are given below:

- Cabinets should be arranged to be ventilated. Forced ventilation is advisable in the presence of unsealed containers particularly in the presence of volatile substances/mixtures; in this case, ventilation of at least 10 changes per hour is required to reduce odor (pressure drop should not exceed 150 Pa). The ventilation system must keep the cabinet under vacuum.
- The cabinet doors should be equipped with a device that causes them to close automatically when the ambient temperature reaches 50°C.
- The ventilation opening and the exhaust air outlet opening must close automatically when the temperature reaches 70°C. The gaskets and valves in the ventilation openings must therefore close automatically at this temperature. Gaskets are normally thermo-expanding so when heated they turn into a foam with high insulating power.
- The height of the highest of the shelves must not exceed 1.75 m.
- Shelves should be tray-shaped so as to contain any spillage of liquids from accidental damage or breakage of containers.
- There must always be a bottom tray to collect any liquid spills that have not been completely retained by the tray shelves. The capacity of the bottom tray must be at least 10 percent of the volume of all containers stored in the cabinet or at least 110 percent of the volume of the largest container.
- To prevent electrostatic discharges, cabinets are provided with a grounding, which must be connected to the ground of electrical systems when these are present.

10.1.2 Safety cabinets for acids/bases and corrosives

Corrosive liquid substances/mixtures must be stored in special ventilated cabinets. The intake system is recirculating; thus, it results in the air coming out of the cabinet being decontaminated by passing through a special activated carbon filter before being introduced back into the working environment. The materials used to make these cabinets are particularly resistant to corrosion. As with all liquid cabinets, it is a good idea to have tray shelves and a bottom basin. It is important to note that acids and bases are incompatible and therefore should be placed in different compartments.

10.1.3 Solvent cabinet

A solvent cabinet is a ventilated cabinet with tray shelves and a holding tank at the bottom suitable for the storage of nonflammable, noncorrosive volatile solvents. Air flow should be at least 10 volume changes per hour. It is convenient to make the exhaust system so that both the cabinet and the section of the exhaust piping present in the working environment are under vacuum.

A ventilated cabinet is necessary when the release of non-negligible amounts of vapors from volatile liquid containers can contaminate the environment by exposing operators to concentrations above the threshold values allowed for hygiene issues. If the liquids are flammable, it is necessary to ventilate the fire-fighting cabinet; if they are corrosive, the appropriate safety cabinets are already ventilated; in other cases, a solvent cabinet must be adopted.

10.2 Refrigerators

Refrigerators used in chemical laboratories can be either household or laboratory refrigerators. To refrigerate volatile organic liquids, however, laboratory refrigerators must necessarily be used.

10.2.1 Domestic refrigerators

Domestic refrigerators can only be used to refrigerate aqueous solutions or otherwise non-hazardous materials. They are absolutely unsuitable for holding flammable liquids because they have the following drawbacks:

- The internal temperature of a refrigerator is normally higher than the flash point of the stored volatile liquids, so their vapors can give rise to combustion in the presence of an ignition.
- Inside a household refrigerator there are many trigger sources such as the thermostat and interior light.
- In domestic refrigerators, the compressor is normally located at the bottom where any cold vapors escaping from the inner compartment can accumulate.

10.2.2 Laboratory refrigerators

Laboratory refrigerators are professional refrigerators equipped with an accurate temperature control and regulation system ; they usually have an automatic door closing device, a power failure warning light; they may be equipped with over/under temperature alarms, an open door alarm, and an internal temperature recording system; in case they are intended for storage of very temperature-sensitive and unstable substances/mixtures they also have a backup battery that intervenes in case of power failure. An important property of these refrigerators is that, even in their minimal configuration, they are made in such a way 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 gaskets, usually magnetic, provide an excellent seal; finally, the compressor and its circuit are placed on top of the unit so as to reduce the possibility of ignition of cold vapors stratified at floor level. In the case of highly flammable or explosive substances/mixtures, special explosion-proof refrigerators are available.

10.2.3 Recommendations for the use of refrigerators.

Location and electrical 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.
- Avoid using adapters and/or power strips to connect the refrigerator to the mains.

Requirements for hazardous materials

- Use only explosion-proof (ATEX) refrigerators for storing flammable and/or explosive materials.
- In the presence of hazardous materials because of their instability with temperature, use a refrigerator equipped with an optical and audible high-temperature alarm and a backup battery that will kick in when there is no power supply.

Safety signage

- Post all safety signs on the refrigerator in a clearly visible position.
- Report the hazardousness of the substances/mixtures in storage (flammability, explosiveness, toxicity, etc.).
- Mark the ban on the introduction of flammable or explosive materials for refrigerators not suitable for the storage of these products, i.e., without an explosion-proof inner compartment.
- Report, particularly for domestic refrigerators, the prohibition of storing food and beverages for consumption.

Reagent management

- Keep an up-to-date logbook indicating the substances/mixtures and quantities in storage.
- Place all liquid substances/mixtures in tightly sealed containers so as to minimize the release of vapors.
- Place containers containing substances/mixtures in an unbreakable secondary container.
- Reduce the storage of hazardous substances/mixtures to the minimum amount necessary to be able to work.
- Avoid overloading the refrigerator with excessive amounts of products.
- Limit the door opening time to the minimum necessary so as to avoid deterioration of the material and possible dangerous reactions.

11 Cryogenic liquids

Cryogenic liquids are fluids that have a boiling temperature below -100°C (173.16 K) at atmospheric pressure. These liquids are frequently used in many instruments to cool the measurement cell (e.g., DSC) or to maintain a semiconductor detector at a low temperature (e.g., EDX and FT-IR spectroscopy detectors). Liquid nitrogen, which has a boiling temperature of -196°C, is the most commonly used cryogenic liquid; when lower temperatures are needed, liquid helium, which has a boiling temperature of -269°C, is usually used.

The following discussion concerns inert cryogenic liquids, as these are the ones most frequently used; flammable or oxidizing fluids such as hydrogen and oxygen will not be considered.

Hazards of cryogenic liquids

The main properties of a cryogenic liquid are its low temperature and its high expansion when vaporized. Low temperatures can cause cryogenic burns and a fire hazard in the event of air oxygen condensation, while high expansion poses an asphyxiation hazard if it occurs in the working environment and an explosion hazard if it occurs in a closed container. Other sources of danger are those typical of equipment operating at low temperature. Condensation of moisture in the air can make it dangerous to operate switches, outlets, and energized equipment, while ice formation can lead to blockage of valves or other devices. Embrittlement of materials and their different thermal contraction can lead to sudden breakage resulting in splintering.

Burn Hazard

Contact with fluids or materials at cryogenic temperatures causes lesions, called cryogenic burns, on the skin that are quite similar to thermal burns; the extent of damage suffered by tissues increases as the temperature decreases and as the contact time is prolonged. Burns can be caused by direct contact with a cryogenic fluid (gas or liquid) or with a cold surface.

In the case of direct exposure to cryogenic liquids, the duration is very important; if the contact is brief (a few seconds), the risk of injury is contained because of the formation of a vapor barrier between the cold liquid and the hot skin; however, in the case of the eyes, since the tissues are very delicate, a small splash is sufficient to bring about immediate damage. Prolonged exposure, on the other hand, is always very dangerous; in fact, it can produce tissue injuries similar to those of a direct flame; particularly risky is the impregnation of hats or clothing; prolonged contact with the eyes is to be avoided at all costs, since, as already noted, they can easily suffer permanent damage because of their high sensitivity to freezing. Regarding cryogenic gas jets, they are always very dangerous as they tend to freeze faster than contact with a liquid.

In the case of contact with a very cold surface, the freezing of skin moisture attaches it to the surface, the rapid subtraction of heat burns its tissues, while its removal of the surface causes it to tear. This phenomenon occurs easily with surfaces of highly conductive materials such as metals; however, at cryogenic temperatures any cold surface can be dangerous.

Since accidental contact while handling cryogenic liquids is always possible, it is always necessary to protect oneself adequately as these operations are performed. Operators are therefore required to wear a face shield, goggles, gloves, apron and safety shoes.

Fire hazard

Except for the use of flammable or oxidizing liquids such as hydrogen and cryogenic oxygen, the fire hazard is present when temperatures are low enough to condense the oxygen in the air. This situation exists for nitrogen, helium and all cryogenic liquids that have a boiling temperature lower than that of oxygen (-186°C).

The condensation of oxygen increases its comburent power, creating a fire hazard. In fact, many materials that are not flammable when exposed to air, become so if they are brought into contact with fluids with a higher oxidizing power (an oxidizing power equivalent to 30 percent enriched air poses a risk of clothing combustion). The situation is aggravated by the fact that the higher the oxidizing power, the faster the flame spreads, so containing these fires is more difficult. In the case of liquid nitrogen, oxygen that condenses near the air-nitrogen interface is also absorbed into the liquid; this phenomenon, if it occurs for prolonged times, can turn the cryogenic liquid into a dangerous oxidizer.

Oxygen condensation can occur locally due to the cold walls of uninsulated equipment containing cryogenic fluids with a lower boiling point than oxygen; while, oxygen absorption in cryogenic nitrogen can become dangerous when Dewer jars or other wide-mouth opening vessels are kept for a long time without the cover cap. It is necessary to check thermal insulation in very cold areas of equipment and pay attention to the cover of liquid nitrogen vessels.

Danger of asphyxiation

Rapid evaporation of a cryogenic liquid results in a large increase in its volume (e.g., one liter of expanded liquid nitrogen occupies about 700 liters), which can easily asphyxiate the atmosphere of poorly ventilated rooms. Because the gases produced are generally odorless and colorless and oxygen deficiency does not cause easily recognizable effects, suffocation occurs without premonitory signs, leading to fainting and death. Given the serious consequences, ventilating the room and installing oxygen detectors are necessary precautions if there is a danger of asphyxiation.

Danger of explosion

The overpressure generated by the evaporation of a cryogenic liquid inside a closed container (e.g., a cryogenic container with blocked vent valves) can be so high as to result in a mechanical explosion. This hazard requires special precautions in storage: containers must be open or equipped with a venting device.

11.2 Cryogenic vessels

Cryogenic vessels must store liquid at low temperatures and allow normal loading/unloading and tapping operations. Fundamental are: the materials used in their construction, which must not embrittle at low temperatures; thermal insulation, which is necessary to limit evaporation; venting of expanded vapors, which is essential to prevent the generation of dangerous pressures; and loading/unloading and tapping devices.

The materials used in the construction of these vessels are stainless steel and aluminum alloy. Manually transportable containers are normally made of aluminum alloy; larger containers that can be wheeled or fixed are made of stainless steel. Thermal insulation is achieved by a multi-wall structure with interposed insulation material placed in a vacuum; in the simplest cases, there are two walls.

Cryogenic vessels can be divided into two categories depending on whether venting takes place at atmospheric pressure (open vessels) or under overpressure (closed vessels). In both cases, regular venting of the gas from the vaporization of the cryogenic liquid must always be ensured in order to avoid the generation of high pressures dangerous to the integrity of the vessel; in fact,despite excellent insulation, part of the contained liquid inevitably evaporates due to the heat flow from the external environment.

Atmospheric pressure vessels have an opening that, when not in use for loading and tapping operations, is covered by placing a cap of a very light insulating material (plastic) over it; this limits heat loss and simultaneously allows the evaporating gas to escape with negligible overpressure.

Closed vessels are more suitable for holding larger quantities of liquid (25-250 liters), and are usually careened. They are self-pressurizing vessels, equipped with a filling and pouring device, a level indicator, a pressure gauge, and a pressurizing circuit with a pressure regulator and vent valve. A pressurizing coil draws cryogenic liquid from the bottom of the vessel; the liquid vaporizes in the coil, cooling the system, and, passed a valve, called a pressurizing valve, is fed in a gaseous state into the inner vessel, pressurizing it; when the internal pressure exceeds the set value, the pressurizing regulator intervenes, opening the vent valve. A rupture disk connected with the inner chamber protects it from any uncontrolled increase in pressure, generated, for example, by an obstruction of the vent due to some frozen atmospheric moisture. In the case of double-walled vessels, there is also a rupture disk connected with the vacuum cavity; in fact, this becomes pressurized if due to a rupture cryogenic liquid flows into it.

11.3 Assessing the possibility of asphyxiation and controlling the risk

A room is considered an asphyxiation hazard when there is enough cryogenic liquid present to reduce, upon evaporation, the oxygen concentration in the room to a value of less than 18 percent by volume.

In estimating the reduction in oxygen concentration, it should be considered that due to its temperature, the expanded gas does not disperse evenly in the room, but tends to stratify downward; the volume actually available is therefore less than that of the room. To take this phenomenon into account, the volume of the room is cautiously reduced by multiplying it by a filling coefficient (k); in the case of a room height less than or equal to three meters, the coefficient is assumed to be 0.5; for higher rooms, it must be further reduced by placing it equal to $1{,}5/H$, where H is the height of the room expressed in meters.

If we assume that in the absence of forced aeration all cryogenic fluid evaporates in the laboratory by replacing part of the air present with its volume, the maximum amount in moles (n_f) of fluid that can be stored per unit volume that can be occupied (kV) to have no appreciable risk of asphyxiating atmosphere, i.e., an oxygen concentration of at least 18%, turns out to be:

$$\frac{n_f}{kV} = 5{,}76\, mol/m^3$$

In the case of nitrogen, expressing the quantity in mass (m_f) and in liters of cryogenic liquid (V_f), we obtain:

$$\frac{m_f}{kV} = 0{,}162\ \frac{kg_{N_2}}{m^3} \qquad e \qquad \frac{V_f}{kV} = 0{,}200\ \frac{litri_{N_2 liq.}}{m^3}$$

Even if these limits are met, it is still recommended that the room be ventilated as much as possible by opening doors and windows when performing actions involving cryogenic liquids such as loading, unloading, pouring, and refilling.

If it turns out that a vessel or equipment has a capacity that could result in an asphyxiation hazard, it is necessary, in order to reduce the risk, to install in the room an oxygen detection system and a forced ventilation system.

11.4 Oxygen detection system

The detection system should be equipped with an optical and audible alarm that cannot be deactivated (or deactivated by password). It is recommended that the first alarm be set at an oxygen concentration of 19.5 percent. Detectors can be mounted sideways on the wall or on columns about 30 cm above the floor in areas where there is no appreciable airflow (estimated air velocity less than 0.5 m/s). At least one of the detectors should be located in close proximity to the possible point of refrigerant leakage (cryogenic vessel or equipment tank). If the floor is sloping, one detector should be placed at the lowest point of the floor, about 30 cm above the floor. The presence of manholes or crawl spaces requires the installation of additional detectors.

11.5 Room ventilation

The forced ventilation system should have the air intake from the outdoor environment positioned at the top and the exhaust from the indoor environment at the bottom. The air flow rate, conditioned so as not to create discomfort for operators, should ensure at least 6 volume changes of the room every hour. If emergency ventilation is also to be installed, an air flow rate, unconditioned, that guarantees at least 20 changes per hour is recommended. Emergency response should possibly be triggered automatically in the event of an oxygen detection system alarm.

11.5 Recommendations for the use of cryogenic vessels.

When using cryogenic vessels, it is best to follow the operating and maintenance instructions given by the manufacturer in the equipment manual. In general, it is recommended that the following guidelines be followed.

Conditions for use.

- Use only containers specially constructed and certified to hold cryogenic liquids.
- Use a cryogenic vessel only with the specific cryogenic liquid for which it was made.
- Use only open-type vessels or those protected by a pressure-limiting and gas-discharge device.
- Do not use vessels that appear to be damaged in insulation or have a high evaporation rate than the manufacturer indicates.
- Do not use caps or lids that were not supplied with the container.

Checks

- Regularly check the operation of the venting devices to ensure that they are not obstructed by frozen atmospheric moisture.
- Check, for self-pressurizing vessels, that the pressure indicated by the pressure gauge meets the limits specified by the supplier.

Transport and placement

- Always use appropriate means such as trolleys designed for the purpose when transporting cryogenic vessels; they must ensure stability of the load so as to prevent accidental falls and spills.
- Transport loaded cryogenic vessels only in a freight elevator or elevator operating in freight elevator mode. *No person should be inside an enclosed cabin when a loaded cryogenic vessel is present, even if it is of small capacity.* If accidentally locked, evaporation of the cryogenic liquid can create an asphyxiating environment.
- Do not place a cryogenic vessel near heat sources (direct sunlight, heating radiators, furnaces etc.)

11.6 Recommendations for handling cryogenic liquids.

During pouring and tapping operations of cryogenic liquids, contact of the cryogenic fluid with "hot" (room temperature) parts leads to its rapid and uncontrolled vaporization, which easily produces splashes. Therefore, pouring and tapping operations must be carried out slowly and with appropriate personal protection.

The following precautions should be taken when using cryogenic liquids.

Personal protection

- Remove any wristbands or other objects that may be in the way during cryogenic liquid handling operations.

- Wear long pants without lapels and a long gown possibly without pockets.
- Protect your eyes and face by wearing a visor (face shield) and safety glasses.
- Protect your hands by wearing waterproof gloves with extensions specifically for handling cryogenic liquids. The gloves should fit loosely so that they can be thrown off quickly if liquid is spilled or splashed inside them.
- Protect your body by wearing an insulating and waterproof apron/parasol for cryogenic liquids.
- Protect your feet by wearing closed shoes, preferably safety shoes; absolutely avoid open shoes or shoes made of porous or otherwise permeable materials.
- Always wear pants on the outside of boots or shoes in general so as to avoid the danger of cryogenic liquid getting inside the footwear.

Prohibitions

- Do not perform any operation unless you have been specifically trained to perform it.
- Never operate cryogenic liquids alone.
- Never directly touch uninsulated pipes or vessels containing cryogenic liquids with your hands or other uncovered body parts. Non-metallic materials can also be hazardous at those temperatures.
- Never fill containers beyond the safety level prescribed by the manufacturer (usually no more than 80 percent of volumetric capacity). Excess liquid increases the rate of evaporation and the danger of overflow during transport.
- Never block the discharge of a venting device or close the opening of an atmospheric pressure vessel.

Operational modes and controls

- Before performing any operation, ventilate the room as much as possible, or if the room is artificially ventilated, check the efficiency of the system.
- Before filling, always make sure that the supposedly empty container does not contain water or cryogenic liquids instead.
- Before refilling a vessel, ascertain the nature of the liquid contained. Mixing two different cryogenic liquids will cause the liquid to evaporate to its lowest boiling point. If liquid oxygen is involved this can create an oxidizing atmosphere resulting in a fire hazard. If liquid oxygen is introduced into a liquid nitrogen container, spontaneous ignition of the contained organic material can occur.
- Use a funnel to decant cryogenic liquids into small containers.
- Use a pressure tapping device (or dispenser) to extract cryogenic liquids from large vessels. The dispenser should be inserted through the neck of the vessel and slowly submerged all the way into the liquid. Use just enough pressure to perform the liquid extraction.
- Always perform operations slowly, especially decanting into a "hot" (room temperature) container and immersing a "hot" object, so as to reduce splashing generated by boiling.
- Always use tongs to immerse or extract objects from a cryogenic liquid.
- Check regularly that the venting devices are not obstructed by frozen material. If a tapping device (or dispenser) or a pouring spout is used, check, at regular intervals, that the vent is not obstructed by ice formed by the solidification of atmospheric moisture. Inadequate venting

can be the cause of excessive pressure buildup with possible vessel damage or, in borderline cases, bursting.

List of some incompatible chemicals with risk of violent reactions

ACETILENE
fluorine, chlorine, bromine, silver, copper and mercury
ACETONE
mixtures of concentrated nitric and sulfuric acid
ACETIC ACID
Chromic acid, nitric acid, peroxides and permanganates
HYDROGEN CYANIDE
nitric acid and alkali
CHROMIC ACID AND CHROMIUM TRIOXIDE
Acetic ac., naphthalene, camphor, glycerol, aqua regia, alcohol and other liquids flammables
CONCENTRATED NITRIC ACID
acetic ac, acetone, alcohol, aniline, chromic ac, hydrogen cyanide, sulfide of Hydrogen, flammable liquids, flammable gases, nitrable substances
OSSALIC ACID
silver and mercury
PERCHLORIC ACID
Acetic anhydride, bismuth and its alloys, alcohol, paper, wood,grease and oils
SULFURIC ACID
chlorate, perchlorates, permanganates
ANHYDROUS AMMONIA
Mercury, chlorine, hypochlorite calcium, iodine, bromine and hydrogen fluoride
ANILINE
nitric acid,hydrogen peroxide
SILVER
Acetylene, oxalic acid, tartaric ac., fulminic ac.
BROMO
ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, white spirit, benzene
ACTIVE COAL.
calcium hypochlorite, oxidants
CHLORATES
Ammonium salts, acids metal powders, sulfur
CHLORINE
see bromine
CHLORINE DIOXIDE
Ammonia, methane, phosphine, hydrogen sulfide
FLUORO
responsive to all
HYDROGEN FLUORIDE
aqueous or anhydrous ammonia
WHITE PHOSPHORUS
air and oxygen
HYDRAZINE
Hydrogen peroxide, nitric acid, any oxidant
HYDROCARBONS (BENZENE, BUTANE,PROPANE, GASOLINE)

fluorine, chlorine, chromic ac., peroxides
IODIUM
Acetylene, aqueous or anhydrous ammonia
MERCURY
Acetylene, ac. fulminic, ammonia
ALKALI AND ALKALINE EARTH METALS
Carbon dioxide, carbon tetrachloride and other chlorinated hydrocarbons
AMMONIUM NITRATE
Acids, metal powders, flammable liquids, chlorinated nitrites, sulfur substances organic or combustible
NITROPARAFFIN
inorganic bases amines
CALCIUM OXIDE
water
OXYGEN
Flammable oils, fats, hydrogen, liquids,solids or gases
POTASSIUM PERMANGANATE
Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
HYDROGEN PEROXIDE
copper, chromium, metals or their salts, inflammable liquids, combustible materials

List of some incompatible chemicals with risk of formation of toxic substances

ARSENIACAL PRODUCTS
any reducing agent **ARSINE** is generated
NITRIC ACID
copper, brass, any heavy metal **nitrogen dioxide** is generated
CIANURI
acids **cyanidic acid** is generated
PHOSPHORUS
caustic alkalis or reducing agents **PHOSPHINE** is generated
HYPOCHLORES
acids **CHLORINE, HYPOCHLOROSIC ACID** is generated.
NITRATES
sulfuric acid **nitrogen dioxide** is generated
SULFUR
Acids **hydrogen sulfide** is generated

Removal methods for some chemical spills

Type of deposit	Recommended cleaning
Organic acids	Apply 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 baking soda.
Aldehydes	Absorb with granules or vermiculite
Aliphatic amines	Apply sodium bisulfate. Absorb with granules or vermiculite.
Aromatic amines	Absorb with granules or vermiculite. Avoid skin contact and inhalation.
Halogenated aromatic amines	Absorb with granules or vermiculite. Avoid skin contact and inhalation.
Azides (potentially explosive)	Absorb with granules or vermiculite. Decontaminate with a 10% solution of ceric ammonium nitrate.
Bases (caustic alkali)	Neutralize with acid or other commercial chemical neutralizers and absorb with granules or vermiculite.
Carbon sulfide	Absorb with granules or vermiculite
Chlorhydrin	Absorb with granules or vermiculite. Avoid skin contact and inhalation
Cyanides	Wet or dampen solids before sweeping or use a vacuum cleaner with a HEPA filter. Absorb liquids with granules or vermiculite
Alids, organic or inorganic	Apply baking soda
halogenated hydrocarbons	Absorb with granules or vermiculite
ldrazine	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. Take great care in choosing granules for acid absorption, those containing silicates incompatible with hydrofluoric acid
Solutions of inorganic salts	Apply soda
Mercaptans/organic sulfides	Neutralize with a calcium hypochlorite solution. Absorb with granules or vermiculite.
Nitriles	Sweep away solids. Absorb liquids with granules or vermiculite.
Nitro organic compounds	Absorb with granules or vermiculite. Avoid skin contact and inhalation
Oxidizing agents	Apply sodium bisulfite
Peroxides (violent reactions with water)	Absorb with granules or vermiculite

Phosphates, organic	Absorb with granules or vermiculite
Reducing substances	Apply soda or baking soda

Guide to safety in chemical laboratories (version 3)

Appendix A - Safety Signs

Prescription signs

ALWAYS WASH THE
HANDS AT THE END
OF OPERATIONS

MANDATORY
PROTECTION
OF THE BODY

MANDATORY PROTECTION
ABOUT HEARING.

MANDATORY GLOVES

MANDATORY SAFETY
FOOTWEAR

MANDATORY PROTECTIVE
HELMET

PROTECTION
OF THE MANDATORY
EYES

PROTECTION
OF THE FACE
MANDATORY

MANDATORY PROTECTION
OF THE WAYS
RESPIRATORY

Prohibition signs

PROHIBITION OF ACCESS TO UNAUTHORIZED PERSONS

PEDESTRIAN BAN

DO NOT TOUCH

FORBIDDEN TO SMOKE

FORBIDDEN TO USE. FREE FLAMES.

PROHIBITION OF DRINKS AND FOOD.

NON-POTABLE WATER

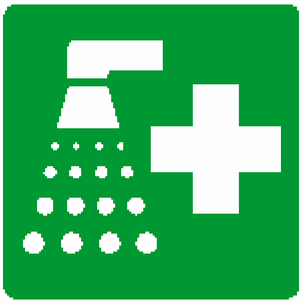
VIETATO SPEGNERE CON ACQUA

PROHIBITED TO USE FIRE EXTINGUISHERS

Signs of rescue or relief

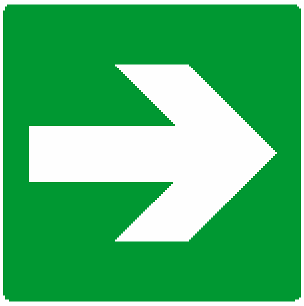
PRONTO SOCCORSO

DOCCETTA
LAVAOCCHI
DI EMERGENZA

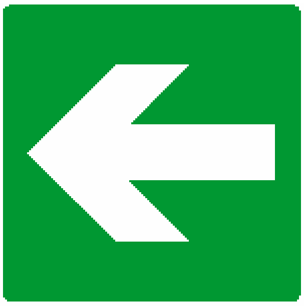


DOCCIA DI
EMERGENZA

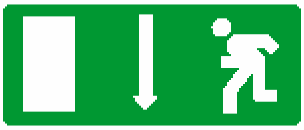
PERCORSO/USCITA
DI EMERGENZA



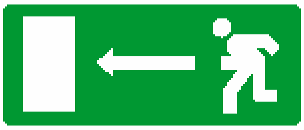
DIREZIONE DA SEGUIRE
(cartello da aggiungere
a quelli che precedono)



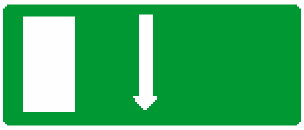
DIREZIONE DA SEGUIRE
(cartello da aggiungere
a quelli che precedono)



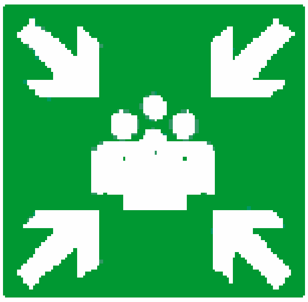
PERCORSO/USCITA
DI EMERGENZA



PERCORSO/USCITA
DI EMERGENZA



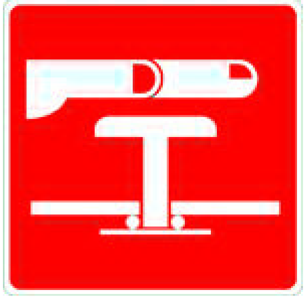
PERCORSO/USCITA
DI EMERGENZA



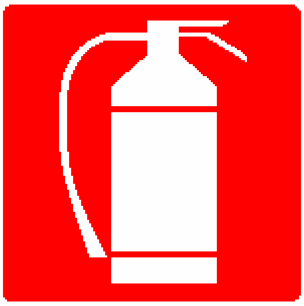
PUNTO DI RACCOLTA

Fire signals

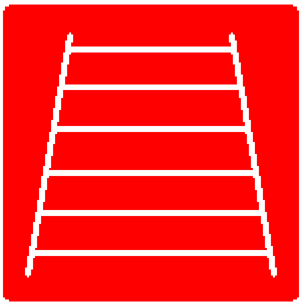
HYDRANT



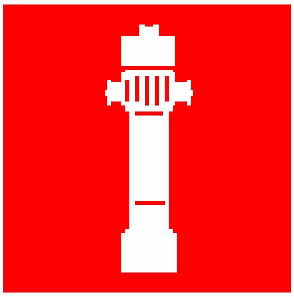
ALARM BUTTON



ESTINTORE

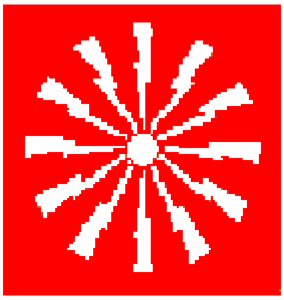


SCALA ANTINCENDIO



ATTACCO VV.FF.

TELEFONO PER GLI INTERVENTI ANTINCENDIO



PULSANTE DI ALLARME ANTINCENDIO

Guide to safety in chemical laboratories

Appendix B - EC Regulation No. 1237/2008

Tables B.1, B.2 and B.3 give a brief description of each class along with an indication of their subdivision, if any, into categories, subcategories, divisions, types, and groups. Tables B.4, B.5 and B.6 list the warnings, codes the hazard indicators and pictograms associated with each class, category and any other subdivisions. Subsequent lists associate each code with the corresponding standard phrase used as a hazard indicator or cautionary advice.

Table B.1- Physical Hazards

Class	Definitions, categories, and other subdivisions
Explosives	The class of explosives includes:explosive substances and mixtures;explosive articles, substances and mixtures not mentioned that are manufactured for the purpose of producing a practical explosive or pyrotechnic effect. Unstable explosive; divisions 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6
Flammable gases	Gases that have a flammable range when mixed with air. Categories 1 and 2
Flammable aerosols	Aerosols that contain a component classified as flammable (liquid with a flash point less than or equal to 95°C; flammable gas; flammable solid). Categories 1 and 2
Oxidizing gases	A gas capable, usually by oxygen supply, of causing or promoting more than air the combustion of other matter. Category 1
Gas under pressure	Gases contained in a vessel at a relative pressure of 200 kPa or more or in the form of liquefied gases or liquefied gases and refrigerated or dissolved in a solvent. Groups: compressed gases, liquefied gases, refrigerated liquefied gases, and dissolved gases.
Flammable liquids	Flammable liquid is defined as a liquid having an ignition point not exceeding 60°C. Categories 1,2 and 3
Flammable solids	Easily flammable solid or one that can cause or promote a fire by rubbing. Categories 1 and 2
Self-reactive substances and mixtures	Thermally unstable liquid or solid substances or mixtures that can undergo strongly exothermic decomposition, even in the absence of oxygen (air). This definition excludes substances and mixtures classified as explosives, organic peroxides or oxidizers. Types A, B, C, D, E, F and G
Pyrophoric liquids	Liquid substance or mixture that, even in small amounts, can ignite. Category 1
Pyrophoric solids	Solid substance or mixture that, even in small amounts, can ignite in less than five minutes when it comes into contact with air. Category 1
Self-heating substances and mixtures	A liquid or solid substance or mixture other than a pyrophoric liquid or solid that, by reaction with air and without energy input, can self-heat. Such a substance or mixture differs from a pyrophoric liquid or solid in that it ignites only when in large quantities (kilograms) and after a long period of time (hours or days). Categories 1 and 2
Substances and mixtures that, in contact with water, emit flammable gases	Solid or liquid substances or mixtures which, by interaction with water, may become spontaneously flammable or develop flammable gases in hazardous quantities. Categories 1, 2 and 3
Oxidizing liquids	A liquid substance or mixture which, while not necessarily combustible in itself, can-usually by yielding oxygen-cause or promote the combustion of other matter. Categories 1, 2 and 3
Oxidizing solids	A solid substance or mixture that, while not necessarily combustible in itself, can-usually by yielding oxygen-cause or promote the combustion of other matter. Categories 1, 2 and 3
Organic peroxides	Organic peroxides are liquid or solid organic substances that contain the bivalent structure -O-O-. Also included under this designation are mixtures (formulations)

	of organic peroxides containing at least one organic peroxide. Types A, B, C, D, E, F and G
Corrosive substances and mixtures for metals	A metal-corrosive substance or mixture is a substance or mixture that, by chemical action, can attack or destroy metals.

Table B.2- Health Hazards

Class	Definition and classification by Categories
Acute toxicity	Substance or mixtures that produce adverse effects that occur following oral or dermal administration of a single dose or multiple doses spread over 24 hours, or following 4-hour inhalation exposure. Categories 1, 2, 3 and 4
Skin corrosion/irritation	Substances or mixtures that produce irreversible skin injury, such as visible necrosis through the epidermis and into the dermis, following the application of a test substance for a duration of up to four hours. Categories 1A/B/C and 2
Severe eye injury/eye irritation	Substances or mixtures that produce ocular tissue injury or severe visual impairment resulting from the application of a test substance to the anterior surface of the eye, which is not totally reversible within 21 days of application or an impairment of the eye resulting from the application of test substances to the anterior surface of the eye, which is totally reversible within 21 days of application. Categories 1 and 2
Respiratory sensitization	Respiratory sensitizing substance means a substance that, when inhaled, causes hypersensitivity of the respiratory tract. Category 1
Skin sensitization	Skin-sensitizing substance means a substance that causes an allergic reaction upon contact with the skin. Category 1
Mutagenicity on germ cells	Substances proven to cause heritable mutations or to be considered as capable of causing heritable mutations in human germ cells. Categories 1A/B and 2
Carcinogenicity	A substance or mixture of substances that causes cancer or increases its incidence is a carcinogen. Categories 1A/B and 2
Reproductive toxicity	Substances and mixtures that have detrimental effects on sexual function and fertility of adult men and women and on the development of offspring are toxic to reproduction. Categories 1A/B and 2 + Additional category for effects through or on lactation.
Specific Target Organ Toxicity - Single Exposure	Specific, nonlethal target organ toxicity resulting from a single exposure to a substance or mixture. Includes all significant health effects that may alter function, reversible or irreversible, immediate and/or delayed. Categories 1, 2 and 3
Specific Target Organ Toxicity - Repeated Exposure	Specific target organ toxicity resulting from repeated exposure to a substance or mixture. Includes all significant health effects that may alter function, reversible or irreversible, immediate and/or delayed. Categories 1 and 2

Toxicity upon aspiration	Substances or mixtures that may present a hazard to humans upon aspiration. Aspiration toxicity can have severe acute effects, such as chemical pneumonitis, lung injury of varying degrees, and death. Category 1

Table B.3- Hazards to the Environment or the Ozone Layer.

Class	Definition and classification by Categories
Hazardous to the aquatic environment - Acute toxicity	Acute aquatic toxicity is defined as the inherent capacity to cause harm to an organism subjected to short-term exposure. Category 1
Hazardous to the aquatic environment - Chronic toxicity	Chronic aquatic toxicity means the inherent property of causing adverse effects on aquatic organisms during exposures determined in relation to the life cycle of the organism. Categories 1, 2, 3 and 4
Hazardous to the ozone layer (additional class)	Substance that may present a hazard to the structure and/or function of the stratosphere ozone layer. In the case of mixtures, the individual concentration of the substance or substances in them that are hazardous to the ozone layer must be ≥ 0.1 %.

Table B.4a - Warnings, Hazard Indicators and Pictograms - (Part 1 of 3)

Class	Category, Division or Group	Warning	Danger Indicator	Pictogram
Explosives	Unstable explosive	Danger	H200	
	Division 1.1	Danger	H201	
	Division 1.2	Danger	H202	
	Division 1.3	Danger	H203	
	Division 1.4	Danger	H204	
	Division 1.5	Danger	H205	-
	Division 1.6	-	-	-
Flammable gases	Category 1	Danger	H220	
	Category 2	Attention	H221	-
Flammable aerosols	Category 1	Danger	H222	
	Category 2	Attention	H223	
Oxidizing gases	Category 1	Danger	H270	
Gas under pressure	Compressed gas group	Attention	H280	
	Liquefied gas group	Attention	H280	
	Refrigerated liquefied gas group	Attention	H281	
	Dissolved gas group	Attention	H280	

Table B.4b- Warnings, Hazard Indicators and Pictograms- Physical Hazards (Part 2 of 3)

Class	Category, Division, or Type	Warning	Danger Indicator	Pictogram
Flammable liquids	Category 1	Danger	H224	
	Category 2	Danger	H225	
	Category 3	Danger	H226	
Flammable solids	Category 1	Danger	H228	
	Category 2	Attention	H228	
Self-reactive substances and mixtures	Type A	Danger	H240	
	Type B	Danger	H241	 
	Type C and D	Danger	H242	
	Type E and F	Attention	H242	
	Type G	-	-	-
Pyrophoric liquids	Category 1	Danger	H250	
Pyrophoric solids	Category 1	Danger	H250	
Self-heating substances and mixtures	Category 1	Danger	H251	
	Category 2	Attention	H252	
Substances and mixtures that, in contact with water, emit flammable gases	Category 1	Danger	H260	
	Category 2	Danger	H261	
	Category 3	Attention	H261	

Table B.4c- Warnings, Hazard Indicators and Pictograms - Physical Hazards (Part 3 of 3)

Class	Category or Type	Warning	Danger Indicator	Pictogram
Oxidizing liquids	Category 1	Danger	H271	
	Category 2	Danger	H272	
	Category 3	Attention	H272	
Oxidizing solids	Category 1	Danger	H271	
	Category 2	Danger	H272	
	Category 3	Attention	H272	
Organic peroxides	Type A	Danger	H240	
	Type B	Danger	H241	 
	Type C and D	Danger	H242	
	Type E and F	Attention	H242	
	Type G	-	-	-
Corrosive substances and mixtures for metals	Category 1	Attention		

Table B.5a -Warnings, Hazard Indicators and Pictograms- Health Hazards (Part 1 of 2)

Class	Category	Warning	Danger Indicator	Pictogram
Acute toxicity	Category 1	Danger	H300	
	Category 2	Danger	H300	
	Category 3	Danger	H301	
	Category 4	Attention	H302	
Skin corrosion/irritation	Category 1A /1B/1C	Danger	H314	
	Category 2	Attention	H315	
Severe eye injury/eye irritation	Category 1	Danger	H318	
	Category 2	Attention	H319	
Respiratory sensitization	Category 1	Danger	H334	
Skin sensitization	Category 1	Attention	H317	
Mutagenicity on germ cells	Category 1A /1B	Danger	H340	
	Category 2	Attention	H341	
Carcinogenicity	Category 1A /1B	Danger	H350	
	Category 2	Attention	H351	
Reproductive toxicity	Category 1A /1B	Danger	H350	
	Category 2	Attention	H351	
	Supp. category for effects through or on lactation	-	H361	-

Table B.5b - Warnings, Hazard Indicators and Pictograms - Health Hazards (Part 1 of 2)

Class	Category	Warning	Danger Indicator	Pictogram
Specific Target Organ Toxicity - Single Exposure	Category 1	Danger	H371	
	Category 2	Attention	H372	
	Category 3	Attention	H373	
Specific Target Organ Toxicity - Repeated Exposure	Category 1	Danger	H372	
	Category 2	Attention	H373	
Toxicity upon aspiration	Category 1	Danger	H304	

Table B.6- Warnings, Hazard Indicators and Pictograms - Environmental and Ozone Layer Hazards.

Class	Category	Warning	Danger Indicator	Pictogram
Hazardous to the aquatic environment - Acute toxicity	Category 1	Attention	H400	
Hazardous to the aquatic environment - Chronic toxicity	Category 1	Attention	H372	
	Category 2	-	-	
	Category 3	-	-	-
	Category 4	-	-	-
Hazardous to the ozone layer (additional class)	-	Danger	EUH059	-

List of Hazard Statements and Supplementary Hazard Statements for the European Union

Hazard statements - Physical properties

H200	Unstable explosive
H201	Explosive; mass explosion hazard
H202	Explosive; serious danger of projection
H203	Explosive; fire, air displacement or projection hazard
H204	Fire or projection hazard
H205	Danger of mass explosion in case of fire
H220	Highly flammable gas
H221	Flammable gas
H222	Highly flammable aerosol
H223	Flammable aerosol
H224	Highly flammable liquid and vapors
H225	Easily flammable liquid and vapors
H226	Flammable liquid and vapors
H228	Flammable solid
H240	Heating explosion hazard
H241	Risk of fire or explosion due to heating
H242	Heating fire risk
H250	Spontaneously flammable in air
H251	Self-heating; can ignite
H252	Self-heating in large quantities; can ignite
H260	In contact with water releases flammable gases that can spontaneously ignite
H261	In contact with water releases flammable gas
H270	May cause or aggravate a fire; combustible
H271	May cause a fire or explosion; very combustible
H272	May aggravate a fire; oxidizer
H280	Contains gas under pressure; can explode if heated
H281	Contains refrigerated gas; may cause burns or cryogenic injury
H290	Can be corrosive to metals

Hazard Statements - Health Hazard	
H300	Lethal if ingested
H301	Toxic if ingested
H302	Harmful if swallowed
H304	Can be lethal if swallowed and penetrated into the respiratory tract
H310	Lethal by skin contact
H311	Toxic by skin contact
H312	Harmful by skin contact
H314	Causes severe skin burns and serious eye injury
H315	Causes skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye injury
H319	Causes severe eye irritation
H330	Lethal if inhaled
H331	Toxic if inhaled
H332	Harmful if inhaled
H334	May cause allergic or asthmatic symptoms or breathing difficulties if inhaled
H335	May irritate the respiratory tract
H336	May cause drowsiness or dizziness
H340	May cause genetic alterations *<indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*
H341	Suspected of causing genetic alterations <*indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*
H350	Can cause cancer<indicate *the route of exposure if it is established that no other route of exposure poses the same danger>*
H351	Suspected of causing cancer *<indicate the route of exposure if it is determined that no other route of exposure poses the same hazard>*
H360	May harm fertility or fetus *<indicate specific effect, if known><indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*
H361	Suspected of harming fertility or fetus *<indicate specific effect, if known><indicate route of exposure if it is established that no other route of exposure poses the same hazard>*
H362	May be harmful to breastfed infants
H370	Causes organ damage *<or indicate all organs affected, if known><indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*
H371	May cause organ damage *<or indicate all organs affected, if known><indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*

H372	Causes organ damage *<or indicate all organs affected, if known>* in case of prolonged or repeated exposure<indicate *route of exposure if it is established that no other route of exposure poses the same hazard>*
H373	May cause organ damage *<or indicate all organs affected, if known>in* case of prolonged or repeated exposure *<indicate route of exposure if it is determined that no other route of exposure poses the same hazard>*

Hazard statements - Danger to the environment	
H400	Very toxic to aquatic organisms
H410	Very toxic to aquatic organisms with long-lasting effects
H411	Toxic to aquatic organisms with long-lasting effects
H412	Harmful to aquatic organisms with long-lasting effects
H413	May be harmful to aquatic organisms with long-lasting effects

Additional hazard statements	
EUH001	Dry state explosive
EUH006	Explosive in contact or without air contact
EUH014	Reacts violently with water
EUH018	An explosive/flammable vapor-air mixture may form during use
EUH019	Can form explosive peroxides
EUH044	Risk of explosion due to heating in a confined environment
EUH029	In contact with water releases a toxic gas
EUH031	Contact with acids releases toxic gas
EUH032	On contact with acids it releases very toxic gases
EUH066	Repeated exposure may cause dryness or cracking of the skin
EUH070	Toxic by eye contact
EUH071	Corrosive to the respiratory tract
EUH059	Hazardous to the ozone layer
EUH 201/201A	Contains lead Do not use on objects that can be chewed or sucked by children Warning. Contains lead
EUH202	Cyanoacrylate Danger Paste to skin and eyes in seconds Keep out of reach of children
EUH203	Contains chromium (VI) May cause an allergic reaction
EUH204	Contains isocyanates May cause an allergic reaction
EUH205	Contains epoxy components May cause an allergic reaction

EUH206	Caution. Do not use in combination with other products Hazardous gases (chlorine) may be released
EUH207	Caution. Contains cadmium Hazardous fumes develop during use Read the information provided by the manufacturer Comply with safety regulations
EUH208	Contains <sensitizing substance name> May cause an allergic reaction
EUH209/209A	Can easily become flammable during use Can become flammable during use
EUH210	Safety data sheet available upon request
EUH401	To avoid risks to human health and the environment, follow the instructions for use

Hazard statements with additional codes	
H350i	Can cause cancer if inhaled
H360F	Can harm fertility
H360D	Can harm the fetus
H361f	Suspected of harming fertility
H361d	Suspected of harming the fetus
H360FD	May harm fertility, may harm fetus
H361fd	Suspected of harming fertility, suspected of harming fetus
H360Fd	May harm fertility, suspected of harming fetus
H360Df	May harm fetus, suspected of harming fertility

List of Prudence Councils

General precautionary advice	
P101	In case of consultation with a physician, keep the product container or label available
P102	Keep out of the reach of children
P103	Read the label before use

Cautionary Advice - Prevention	
P201	Obtain specific instructions before use
P202	Do not handle before reading and understanding all warnings
P210	Keep away from heat sources/sparks/open flames/heated surfaces - Do not smoke
P211	Do not vaporize over an open flame or other source of ignition
P220	Keep/store away from combustible clothing/materials
P221	Take every precaution to avoid mixing with combustible substances
P222	Avoid contact with air
P223	Avoid any contact with water: danger of violent reaction and spontaneous inflammation
P230	Keep moist with
P231	Handling in an inert gas atmosphere
P232	Protect from moisture
P233	Keep the container tightly closed
P234	Store only in the original container
P235	Store in a cool place
P240	Ground/ground the container and the receiving device
P241	Use electrical/ventilation/lighting/.../ explosion-proof systems
P242	Use only non-sparking tools
P243	Take precautions against electrostatic discharge
P244	Keep the reduction valves free of grease and oil
P250	Avoid abrasions/shocks/.../friction
P251	Pressure vessel: do not puncture or burn, even after use
P260	Do not breathe dust/fume/gas/mist/vapors/aerosols
P261	Avoid breathing dust/fume/gas/mist/vapors/aerosols
P262	Avoid contact with eyes, skin or clothing
P263	Avoid contact during pregnancy/lactation
P264	Wash thoroughly ... after use

P270	Do not eat, drink or smoke during use
P271	Use only outdoors or in a well-ventilated place
P272	Contaminated work clothes should not be taken out of the workplace
P273	Do not disperse into the environment
P280	Wear gloves/protective clothing/eye/face protection
P281	Use the required personal protective equipment
P282	Use thermal gloves/face shield/eye protection
P283	Wear clothing that is fully flame-retardant or made of flame-retardant fabrics
P284	Use a respiratory device
P285	In case of insufficient ventilation, use a respiratory device
P231+P232	Handle in inert gas atmosphere, keep away from moisture
P235+P410	Keep in a cool place, protect from sunlight

Cautionary Advice - Reaction	
P301	IN CASE OF INGESTION:
P302	IN CASE OF SKIN CONTACT:
P303	IN CASE OF CONTACT WITH SKIN (or hair):
P304	IN CASE OF INHALATION:
P305	IN CASE OF CONTACT WITH THE EYES:
P306	IN CASE OF CONTACT WITH CLOTHING:
P307	IN CASE of exposure:
P308	IN CASE of exposure or possible exposure:
P309	IN CASE of exposure or discomfort:
P310	Contact an ANTIVENITION CENTER or physician immediately.
P311	Contact an ANTIVELENI CENTER or physician.
P312	If you feel unwell, contact an ANTI-VALVENIATION CENTER or a physician
P313	Consult a physician
P314	If you feel unwell, consult a doctor
P315	Seek immediate medical attention
P320	Specific urgent treatment (see ... on this label)
P321	Specific treatment (see ...on this label)
P322	Specific measurements (see ...on this label)
P330	Rinse the mouth
P331	DO NOT induce vomiting
P332	In case of skin irritation:

P333	In case of skin irritation or rash:
P334	Soak in cold water/wrap with a wet bandage
P335	Remove particles deposited on the skin
P336	Thaw frozen parts using lukewarm water Do not rub the affected part
P337	If eye irritation persists:
P338	Remove any contact lenses if it is easy to do so Continue rinsing
P340	Carry the casualty outdoors and keep him at rest in a position conducive to breathing
P341	If breathing is difficult, transport the casualty to fresh air and keep the casualty at rest in a position conducive to breathing
P342	In case of respiratory symptoms:
P350	Wash gently and thoroughly with soap and water
P351	Rinse thoroughly for several minutes
P352	Wash thoroughly with soap and water
P353	Rinse the skin/take a shower
P360	Rinse contaminated clothing and skin immediately and thoroughly before removing clothing
P361	Remove all contaminated clothing immediately
P362	Remove contaminated clothing and wash it before wearing it again
P363	Wash contaminated clothing before wearing it again
P370	In case of fire:
P371	In case of severe fire and large quantities:
P372	Risk of explosion in case of fire
P373	DO NOT use extinguishing media if the fire reaches explosive materials
P374	Use extinguishing media with the usual precautions at a reasonable distance
P375	Explosion hazard Use extinguishing media at a great distance
P376	Stop the leak if there is no danger
P377	In case of fire due to gas leak, do not extinguish unless the leak can be stopped without danger
P378	Extinguish with...
P380	Evacuate the area
P381	Eliminate all ignition sources if there is no danger
P390	Absorb the spill to avoid property damage
P391	Collect the spilled material
P301+P310	IN CASE OF INGESTION: Immediately contact a POISON CENTER or physician.
P301+P312	IN CASE OF INGESTION accompanied by malaise: contact a POISON CENTER or physician

P301+P330+P331	IF INGESTION: rinse mouth DO NOT induce vomiting
P302+P334	IF ON SKIN CONTACT: soak in cold water/wrap with a damp bandage
P302+P350	IF ON SKIN: Wash gently and thoroughly with soap and water.
P302+P352	IF ON SKIN: Wash thoroughly with soap and water.
P303+P361+P353	IF ON SKIN (or hair): remove all contaminated clothing immediately Rinse skin/take a shower
P304+P340	IN CASE OF INHALATION: Transport the casualty to fresh air and keep the casualty at rest in a position conducive to breathing
P304+P341	IN CASE OF INHALATION: If breathing is difficult, transport the casualty to fresh air and keep the casualty at rest in a position conducive to breathing
P305+P351+P338	IF IN EYE CONTACT: Rinse thoroughly for several minutes Remove any contact lenses if it is convenient to do so Continue rinsing
P306+P360	IN CASE OF CLOTHING CONTACT: Immediately rinse contaminated clothing and skin thoroughly before removing clothing
P307+P311	IF exposed, contact a POISON CENTER or physician.
P308+P313	IF exposed or possibly exposed, consult a physician
P309+P311	IF you are exposed or feel unwell, contact a POISON CENTER or physician
P332+P313	In case of skin irritation: consult a doctor
P333+P313	In case of skin irritation or rash: consult a doctor
P335+P334	Remove particles deposited on the skin Soak in cold water/wrap with a wet bandage
P337+P313	If eye irritation persists, consult a physician
P342+P311	In case of respiratory symptoms: contact an ANTIVELENI CENTER or a physician
P370+P376	In case of fire: stop the leak if there is no danger
P370+P378	In case of fire: extinguish with
P370+P380	Evacuate the area in case of fire
P370+P380+P375	In case of fire: evacuate the area Risk of explosion Use extinguishing media at a great distance
P371+P380+P375	In case of a large and severe fire: evacuate the area Explosion risk Use extinguishing media at a great distance

Cautionary Advice - Storage	
P401	Store...
P402	Store in a dry place
P403	Store in a well-ventilated place
P404	Store in a closed container
P405	Store under lock and key
P406	Store in corrosion-resistant container/ provided with durable inner lining
P407	Maintain a clear space between shelves/pallets
P410	Protect from the sun's rays
P411	Store at temperatures not exceeding ...°C/...°F
P412	Do not expose to temperatures above 50°C/122°F
P413	Store bulk items weighing more than ...kg/...lb at temperatures not exceeding ...°C/°F
P420	Store away from other materials
P422	Store under...
P402+P404	Store in a dry place and in a closed container
P403+P233	Keep the container tightly closed and in a well-ventilated place
P403+P235	Store in a cool, well-ventilated place
P410+P403	Protect from sunlight Store in a well-ventilated place
P410+P412	Protect from sunlight Do not expose to temperatures above 50°C/122°F
P411+P235	Store in a cool place at temperatures not exceeding °C/°F

Cautionary Advice - Disposal	
P501	Dispose of the product/recipient in