



# **Chemical Laboratory Safety Guide**

**Department of Materials Science  
and Chemical Engineering**

**Document for internal use**



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## General behaviour rules

### First access to the laboratory

When one enters a laboratory for the first time, it is necessary to:

- Read the sign at the entrance which shows the name of the person in charge of the laboratory and the emergency telephone numbers (of the person in charge, the infirmary, the fire-brigade, the janitor's desk, etc.).
- Read the emergency signs.
- **Inform oneself of the presence and position of the safety protection systems** (first aid box, fire extinguishers, eye baths, exits, emergency stairs etc.).
- Inform oneself of how to have access to the available documentation (material safety data sheets, manuals, waste disposal procedures, laboratory regulations, etc.).

### General operating procedures

- Respect all the rules defined by the person in charge of the laboratory (safety regulations, waste disposal, booking instruments, etc.).
- Before using any piece of equipment, it is necessary to be trained on how to use it correctly and in particular on what to do in the case of an emergency (equipment manual, working procedures, instructions from the personnel etc.).
- Only use electric equipment that is of a type that is valid according to the laws in force and connect it to the electric network in a correct manner, without losing protection against direct contact, maintaining connection with the grounding plant and an adequate IP protection
- All the operations carried out during the laboratory activities should be planned considering all the possible sources of accidents.
- Do not leave dangerous equipment turned on unattended.
- Inform the person in charge of the laboratory of any breakdowns, malfunctioning or safety problems.
- Inform the person in charge of the laboratory of any incident, even of slight importance, that should occur in the laboratory.
- Avoid overcrowding the laboratories.

### Hygiene and cleanliness

- **One should wash oneself in the case of contact with any chemical substance whatsoever.** Profusely wash your hands, face and any other part of the body that has come into contact with the chemical substance with soap and water.
- **Always wear a lab coat in non-flammable material or cotton and keep it clean.** The lab coat and the other clothes worn can detain discrete quantities of toxic substances and transmit them through inhalation or skin absorption. It is therefore advisable to wash your lab coat frequently and to avoid wearing the shoes and clothes worn in the laboratory at home.
- **Keep your workbench clean and tidy.** Cleanliness reduces the possibility of contact with dangerous substances while being tidy reduces the possibility of causing accidents, such as the



toppling of containers or glassware, or mistakes in the use of substances; moreover, a tidy workplace makes intervention easier in the case of an accident.

- **Avoid introducing food and drinks into chemical laboratories.** Do not eat or drink in the chemical laboratories and avoid, even for short periods of time, keeping any type of food in the laboratory. This contamination risk also concerns sweets, chewing gum and cigarettes placed in the pockets of the lab coats. Do not use containers in the laboratory to contain food.

### **Precaution in the use of chemical substances**

- Before manipulating a chemical substance, **inform yourself on its dangers** so as to be able to adopt all the precautions necessary. All the workers should know the chemical-physical characteristics and the dangers (flammability, toxicity, chemical compatibility etc.) of the chemical substances in use in the laboratory. Carefully consult the container **labels** and the relative **material safety data sheets** of the utilised chemical products and follow the indications reported concerning their handling, storage and disposal. Additional information can be obtained by consulting paper or computer data banks.

- **Verify the chemical compatibility** between the utilised substances.

- If it is possible, adopt methods that are able to reduce the presence of hazardous concentrations of inflammable and chemically instable substances.

- **Avoid the presence of sources of ignition** that cause fires and explosions (e.g. , it is forbidden to use Bunsen burners or any other unguarded flame in the presence of inflammable substances and outside the chemical hood). Never heat up inflammable solvents using “naked flames”, instead use electric heaters.

- **Never leave chemical reactions that are underway unattended.**

- The transport of solvents or hazardous substances should be undertaken using protection buckets.

- **Do not abandon unidentified material** in the laboratory or under the hood.

- **All the chemical substances**, and in particular inflammable substances, should be **replaced in the specific safety cabinets** at the end of the activity.

- **Collect, separate and eliminate the chemical**, solid and liquid **wastes** produced in the laboratory **in the correct way**; it is forbidden to dump them down drains or abandon them in the environment; in particular, **do not pour inflammable material** into the waste paper baskets.

### **Protection Equipment**

- **Protection of the eyes.** Always wear eye spectacles or protection goggles when working with chemical substances. Whoever wears contact lenses should always wear protection goggles. Contact lenses could hinder eye washing operations and it is therefore preferable to remove them before entering the laboratory. In the case of contact of a substance with the eyes, continuously wash the eyes, whilst waiting for a medical intervention, for about ten minutes with an eye wash or with the tap tube pointed upwards.

- **Protect your hands with adequate gloves.** Gloves in latex or other suitable material should be used for chemical operations. Work gloves should be used for particular operations such as when inserting a glass tube into a rubber pipe or into a plug.



- Always wear the opportune **Personal Protection Equipment** (goggles, visors, shields, masks etc.) as requested in the material safety data sheet pertaining to the substance or in any other integrated sources of information.
- **The operations that involve volatile, toxic-hazardous products or explosive products must be carried out under a chemical hood** (whose good suction working order must be ascertained by conducting periodic checks). The chemical hoods have the purpose of eliminating the risk of exposition to hazardous substances. Carrying out an operation under the chemical hood makes it possible to eliminate the risk of exposition to hazardous substances and to reduce the risk of primers, the development of fires and explosions. A chemical hood should be used for the decanting or withdrawal of solvents (especially if volatile) for chemical reactions with the development of hazardous gases or vapours, for the use of apparatus that can free fumes, gases or vapours into the environment (e.g. a rotating evaporator without any solvent recuperation system).

### **The handling of liquids**

- **Never use your mouth to suck up a liquid.** In particular, do not use pipettes by directly sucking in with your mouth, instead you should always use pipette fillers.
- **Always add the reagents very slowly and stirring continuously in order to avoid violent and uncontrollable reactions.**
- **For dilutions, gradually pour the concentrated solution into the solvent or into the more diluted solution, stirring the mixture continuously.** Never carry out this procedure by pouring the diluted solution (or the solvent) into the concentrated substance.

### **The prevention of fire risks**

- **Respect the prohibition of smoking in the premises.** Avoid smoking in areas at risk and do not use any ashtrays
- **Avoid the use of naked flames.**
- **Keep the exit routes and the safety exits free** of all obstacles.
- **Reduce the quantities of hazardous chemical substances to the minimum necessary.**
- **Avoid the accumulation of waste,** paper or other combustible material that could easily catch fire.
- **Avoid placing combustible materials** (paper, wood, inflammable liquids) and **triggering sources** (electric apparatus, heating apparatus etc. ) **close to each other.**
- Use protected electric panels and **avoid the use of adaptors and extensions.**
- **Avoid overcharging the electrical equipment.**
- **Do not obstruct the ventilation** of electrical apparatus or equipment used for heating.
- **Do not use electrical equipment of a type that is not valid according to the laws in force,** and do not keep them turned on if not in use.



# Sign system

## Safety signs

The purpose of the safety sign system is that of **attracting the attention to objects and situations that could cause determined dangers in a quick and easily understandable way** and in particular: to prohibit dangerous behaviour; warn the people exposed of a risk or danger; prescribe safe behaviour for safety purposes; supply indications relative to the safety exits and to the aid and rescue means; indicate prevention and safety elements.

### Dimensions

The **surface of the notice sign** should be opportunely **dimensioned in relation to the distance from which the notice should be recognisable**. On the basis of the laws in force, the dimensions of the notice sign should respect the following formula:

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

where  $A$  represents the area of the surface of the sign expressed in  $m^2$  and  $L$  is the distance in metres at which the sign should be recognisable.

The minimum areas admissible for some distances are reported in the following table.

Distance in metres	5	10	15	20	25	30
Area of the placards in $cm^2$	125	500	1125	2000	3125	4500

### Shape and colours

The regulations define the shape of the notice sign, the colours of the borders, of the background and of the pictograms on the basis of the type of sign:

- **prohibition signs** are round with a red border, a red transversal bar and a black pictogram on a white background. The red colour must cover at least 35% of the surface on this type of sign;
- **warning signs** are triangular with a black pictogram on a yellow background. The yellow colour must cover at least 50% of the surface of this type of sign;
- **prescription signs** are round with a white pictogram on a light blue background. The light blue colour must cover at least 50% of the surface of this type of sign;
- **aid and rescue signs** are square or rectangular in shape with a white pictogram on a green background. The green colour must cover at least 50% of the surface of this type of sign;
- **fire protection 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 light blue background.

	Prohibition		Fire protection
		Warning Hazardous	
			Rescue Aid
	Prescription		Information Instructions



## Examples of safety signs

Significance or purpose	Indications and clarifications	Examples
Prohibition signs	Hazardous behaviour	
Fire protection materials and equipment	Identification and location	
Warning signs	Precautions, safety, verification	
Prescription signs	Specific behaviour or action, obligation to wear personal safety equipment.	
Aid and rescue sign	Doors, exits, routes, materials, locations, premises	
Safety situations	Safety situations	



## Arrangement of the signs in the chemical laboratories

When arranging the notice signs with safety indications in the chemical laboratories, it is necessary to follow these indications:

- Attach a signboard **at the entrance to the laboratory** which states the main prohibitions, prescriptions and warnings (an example is given in the figure).
- Attach the necessary signboards pertaining to warnings and hazards **to each cabinet, refrigerator or any other structure containing chemical products.**
- Attach signboards pertaining to the main prohibitions, hazards, warnings etc. in the laboratory inside the premises.



List of the main safety signs

## Sign system of the pipes that contain fluids

The pipes that contain or have the purpose of transporting fluids have distinctive colours that identify the category of fluids they contain.

### Colours of the sign system of the pipes that contain fluids

Red	Fire protection
Green	Water
Grey or silver	Vapour or overheated water
Brown	Mineral oils, vegetable oils or animal oils, combustible liquids
Ochre	Gases or liquefied fluids (excluding air)
Orange	Acids
Yellow	Dangerous fluids
Light blue	Air
Black	Other liquids



# Protection of the body

## Laboratory coat

The laboratory coat should be in a suitable material to prevent accidental contact and should be of a type that can be worn for the entire working day. The normal laboratory coat in cotton or in cotton and polyester is suitable for this purpose, but it only protects one from very slight risks; therefore, if one has to carry out operations in which it is necessary to handle huge quantities of hazardous substances, it is advisable to use **laboratory coats** in special materials, defined **anti-acid**. In the case in which protection from a specific risk is requested, the laboratory coat should be composed of material resistant to that particular type of chemical agent.

When using the laboratory coats, the following rules should be followed:

- put on the laboratory coat each time you enter the laboratory or when handling dangerous liquids or which could be absorbed by the skin;
- keep the laboratory coat in the laboratory and do not wear it outside the laboratory area;
- clean the laboratory coat regularly; whenever the laboratory coat or personal clothes become contaminated to a significant extent, they should be decontaminated before using them again.

## Spectacles, goggles and visors

Eye protection should be chosen on the basis of the physical state, the operations and the level of toxicity of the product.

### Safety spectacles



**Safety spectacles with lateral screens are required for any work whatsoever in the laboratory. Safety spectacles protect the eyes from solid materials (splinters) but are less effective in protecting the eyes from splashes.**



## Goggles



**Goggles are used whenever there is the possibility of splashes or if one is obliged to wear eye spectacles.** They should have openings to prevent them from steaming up.

## Visors



**Visors, facial screens or protective masks** are requested when **corrosive materials or dangerous liquids are poured or decanted, above all when dealing with large quantities.** The shields **should not be considered as a substitute for eye protection,** both forms of protection should be used together.

Whoever wears **contact lenses should be informed about the particular risks** that their use involves (e.g. absorption of chemical agents in the air), above all if of a permeable gas type. Gases and vapours can condensate between the lens and the eye causing permanent damage to the eye. Splashes that arrive behind the lens would be difficult to remove with a simple eye wash. Furthermore, some types of solvents “melt” polymeric lenses.

**Before wearing spectacles or screens, inspect them to see if there is any damage or deterioration.**



## Gloves for chemical products

Gloves have the purpose of protecting the hands from contact with damaging substances. The most commonly used materials for these gloves are latex, nitrile, neoprene, PVC etc.; if there is no textile support inside the gloves, it is possible to wear an under-glove in fabric to avoid direct contact with the skin.

Allergic reactions can occur in the case of gloves in latex.

When using gloves, it should be recalled that:

- **All types of gloves only protect for a limited period of time;** they in fact always allow a slight permeation of most substances in proportion to their thickness.
- **Gloves should be worn each time there is a potential risk of contact with the skin.**
- **The choice of the type of glove** (material and thickness) should be made on the basis of the **material safety data sheet** and of any other information available (chemical resistance of the material, penetration and permeation indices). In the case of **unknown risks, at least nitrilic rubber gloves should be used.** Hot or abrasive materials require **special gloves that are not suitable for handling chemical products.**
- **Examine the gloves before using them each time** in order to note any damage or contamination that may have occurred (cuts, puncturing, faded points).
- The gloves **should be removed before touching any surfaces that should not be contaminated** (handles, telephone etc.).
- **The gloves should be removed while paying attention to turn them inside out** and then placing them among the **hazardous waste.**
- **Disposable gloves should never be reused.**
- **Non disposable** gloves should however be **substituted periodically** in function of their frequency of use and their resistance to the substances used. The washing and use of non polar solvents remove the plastic agents and rapidly deteriorate the gloves.
- **In the case of spillage** onto the gloves, it is necessary **to remove the gloves and wash your hands immediately.**
- **Always wash your hands** after removing the gloves.

### Characteristics and marking of the gloves

The two main characteristics that determine the behaviour of gloves, relative to their chemical protection, are their resistance to **penetration** and **permeation**.

With the term **penetration** we mean the passage of a chemical substance or of a microorganism through the porosity of the materials, the sewing, possible micro-puncturing or other imperfections of the protective glove material, while the term **permeation** refers to the passage of chemical substances through the glove by diffusion.

#### Penetration

The **resistance to penetration** is evaluated by subjecting a glove to standardised sealing tests with air and/or water. The result, which should be checked in conformity with the mean quality levels (AQL), can be quantified through performance indices at three levels:

<b>Penetration index</b>	<b>Mean quality level</b>
level 3	< 0.65
level 2	<1.5
level 1	<4.0



**Level 2 in the penetration test conducted with water** is considered sufficient to constitute **an effective barrier against microorganisms**. In this case, the following pictogram is attached.



### Permeation

The **resistance to permeation** is expressed through an index which is a function of the time necessary for a particular liquid substance to completely impregnate the thickness of a glove. Glove producers normally supply the permeation indices of their products to their clients for an elevated number of substances in order to make it easier to choose the most suitable glove.

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

The regulations in force have defined a list of twelve characteristic chemical substances that should be used to carry out permeation tests. For a glove to be considered resistant to certain chemical products, it should have a permeation time above 30 min (permeation index 2) for at least three of these standard substances. The standard substances have been codified through letters which have been reported in the following table.

Letter code	Substance	Class
A	Methanol	Primary alcohol
B	Acetone	Ketone
C	Acetonitrile	Nitrile
D	Dichlorometano	Chlorinated alkane
E	Carbon disulfide	Organic sulfide
F	Toluene	Aromatic hydrocarbon
G	Diethylamine	Amine
H	Tetrahydrofuran	Ether and heterocyclic compound
I	Ethyl acetate	Ester
J	<i>n</i> -Heptane	Alkane
K	Sodium hydroxide 40%	Inorganic base
L	Sulfuric acid 96%	Inorganic mineral acid

The pictogram referring to the “Resistance to chemical products” is followed by at least three letters which refer to the standard chemical substances that have a permeation index of at least 2, for example:



ACK



In the case in which the permeation indices are above two, their values can be reported before the sequence of letters.

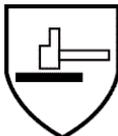


6363  
ACKL

The pictogram referring to the “Low resistance to chemical products” is applied to gloves that do not reach a permeation time of at least 30 minutes for at least three chemical substances of the twelve reference ones, but which conform to the penetration test (penetration index 2).



Chemical gloves should, however, have an adequate protection against hazards of a mechanical nature, which is represented by the “mechanical risk” pictogram followed by four letters (performance indices) each of which indicates the performance level of the glove obtained during the test for a determined risk.



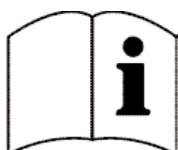
a b c d

The performance indices represented in the figure with the letters refer to the following:

- Resistance to abrasion indicated with the number of cycles required to completely scrape the test glove;
- Cut resistance test (from a blade) indicated with a factor calculated according to the number of passages, at a constant velocity, necessary to cut the test glove;
- Resistance to tearing indicates the force necessary to lacerate the test glove;
- Resistance to perforation indicates the force necessary to perforate the test glove with a point of standard dimensions.

Test	Performance index					
	0	1	2	3	4	5
a. Resistance to abrasion (cycles)	<100	100	500	2000	8000	
b. Cut resistance (factor)	<1,2	1,2	2,5	5,0	10,0	20,0
c. Resistance to tearing (newton)	<10	10	10	25	50	75
d. Resistance to perforation (newton)	<20	20	20	60	100	150

Finally, the following pictogram indicates that the gloves have been supplied with the instructions for use.





### Selection of the gloves

When choosing gloves, it is necessary to first identify the most suitable material, that is, the material which has an adequate chemical resistance to the substance/ substances from which the worker's hands must be protected. This first selection can be based on the tables supplied by the producers; a rough indication can be obtained from the following table.

Substance	Latex	Nitrile	Neoprene	PVC
Acid	x	x	x	x
Bases	x	x	x	x
Hydrocarbons		x	x	
Ketons	x		x	
Organic solvents		x	x	
Oils		x	x	x
Greases		x	x	x

Once the material has been chosen, the gloves are chosen according to their **permeation index**. The permeation value must be **sufficient to protect the worker for the entire period in which there of contact between the gloves and the chemical substance**. Normally, 30 minutes (index 2) are more than sufficient, but if it is necessary to protect the worker for an entire working day (eight hours of continuous contact with a substance), it is necessary to choose a pair of gloves which has a permeation value of 6. For the cases in which the permeation indices of the chemical substance are not available, it is convenient to use, as a reference, those of the substance with the most similar characteristics from a chemical point of view for which the indices are available.



## Footwear

Work footwear can be of the following kinds:

- safety footwear, marked with the letter “S” (safety);
- protective footwear, marked with the letter “P” (protective);
- occupational footwear, marked with the letter “O” (occupational).

## Safety footwear

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

- A safety toecap providing protection against an impact of 200 joules;
- a closed heel area ;
- the basic height sufficient for the purpose of the shoe;
- an upper (which can be open in the basic type);
- a vamp lining;
- an insole;
- a sole in any type of material (which can even be smooth).

The subsequent categories S1, S1P, S2, S3, S4 and S5 must have other requirements which are identified with the symbols A, E, WRU, P, HI, CI, HRO and ORO.

Symbol	Requirements
A	Antistatic properties
E	Energy absorption in the heel zone
WRU	Water proofing and absorption of the upper
P	Steel midsole giving protection against perforation
HI	Heat isolation
CI	Cold isolation
HRO	Contact heat resistance
ORO	Oil resistant outsole

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

(\*) non obligatory requirements which, if present, are indicated on the footwear.

Categories S4 and S5 are suitable boots for environments with an elevated presence of liquids. They have anti-static and energy absorption properties in the heel zone. S5 offers protection against perforation as an additional requirement.

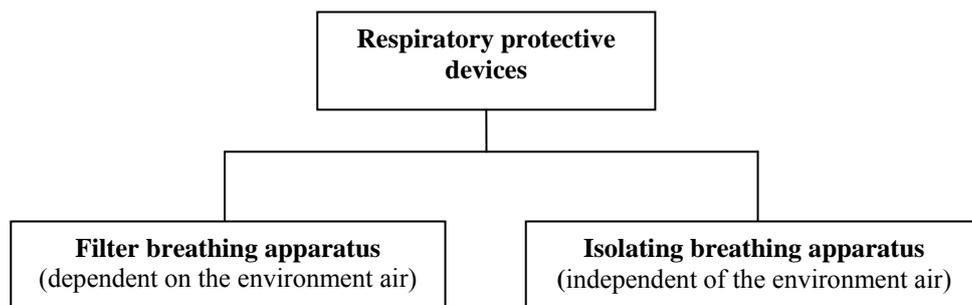
## Protective and occupational footwear

This type of footwear is similar to the safety type of footwear, the only difference being in the steel toecap. The steel toecap in protective footwear has an energy absorption of 100 J, while it is absent in occupational footwear.



## Respiratory protection

In chemical laboratories, it is possible to work with volatile, gas or particle substances that can be assimilated through inhalation and which can cause toxic effects. The use of a chemical hood with adequate ventilation is not sufficient to guarantee the safety of the workers. It is therefore necessary to protect the respiratory pathways with Individual Protection Devices called breathing apparatus. These devices can be divided into two categories: **filter breathing apparatus** which works by removing the polluting substances from the environment air before this is inhaled by the worker and **isolating breathing apparatus** which is equipped with self-contained breathing apparatus.



Filter breathing apparatus is the type that is used most frequently; however, there are situations in which it is not possible to use this type of apparatus. For example, this type is not able to replace the possible lack of oxygen necessary for breathing (a fact that can occur during a fire in a poorly ventilated environment), or when the pollutant concentration is elevated or unknown.

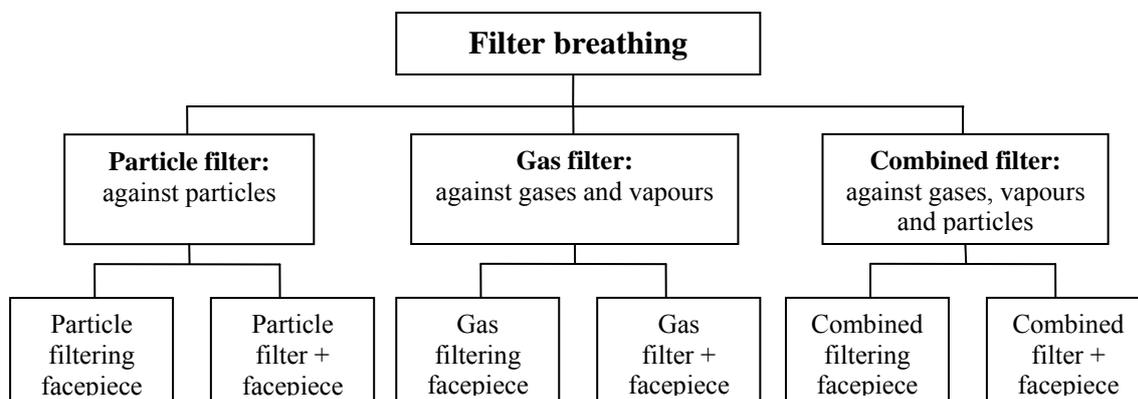
## Filter breathing apparatus

**Filter breathing apparatus** can be divided into the following three categories on the basis of the hazardous substances that have to be removed:

- **Particle filters** for particles, fibres, fumes (particles below 4 micron) and mist (liquid drops on a water or organic base).
- **Gas filters** for gases and vapours (**gaseous form of liquid substances at environmental temperature**).
- **Combined filters** against particles, gases and vapours.

As filters have a limited functioning time, breathing apparatus is usually made up of two separable elements: **a facepiece** and **a substitutable filter**. Disposable breathing apparatus, known as **filtering facepieces**, where the facepiece and the filter constitute a single element, also exist.

The following scheme represents the possible facepiece/filter combinations for the three categories of breathing apparatus.





In the case of particles, the resistance to the flow of air caused by the filter can make breathing so difficult that it is necessary to use **power assisted breathing apparatus** in which the ventilation is assisted by a power assisted blower and is filtered and conveyed to the facepiece (full face mask, half mask, hood or complete helmet) while a certain overpressure is maintained to prevent the entrance of polluted air.

Three types of breathing apparatus can be identified on the basis of the ventilation:

- **Unassisted breathing apparatus**, where the ventilation is only due to the worker's breathing action.
- **Assisted breathing apparatus** which is designed to guarantee a certain protection, even in the case where the power assisted blower is blocked.
- **Forced breathing apparatus** which does not offer any protection without the contribution of the power assisted blower.

## Filter breathing apparatus facepieces

### Filtering facepieces

Filtering facepieces consist of a mask that covers the nose and the mouth which is completely or prevalently made up of filtering material through which the inhaled air passes. The exhaled air can be discharged through the filtering material or through a specific exhalation valve. Most filtering facepieces make use of a mouldable adaptor around the nose (nosepiece). They are prevalently used to retain corpuscles, however, some types of filtering facepieces also retain vapours (organic or acidic). These are disposable types of breathing apparatus that can only be used for one work shift (eight hours).

Filtering facepiece without an exhalation valve



Details of the inside of the mask

Filtering facepiece with an exhalation valve



Details of the inside of the mask

### Masks or half masks

Filtering masks consist of a complete facial element (full mask, full face mask) which also protects the eyes, or of a half mask which only covers the nose and mouth, coupled with one or more filtering elements. Each mask is equipped with both an inhalation valve and an exhalation valve.

Full face masks have a better sealing capacity than half masks.

Half mask with double filtering element





Full face mask with a single filtering element and with a double filtering element



### Unassisted particle filter breathing apparatus

Unassisted particle breathing apparatus filters the inhaled air through a mechanical action which is usually combined with an electrostatic action. These kinds of apparatus are usually in a **white colour** and are made up of either **filtering facepieces** or of **half masks with filters**.

European standards define **3 protection classes** with increasing degrees of total filtering efficiency. Filtering facepieces are indicated with the initials FFP followed by the number of the protection class, while the initial P followed by the number of class indicates a particle filter that should be used together with a half mask. It can be observed that, for the same particle class, **a filtering facepiece and a half mask with a filter offer the same level of protection**.

Protection class	Minimum total filtering efficiency
FFP1/P1	78%
FFP2/P2	92%
FFP3/P3	98%

Another subdivision exists that is based on the type of pollutant. The following two classes in fact exist:

- **S** for solids and a water base mist
- **SL** for mist of an organic base (class not foreseen for FFP1)

In this context, it is important to observe that **particle filters P2 and P3, without indications on the type of pollutant, should be considered as belonging to class SL**.

### Particle filter power assisted breathing apparatus

These types of power blower breathing apparatus are equipped with particle filters. Compared to unassisted filter breathing apparatus, this kind of breathing apparatus offers a greater comfort in that the lower breathing capacity allows them to be used for longer periods. These systems can be equipped with alarms to signal a possible anomaly, an insufficient battery charge or the exhaustion of the filter. If they have to be used in explosive or flammable atmospheres, it is necessary to use intrinsic safety systems to avoid the triggering of sparks by the electric parts.

The degree of protection offered by the breathing apparatus changes according to whether the power assisted breathing apparatus is equipped with a mask (full face mask or half mask) or with a hood/helmet (full helmet).



### Particle filter power assisted breathing apparatus with mask

This is **power assisted ventilation breathing apparatus** which therefore guarantees a certain degree of protection even with the power assisted ventilator turned off, even though this kind of situation should be considered an anomaly (breakdown of the power assisted blower). The protection classes have been defined considering both functioning conditions (power assisted blower on or off): there are therefore two efficiency values for each class. The protection class of the apparatus coincides with the marking on the filter. This type of breathing apparatus is identified with the initials TM (Turbo Mask) followed by P (anti-Particle) and the protection class.

Protection class and marking	Minimum total filtering efficiency Power assisted blower	
	On	Off
TMP1	95%	90%
TMP2	99%	90%
TMP3	99.95%	90%

### Particle filter power assisted breathing apparatus with hood/helmet

This is a kind of **forced blower breathing apparatus**, that is, which does not guarantee any protection should the power assisted blower break down. They are identified with the initials TH (Turbo Hood/Helmet) followed by P (anti-Particle) and by the class of protection. Again in this case, the classification of the apparatus coincides with the marking on the filter.

Protection class and marking	Minimum total filtering efficiency
THP1	90%
THP2	95%
THP3	99.8%

### **Selection criteria of the particle filter breathing apparatus**

The choice of the breathing apparatus depends on the concentration of the hazardous substance present in the work environment air ( $C_{est}$ ) and on the maximum pollutant concentration the air can have to be considered breathable without being hazardous for the worker ( $C_{int}$ ). The ratio between these two concentrations, measured in a laboratory in opportune conditions and fixed by the regulations in force, is called the Nominal Protection Factor (NPF). Since the working conditions are the same as those utilised to determine the total filtering efficiency, the two magnitudes are connected to the following relation:

$$NPF = \frac{C_{est}}{C_{int}} = \frac{100}{100 - \text{filtering efficiency}\%}$$

The Nominal Protection Factor calculated with this equation is cautiously rounded off by defect.

If it is assumed that the working conditions are similar to standard laboratory conditions, and the maximum concentration of the hazardous substance breathable by the worker is known (e.g. making the TLV equal to the pollutant), it is possible to evaluate the maximum external concentration for which the breathing apparatus is utilisable. This method offers the inconvenience that the real working conditions can differ significantly from those of the laboratory in which the NPF has been



measured, above all in the case of high filtering working conditions. The calculation has therefore been made more realistic by introducing a new and more conservative magnitude, called Working Protection Factor (WPF), to use in substitution of the Nominal Protection Factor.

The values of the Working Protection Factor corresponding to the different types of unassisted particle filter breathing apparatus are given in the following table.

Working Protection Factors defined according to the UNI 10720 standard

Particle filter breathing apparatus	WPF	max $C_{est}$
Unassisted breathing apparatus		
FFP1/half-face mask + P1	4	4×TLV
FFP2/half-face mask + P2	10	10×TLV
FFP3/half-face mask + P3	30	30×TLV
Full face mask + P1	4	4×TLV
Full face mask + P2	15	15×TLV
Full face mask + P3	400	400×TLV
Power assisted breathing apparatus with full face masks (assisted ventilation)		
TMP1	10	10×TLV
TMP2	100	100×TLV
TMP3	400	400×TLV
Power assisted breathing apparatus with hood/helmet (forced ventilation)		
THP1	5	5×TLV
THP2	20	20×TLV
THP3	100	100×TLV

If we compare the thus calculated maximum external pollution concentration (WPF x TLV) with the one actually present, it is possible to choose the breathing apparatus that is most suitable for the work environment. This procedure makes it necessary to measure the concentration of pollutant present in the work environment.

In the exceptional and temporary case in which the pollutant concentration is not known, it is possible to estimate the minimum level of protection on the basis of the toxicity of the substance (TLV) alone, using the values reported in the following table as reference values:

Toxicity of the substance	Minimum level of protection
TLV $\approx 10 \text{ mg/m}^3$	FFP1/P1
$10 \text{ mg/m}^3 > \text{TLV} > 0,1 \text{ mg/m}^3$	FFP2/P2
TLV $< 0,1 \text{ mg/m}^3$	FFP3/P3

### Duration of the particle filters

Particle filters should be substituted whenever **a remarkable increase in the breathing resistance** is noted.

Particle filter facepieces are only usable for a limited number of hours (technical regulations foresee the substitution of a facepiece after each work shift) as there is a loss of sealing capacity in time. In the case where they have a sealing border, they can be used for the equivalent of three work shifts.

### Gas filter and combined filter breathing apparatus

Gas filter breathing apparatus protects the breathing tubes by depurating the inhaled air of any hazardous gases and vapours; as the resistance to breathing due to the filtering element is not elevated, this kind of breathing apparatus is not assisted; this kind of breathing apparatus is usually



made up of a mask and a filter, however, some filtering facepieces also exist that retain gases and vapours.

The filtering material can absorb the pollutant, can react chemically with it or exert a catalytic action. The most commonly used absorption material is active carbon. If the action of the active carbon is insufficient, solid reagents are used in granular form (alkali, metallic oxides etc.) or chemical compound form, supported by various materials (active carbon, pumice and silica gel or impregnated active carbon). The reaction can involve a neutralisation which blocks the acidic or basic pollutant in the filter or, if the component is neutral, a conversion into non toxic gaseous products or at least of a type that can be tolerated by the human body. Catalytic filters are available for the removal of carbon monoxide: they catalyse its oxidation to dioxide.

Filters can be constituted by several filtering materials in order to offer protection from different types of substances. Gas filters can therefore be **univalent** (when they protect from only one hazardous gas/vapour) or **polyvalent** (when they protect from several hazardous gasses/vapours). When there is also an aerosol protection (anti-particle) available, these filters are known as **combined filters**.

#### Filters A, B, E and K

European regulations have defined a series of filter typologies that have been identified with the letters A, B, E and K and with a colour (A-brown, B-grey, E-yellow and K-green) which are reported on the filter container or on the filtering facepiece. Each type of filter can be divided into three classes which are characterised by a different removal capacity (quantity of pollutant that the filter is able to eliminate) and therefore a different filtration duration. In spite of the fact that all the filters have the same filtering efficiency (unitary efficiency), threshold use concentrations exist for each class.

The A, B, E and K type filter classes and the corresponding maximum concentrations are indicated in the following table.

Class	Capacity	Maximum use concentrations ( $C_{maxF}$ )
1	low	0,1% in volume- 1000 ml/m <sup>3</sup>
2	medium	0,5% in volume - 5000 ml/m <sup>3</sup>
3	high	1% in volume - 10000 ml/m <sup>3</sup>

#### AX filters

Filters for vapours with a boiling temperature of below 56°C, unlike those for organic vapours removed by Type A filters, cannot be characterised according to the previous classes. The regulations foresee the same colouring as the A filters, but also thresholds concerning the pollutant concentrations and time of use which depend on the capacity of the filter (1 or 2 g of substance removed).

#### SX filters

The regulations foresee the use of the initials SX (violet colour) to refer to a filter that is used for a particular compound which the supplier must specify (e.g. dichloridemethane).

#### Special filters

**Nitrogenated fumes or mercury vapours are always coupled with an aerosol** which requires a particle filter of protection class 3. The particle filter symbol P3 and a white colouring are reported on the marking of these filters in order to signal the presence of the particle filter. Nitrogen fumes are therefore identified by the initials NO-P3 and by the colours blue and white, while filters for mercury vapours have the symbol Hg-P3 and the colours red and white.

**Main types of filters defined according to European regulations**

Colour	Type	Protection	Class	Use thresholds	Standard
	A	Organic gases and vapours with a boiling point above 65°C, as specified by the producer.	1 2 3	1000 ml/m <sup>3</sup> 5000 ml/m <sup>3</sup> 10000 ml/m <sup>3</sup>	EN141
	B	Inorganic gases and vapours (except CO), as specified by the producer.	1 2 3	1000 ml/m <sup>3</sup> 5000 ml/m <sup>3</sup> 10000 ml/m <sup>3</sup>	EN141
	E	Sulphur dioxide, acid gases and vapours, as specified by the producer.	1 2 3	1000 ml/m <sup>3</sup> 5000 ml/m <sup>3</sup> 10000 ml/m <sup>3</sup>	EN141
	K	Ammonia and its derivatives, as specified by the producer.	1 2 3	1000 ml/m <sup>3</sup> 5000 ml/m <sup>3</sup> 10000 ml/m <sup>3</sup>	EN141
	AX	Organic gases and vapours with a boiling point below 65°C, as specified by the producer.	-	1 g 100 ml/m <sup>3</sup> max 40min 1 g 500 ml/m <sup>3</sup> max 20min 2 g 1000 ml/m <sup>3</sup> max60min 2 g 5000 ml/m <sup>3</sup> max20min	EN371
	SX	Specific compounds	-	Must be specified.	EN372

**Special filters defined according to European regulations**

Colour	Type	Protection	Class	Use thresholds	Standard
	NO-P3	Nitrogenated smokes (NO, NO <sub>2</sub> , NO <sub>x</sub> and aerosol )	-	Max 20 min	EN141
	Hg-P3	Mercury vapours and aerosol	-	Max 50 hours	EN141

Other special filters

European regulations **recommend the use of isolating breathing apparatus** in the case of particularly hazardous gases such as **carbon oxide and radioactive gases**. Commercial filters exist for these and other dangerous gases which refer, for example, to the German regulations (DIN 3181).

Colour	Type	Protection	Note	Standard
	CO	Carbon oxide	Single-use filter	DIN 3181
	Reaktor-P3	Radioactive iodine and particles	Single-use filter	DIN 3181



### Marking of the filters

The initials of a univalent filter is constituted by the letter symbol of the type of filter followed by its class, if it exists.

For example

E2  




indicates a class 2 filter for sulphur dioxide.

In the case of filtrating facepieces, the symbol is preceded by FF, and it therefore becomes FFE2.

Filtrating material to remove aerosols are also present in combined filters. In this case, not only is the colour which indicates the type of gas/vapour that is removed reported, but also the colour white (removal of aerosols, mists etc.) and the initials of the particle filter is added to the initials of the gas filter.

For example

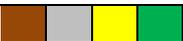
K2-P3  




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

In the case of polyvalent filters, which offer protection for more than one type of substance, the colours of each type of filter are reported on the container. In a similar manner, the initials reported on the label are obtained by indicating the symbol and class (if it exists) of each type of filter in sequence.

For example

A2B2E2K1  


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

A2B2E2K1-P3  




**Selection criteria of the particle filter breathing apparatus**

In order to choose the filter, it is important to have the producer's indications concerning the suitability of the filter for the hazardous substances for which it is intended to be used. Should substances of various types be present, it is necessary to use combined filters already prepared by the producer.

The knowledge of the concentration of the hazardous substance present in the environment in which one should work ( $C_{est}$ ) is fundamental for the choice of the best type of breathing apparatus. First, it is necessary to verify that the concentration is sufficiently low to be able to work with filter breathing apparatus. Should the response be positive, it is necessary to choose such a filter capacity class that the concentration of the hazardous substance is less than or equal to the maximum admissible concentration of the class ( $C_{maxF}$ ):

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

Then, the type of mask is chosen on the basis of the working protection factor necessary to satisfy the following disparity:

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

In this case, the level of protection of the breathing apparatus, expressed by the working protection factor, does not depend on the efficiency of the filter, which is still unitary, but on the sealing capacity of the mask: a full face mask has a better capacity than a half mask.

**Working protection factors (UNI 10720)**

Gas breathing apparatus	WPF	Use thresholds
Half mask + class 1 gas filters Class 1 gas filtering facepiece	30	1000 ml/m <sup>3</sup>
Half mask + class 2 gas filters Class 2 gas filtering facepiece	30	5000 ml/m <sup>3</sup>
Half mask + class 3 gas filters Class 3 gas filtering facepiece	30	10000 ml/m <sup>3</sup>
Full facepiece + class 1 gas filters	400	1000 ml/m <sup>3</sup>
Full facepiece + class 2 gas filters	400	5000 ml/m <sup>3</sup>
Full facepiece + class 3 gas filters	400	10000 ml/m <sup>3</sup>

In conclusion, having chosen a capacity class for which:

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

utilising the protection factors reported in the previous table, we obtain that:

if  $C_{est} \leq 30 \times TLV$  it is possible to work with a half mask or a filtering facepiece

while if  $400 \times TLV \geq C_{est} \geq 30 \times TLV$  it is necessary to work with a full face mask.

In the case of **combined filters**, it is necessary to separately apply the selection criteria for the **particle filters** and those for the **gas filters**.



### **Duration of the gas filters**

The duration of a filter depends on the nature and concentration of the pollutant, on the dampness, temperature, breathing pace and lung capacity. It is therefore not possible to establish the duration of filters *a priori*. The filters should be substituted when the smell or taste of the substance can be noted. This means that the filter is saturated and no longer able to absorb. Some filters have an olfactory warning device which produces a characteristic smell a little before the filter stops functioning.

### **Conservation of the filters**

The filters should be stored in a cool dry place and enclosed in their containers as they arrive from the supplier. In this way, their good working order characteristics do not change over the period of time indicated by the producer. They can undergo a remarkable or total diminishing of their good working order if they have been used even once or if they have been unsealed and opened.

### **Modality of use of the gas masks**

A mask should be put on before the filter has been attached to the facepiece in order to facilitate the operation.

In order to put on a mask and verify its sealing capacity, it is necessary to proceed as follows:

- rest the chin rest on the chin;
- put on the facepiece in such a way that it fits perfectly to the face;
- stretch the upper straps to allow them to pass over the head and arrange them on the nape of the neck;
- tighten all the straps immediately;
- hermetically close the filter connector with the palm of the hand;
- breathe deeply: no air infiltration should be felt.

Once the filter has been removed from the container, check that the rubber plug at the bottom and the metallic cover at the mouthpiece are in position.

Remove the plugs and attach the filter to the connector, screwing it tightly. After this operation, the mask is ready for use.

### **Isolating breathing apparatus**

An isolating breathing apparatus has an independent air source from the environment air and therefore guarantees an elevated degree of protection. These types are often used in emergency situations where the conditions in which one is working are unknown.

The following conditions **require the use of isolating breathing apparatus**:

- a percentage of oxygen below 17%;
- pollutant concentrations above the use thresholds of filter breathing apparatus;
- the presence of odourless gases/vapours or with an olfactory threshold above the limits to work in safe conditions (e.g. TLV/TWA);
- unknown nature and/or concentrations of the pollutants.

In all the other cases, it is possible to use unassisted filter breathing apparatus.

Isolating breathing apparatus can be divided into:

- self-contained open- or closed-circuit breathing apparatus;
- compressed air breathing apparatus with half masks/full masks.

In **self-contained open-circuit breathing apparatus**, the air coming from the compressed air cylinder is exhaled, after breathing, from the mask. These types of apparatus are made up of compressed air cylinders, usually 200 bar, a pressure reduction system, a demand valve, a mask, a support rucksack, supply devices (control pressure gauge and a charged sound alarm).

This kind of breathing apparatus can be divided into:



- negative pressure types where a negative pressure which draws air from the cylinder is created in the mask during inhalation;
- positive pressure types (overpressure) where a positive pressure is maintained inside the mask which completely prevents the passage of pollutants and usually offers a lower resistance to breathing.

**Closed-circuit breathing apparatus** is equipment in which the air is not sent out after breathing but is made to recycle after it is purified with carbon dioxide and enriched with oxygen. These are complex self-contained types of breathing apparatus, with extensive autonomy, but also high costs and remarkable difficulties in their use and maintenance.

**Fresh air breathing apparatus with a mask** is equipment composed of a mask and an external air drawing system, either assisted or unassisted, with hand operated or powered blower systems.

**Breathing apparatus connected to a compressed air network** is a type of protection system that takes advantage of a compressed air network to supply a mask, helmet or hood. It is important that the used air is completely without CO, particles, organic vapours and humidity. Compressed air filters are composed of several levels that eliminate the pollutants, but not carbon monoxide.

There are some types of devices that have alarm signals that show the presence of carbon monoxide.

#### Working protection factors (WPF)

<b>Isolating breathing apparatus</b>	<b>WPF</b>
Self-contained open-circuit breathing apparatus with negative pressure compressed air.	400
Self-contained open-circuit breathing apparatus with positive pressure compressed air.	1000
Self-contained closed-circuit breathing apparatus with enriched compressed air.	400
Breathing apparatus with half mask/full mask with continuous flow compressed air.	30/400
Breathing apparatus with half mask/full mask with compressed air and a demand valve.	30/400
Breathing apparatus with half mask/full mask with positive pressure (overpressure) compressed air and a demand valve.	1000



# Fume cupboard

## Use of a fume cupboard

Chemical fume cupboards are potentially dangerous zones as atmospheres, sometimes extremely inflammable, explosive or toxic, can develop inside them. For this reason, a chemical fume hood must be used correctly and always kept in **perfect working condition** and the operator should know the **emergency procedures** that must be undertaken in the case of an explosion or fire inside the fume cupboard.

When using a chemical fume cupboard, it is necessary to carry out the following procedures:

- before starting the activity, verify the **sash window** (mobile frontal part) **slides without any particular resistance**, that any electrical equipment that is going to be used has a **safety electrical system** and finally that the fume cupboard sucks in correctly. This can be done using specific equipment (if available) or with other less accurate methods (for example, with a sheet of paper placed on the work table of the fume cupboard). If there are any doubts about its functioning or on the carrying out of the verifications, the person in charge of the laboratory should be contacted.
- Avoid creating **draughts close to a working fume cupboard** (by opening doors or windows, the frequent passing of people).
- The **working zone and all the material** should be kept as much as possible towards **the back of the fume cupboard**, without having to lift the sash window.
- Lower the sash window while maintaining a maximum opening of 40 cm during work (the more the sash is lowered, the less the inside of the fume cupboard suffers from spurious currents in the room); do not put parts of the body in the fume cupboard (e.g. ones head) for any reason whatsoever.
- Keep only the material strictly necessary for the activity under the fume cupboard (do not use the fume cupboard for storage purposes). Do not obstruct the air passage along the work surface of the fume cupboard and, whenever it is necessary to use equipment that clutters up the work surface, lift it up by at least 5 cm from the work surface with opportune shims and keep it away from the walls. The **suction slots of the hood should never be obstructed**.
- Do not use the hood as a way of disposing of reagents through forced evaporation.
- Keep the work surface clean and tidy after each activity.
- When the fume cupboard is not in use, turn off the ventilation and close the sash window.

## Periodic verifications of fume cupboards

All the data relative to the maintenance and verifications of the perfect working conditions should be recorded in a **specific register** together with the signature of the person who has carried out the work.

### Suction working conditions

A fume cupboard used for the treatment of **hazardous substances** (labelled with a Saint Andrew's cross and/or a skull) can be considered to have good suction working conditions when it guarantees a frontal velocity of sucked air **above 0.5 m/s**. Such a value refers to a **40 cm opening of the sash window** and should be checked on an at least yearly basis. A fume cupboard can be used for **non volatile hazardous substances** with a frontal air velocity of between **0.4 and 0.5 m/s**. The use of **carcinogenic and/or mutagenic substances requires a frontal velocity of at least 0.7 m/s**.



### Fume cupboard classification

Face velocity ( $v$ )	Indicating colour of the fume cupboard	Class	Use
$v < 0,4 \text{ m/s}$	yellow	Unclassifiable	unusable
$0,4 \text{ m/s} \leq v < 0,5 \text{ m/s}$	green	1	Low toxicity substance
$0,5 \text{ m/s} \leq v < 0,7 \text{ m/s}$	orange	2	Medium toxicity substance
$0,7 \text{ m/s} \leq v < 0,85 \text{ m/s}$	red	3	High toxicity substance

### Sliding of the sash

The latch screen should be kept in good working order: the **sliding system should be checked** on a yearly basis. This check should be recorded in the specific register. A bad functioning of the sash can lead to serious accidents (for example, damage due to shattering of the glass) or to a poor working order of the hood itself (for example, the frontal part blocked at the maximum opening).

### Filters

Pollutant abatement systems are advisable, above all for cases of elevated concentrations of toxic and hazardous substances. The frequency of the substitution of the filters depends on many factors (capacity of the powered blower, type of pollutant, etc.); however, in the absence of specific indications, filters should be **substituted at least every 9-12 months**, regardless of the use of the fume cupboard.



# Hazardous chemical products

Substances and preparations (mixtures or solutions made up of two or more substances) can be divided into four hazard groups.

**Non hazardous** (e.g. drinkable water and atmospheric air in normal conditions). In this case, it is not necessary to undertake any particular precautions.

**Non hazardous, but used in conditions that could cause a hazard** (e.g. water at a high temperature, compressed air...). The risk in this case is not of a chemical type, but could arise above all from the alterations of the physical variables, such as temperature, pressure, concentration, or from particular conditions of use.

**Hazardous, but not classified by the classification standards, labelling or packaging of the hazardous chemical products** (e.g. foul-smelling or infected deteriorated organic material, drainage water with biological risks or material and products excluded from the standards such as medicine, waste, etc.). Not all hazardous products are regulated by the same standards foreseen for the use of “traditional” chemical products.

**Hazardous as indicated by the classification standard, labelling and packaging of the hazardous chemical products** (most substances and chemical preparations normally found in work places belong to this group).

**The degree of danger** can be evaluated on the basis of the **chemical-physical properties** of the substances, the chemical products that are utilised, their **toxicological characteristics** or even on other **specific effects on health** (carcinogenic degree, induction to genetic mutations, toxicity for the reproductive cycle) and on **eco-toxicological properties** (risks for the environment).

The dangers due to the chemical-physical properties puts the immediate safety of an individual at risk (fires, explosions) while, in the other cases, the individual's health or the environment are at risk.

European regulations, utilising the previous classification criteria, have defined the following categories for substances and preparations.



## **Classification on the basis of the physicochemical properties**

### Explosives

Solid, liquid, pasty or gelatinous substances and preparations which may also react exothermically without atmospheric oxygen thereby quickly evolving gases, and which, under defined test conditions, detonate, quickly deflagrate or upon heating explode when partially confined.

### Oxidizing agents

Substances and preparations which give rise to a highly exothermic reaction when in contact with other substances, particularly flammable substances.

### Extremely flammable substances and preparations

Liquid substances and preparations with an extremely low flash-point and a low boiling-point and gaseous substances and preparations which are flammable in contact with air at ambient temperature and pressure.

### Highly flammable substances and preparations

The following substances and preparations are highly flammable:

- a) substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or
- b) solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or
- c) liquid substances and preparations with a very low flash-point, or
- d) substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.

### Flammable substances and preparations

Liquid substances and preparations with a low flash-point.

## **Classification on the basis of the toxicological properties**

### Very toxic substances and preparations

Substances and preparations which in very low quantities cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.

### Toxic substances and preparations

Substances and preparations which in low quantities cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.

### Harmful substances and preparations

Substances and preparations which may cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.

### Corrosives

Substances and preparations which may, on contact with living tissues, destroy them.



### Irritants

Non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, may cause inflammation.

### Sensitizers

Substances and preparations which, if they are inhaled or if they penetrate the skin, are capable of eliciting a reaction of hypersensitisation so that on further exposure to the substance of preparation, characteristic adverse effects are produced;

## **Classification on the basis of specific effects on the health**

### Carcinogens

Substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.

### Mutagens

Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce heritable genetic defects or increase their incidence.

### Toxic for the reproductive cycle

Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may produce, or increase the incidence of, non-heritable adverse effects in the progeny and/or an impairment of male or female reproductive functions or capacity.

These risks are difficult to assess therefore these substances have been further subdivided into three categories (certain, probable or possible damage to the health) which are defined hereafter.

## **Classification on the basis of the effects on the environment**

### Dangerous for the environment

Substances and preparations which, were they to enter the environment, would or could present an immediate or delayed danger for one or more components of the environment.

All of the substances belonging to the previously mentioned hazard categories should be labelled and a sign and symbol of the chemical risks should be added to the hazard indicator, as reported in the following table.



	<b>Hazard category</b>	<b>Hazard indicator</b>	<b>Pictogram</b>	<b>Symbol</b>
Physicochemical	Explosive	Explosive		E
	Oxidant	Oxidant		O
	Extremely flammable	Extremely flammable		F+
	Highly flammable	Highly flammable		F
	Flammable	Flammable		-
Health	Very toxic	Very toxic		T+
	Toxic	Toxic		T
	Harmful	Harmful		Xn
	Corrosive	Corrosive		C
	Irritant	Irritant		Xi
	Sensitizer	Harmful		Xn
		Irritant		Xi
	Carcinogenic Categories 1 and 2	Toxic		T o T+
		Category 3	Harmful	
	Mutagenic Categories 1 e 2	Toxic		T o T+
		Category 3	Harmful	
	Toxic for the reproduction Categories 1 and 2	Toxic		T
		Category 3	Harmful	
	Environment	Dangerous for the environment	Dangerous for the environment	



### Assessment of toxicity

The toxicity hazard indicators include the lethal dose 50 ( $LD_{50}$ ), the lethal concentration 50 ( $LC_{50}$ ) and a wide range of in vitro and in vivo techniques to evaluate irritation of the eyes and skin, sensitizing effects on the skin, toxicity through inhalation, acute and chronic toxicity on the skin, damage to the reproduction system, mutagenic and carcinogenic effects, etc.

$LD_{50}$  is statistically derived single dosage of a substance that can be expectedly cause death in 50% of the sample population. It is an **indicator of acute toxicity** whose value depends on the way the substance is administered and on the guinea-pig that is used.  $LD_{50}$  is usually determined for swallowing using rats or mice; in the case of rabbits, the substance is usually administered through skin contact.

$LC_{50}$  is the lethal concentration of a substance (in the air or in water) that statistically causes the death of 50% of the sample population. This magnitude is a more suitable indicator of acute toxicity than the substance in breathed air (in the water in the case of aquatic organisms).

Acute toxicity data have been considered as hazard classification criteria by the European Union and by IRAC (International Agency for the Research of Cancer). The substances are classified as highly toxic, toxic or harmful according to the  $LD_{50}$  and  $LC_{50}$  values.

### Classification of the toxic substances and labelling

Category	Pictogram	Symbol	$LD_{50}$ oral on rats mg/kg	$LD_{50}$ - skin on rats and rabbits mg/kg	$LC_{50}$ inhalation on rats mg/kg
Very toxic		T+	$\leq 25$	$\leq 50$	$\leq 0,5$
Toxic		T	25-200	50-400	0,5-2
Harmful		Xn	200-2000	400-2000	2-20

This classification is only valid if no other data are introduced which demonstrate toxic effects that are different from acute toxic effects, for example, carcinogenic, mutagenic, sensitizer etc.; in these cases, different classification criteria should be adopted.

### Hygiene standards (exposure thresholds)

Exposure represents the amount of a toxic agent that reaches a determined subject; it is often expressed in terms of concentration, duration, frequency or intensity. Excessive exposure always causes damage to the health, even though various members within a population can often suffer effects to different degrees for the same exposure.

In order to protect health and the environment, numerous national and international scientific organisations have fixed concentration thresholds in direct relation to the potential toxicity of the air dispersed substances. These thresholds are established on the basis of the most modern scientific knowledge and they are often directly adopted from national regulations in order to make the respect of these thresholds obligatory.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes exposure thresholds each year which are known as TLVs (Threshold Limit Values) all of which are expressed in ppm or  $mg/m^3$ . The TLVs, that is, Threshold Limit Values, are concentrations below which it is believed that most workers can remain exposed repeatedly, day after day, without any negative effect on their health. These threshold values do not constitute a clear demarcation line between



non hazardous and hazardous concentrations, nor a relative index of toxicity; furthermore, they are almost always much higher than those indicated for the protection of the population as a whole.

TLVs are divided into TLV-TWA (Threshold Limit Value – Time Weighted Average), TLV-STEL (Threshold Limit Value – Short-Term Exposure Limit) and TLV-C (Threshold Limit Value-Ceiling).

The **TLV-TWA**, that is, the **Threshold Limit Value with Time Weighted Average**, is the time-weighted average concentration to which, it is believed, that nearly all the workers can be repeatedly exposed during a normal working week (day shift of 8 hours, 40 hours per week). The TLV-TWA value can be exceeded if it is compensated, during the working day, by a period below the threshold value.

The **TLV-STEL**, that is, the **Threshold Limit Value with short-term exposure limit**, is the concentration to which, it is believed, the workers can be exposed continuously for a short period of time (15 minutes) without suffering irritation, chronic or reversible alterations of the tissues, or narcosis of sufficient intensity to increase the probability of accidents, or limit the possibility of saving oneself in the case of an accident or reduced working efficiency, on condition that the mean daily threshold imposed by the TWA is satisfied. A STEL is a TWA of 15 minutes of exposition which should never be exceeded during work, even if the TWA is satisfied. The TWA should not be exceeded more than four times a day and at least one hour should pass between one exposition and another.

**TLV-C**, that is, **Threshold Limit Value – Ceiling**, is the concentration that should never be exceeded during any instant of the working day. If instantaneous monitoring is not possible for the whole exposition period, the TLV ( C ) can be evaluated over a 15 minute sampling period, but not for substances that may cause an immediate irritation even for brief expositions.

In order to protect health in work places, biological monitoring is also often activated. This consists of the measuring of a chemical indicator in a biological medium of the exposed people (blood, urine, etc). In order to assess the results of the monitoring, resort is made to the **IBE**, that is, **Biological Index of Exposition**, of the concentration values below which, it is believed, that most exposed workers do not suffer from negative health effects.



## Storage of chemical products

Chemical substances should be kept in safety **cabinets with shelves** (aspirated/fire protected cabinets) for particular categories of products (acids, bases, inflammable and/or toxic substances), equipped with doors that allow them to be closed. Cabinets containing chemical products should have the following characteristics:

- have **shelves with raised edges** to prevent the containers from slipping and to contain any losses or spillages;
- have a **collection basin**, at least at the bottom of the pile of shelves;
- show the **danger and warning signs** of the chemical products it contains **on the outside**.

When choosing the structures to contain hazardous substances, the following indications should be followed:

- **flammable liquids** should be kept in specific **fire safety cabinets** that can be found on the market with guarantees of their suitability;
- **flammable substances that must be kept at a low temperature should be placed in laboratory refrigerators** that are anti-deflagration both inside and outside, even better if supplied with energy from a separate preferential switch. Flammable substances should not be kept in environments in which possible priming sources are present, such as domestic type refrigerators. A sign should be attached to any unsuitable refrigerators with the words: “Do not introduce any flammable substances”;
- **the refrigerators, just like the cabinets, should be marked on the outside with the hazard and warning signs of the products that they contain;**
- periodically check the **state of the refrigerator seals** and change them if necessary;
- **category 1 and 2 carcinogenic and/or mutagenic substances** should be kept separate from other substances and kept in **locked cabinets**.



## Regulations concerning the storage of chemical products

- **Keep the list of all the chemical substances in the laboratory updated** and attach a **sheet of paper outside each cabinet with the list of chemical products it contains**, the date the list was updated and the references on where to find the relative material safety data sheets.
- **Carry out periodic checks** (at least once a year) of the stored chemical products: the ones that cannot be identified, have deteriorated or are very old should be eliminated.
- **Reduce the quantities of hazardous products to a minimum and, when possible, substitute hazardous products with other non hazardous or less hazardous products.**
- Keep each material safety data sheet of each chemical substance in the laboratory updated and **respect any particular indications reported in the sheet** (entries pertaining to Handling and Storage).
- **Keep the material necessary for the absorption and neutralisation of possible spills** close to the cabinets that contain chemical products, according to what is indicated in the material safety data sheet.
- **All the chemical substance containers should be labelled** in order to be able to recognise the contents at any moment.
- **Keep chemically incompatible products well separated.**
- **Keep solids well separated from liquids.**
- For those **substances that are particularly reactive** or subject to a diminishing of their chemical stability in time or on contact with the air (e.g. perchloric acid and peroxides in general), indicate the **date of purchase** of the product and the **date the container was opened** on the label.
- **Corrosive, caustic or irritating substances** should be stored at a **height below eye level.**
- **The largest containers and those containing the most dangerous substances** should be placed on the **lower shelves.**
- **Avoid piling containers** one above the other.
- **Avoid an excessive weight** on the shelves
- Ensure that the substances are not close to **sources of heat or direct sunlight.**



## Labels and material safety data sheets

The **label** on a container of a chemical product allows one to quickly acquire basic information on it in order to be able to handle and manipulate the product in safety. More detailed information should be available in the **material safety data sheet** of the product.

### Label

The following indications are reported on the label, according to European standards:

- The name of the chemical product (some synonyms and the identifying numbers of the product, such as the producer's code, the CAS number and the EEC number are also often indicated).
- The origin of the substance (the name and address of the producer, of the distributor or of the importer).
- The risk category of the substance.
- The chemical risk symbol.
- The risk sentence.
- The safety advice.

### Risk categories

Chemical products are classified in the following hazard categories: corrosive (C), explosive (E), oxidant (O), inflammable (F), extremely inflammable (F+), toxic (T), extremely toxic (T+), irritants (Xi), harmful (Xn) and dangerous for the environment (N). A chemical risk symbol corresponds to each category and this symbol is printed on the label of each packaging together with some conventional sentences that supply information on the risks (R statements) and on the safety advice (S statements).

### Chemical hazard symbols

A **chemical hazard symbol** is associated to each hazard category. This has the purpose of immediately informing one of the type of hazard connected to its use, handling, transport and storage. Chemical hazard symbols are black in an orange square bordered by black. The minimum dimensions of the square are 10 mm x 10 mm, or at least 10% of the total surface of the label.

### Risk statements

**Risk statements**, which are also known as **R statements**, are some conventional sentences that describe the risks for human, animal and environmental health connected to the handling of chemical substances. A univocal code composed of the letter R followed by a number is associated to each sentence.

### Safety statements

The **safety statements**, also known as **S statements**, are some conventional sentences that give indications which it is advised to follow when handling chemical substances. A univocal code composed of the letter S followed by a number is associated to each sentence.

An example of a label is here given.



<h1>ACQUA OSSIGENATA</h1> <p>PEROSSIDO DI IDROGENO - OXIDOL - PEROXAN - BISSIDO DI IDROGENO</p> <div style="text-align: right; border: 1px solid black; padding: 2px;">H<sub>2</sub>O<sub>2</sub></div>	
<p>O - Combustibile</p> 	<p><b>NATURA DEI RISCHI:</b></p> <p>R8 - Può provocare l'accensione di materiali combustibili. R34 - Provoca ustioni.</p>
<p>C - Corrosivo</p> 	<p><b>CONSIGLI DI PRUDENZA:</b></p> <p>S3 - Conservare in luogo fresco. S28 - In caso di contatto con la pelle lavarsi immediatamente ed abbondantemente con: _____</p> <p>S36/39 - Usare indumenti protettivi adatti a proteggersi gli occhi/la faccia.</p>
<p>NUMERO CAS: 7722-84-1      NUMERO CEE: 008-003-00-9</p>	

## Material Safety Data Sheets of a chemical product

All hazardous chemical substances and preparations on the Italian market must be accompanied by a material safety data sheet (MSDS) which must be filled in by and be under the responsibility of whoever puts it on the market (producer, importer or distributor).

The material safety data sheet is a detailed informative document whose purpose is that of *allowing the professional users to take the measures necessary for the protection of the environment as well as of the health and safety of the workplace*. The sheet should be updated on the basis of the most up-to-date technical and scientific knowledge, should be drawn up in Italian and report the date it was drawn up and of the latest revision (sheets updated before 2003 do not conform with the regulations in force).

The following information is reported in a material safety data sheet:

### 1 Identification of the substance/preparation of the society/company.

The name of the product and its code, the society (company name, address, telephone and fax numbers and e-mail address) and above all a telephone number for emergencies are reported.

### 2 Hazard Identification on the basis of the EC classification.

### 3 Composition/information on the ingredients.

A chemical description of the product, the concentrations of the different substances that are present, and the CAS number that identifies the substance are all provided.

### 4 First aid measures.

The first aid interventions are described in detail on the basis of the type of contact had with the substance (for example: inhalation, skin contact, eye contact and swallowing).

### 5 Fire fighting measures.

The flammability conditions, the extinguishing means to use, the particular hazards that occur in the case of fire and the protective kit to wear are reported.

### 6 Accidental release measures.



Remedial methods and the precautions that should be taken to avoid or limit damage to people or the environment in the case of accidental spillage are given.

### **7 Handling and storage.**

The precautions necessary to follow in the handling of the product and a series of recommendations are reported to prevent the risk of fire and explosion, the toxicological risks and the pollution of the environment. The storage conditions, the type of packing necessary and the threshold quantity according to Directive 96/82/EC – 2003/105/EC (Seveso III) are also given.

### **8 Exposure controls/personal protection.**

The threshold exposition values are reported in this section together with the professional exposition checks, the individual protection devices that should be used and environmental exposition checks.

### **9 Physical and chemical properties**

The main physical and chemical properties available are reported, such as the physical state, the density, the boiling point, the fusion point the flammability point, the self-ignition point, the explosion threshold temperature etc.

### **10 Stability and reactivity**

The conditions in which the chemical product is stable, the conditions to avoid and those that can lead to dangerous reactions are specified.

### **11 Toxicological information**

The exposition symptoms, the organs in the human body that could be damaged and which illnesses the product could cause are reported.

### **12 Ecological information**

The hazardous effects that could cause the spread of the substance in the ground or in water and its emission into the atmosphere are indicated. The persistence and the degradability of the substances and any other harmful effects are also reported.

### **13 Disposal considerations**

Indications are supplied on the handling of residual material, the elimination of the empty wrapping and the procedures for the neutralisation or destruction of the product.

### **14 Transportation information**

The indications that should be supplied concerning the transport of hazardous materials are reported on the basis of international agreements, for example, the danger code (or Kemler number) and the code of the goods (ONO number, with UN initials) which are reported on the hazard panel during transport. The main international agreements are: ADR – European Agreement concerning the International Carriage of Dangerous Goods by Road (transport by road); RID – Règlement concernant le transport International ferroviaire des marchandises Dangereuses (transport via rail); IMDG – International Maritime Dangerous Goods Code (transport via sea); IATA – International Air Transport Association and ICAO – International Organisation of Civil Aviation (air transport).

### **15 Regulatory information**

Indications can be found on legislation regarding the classification and labelling of the substance. The R and S sentences are reported.

### **16 Other information**

Supplementary information is supplied on the product. Use constraints (for example, for research and development) are given.



## Carcinogens, mutagens and reproductive toxicants

A substance or preparation is called **carcinogenic** if it is able, through inhalation, swallowing or contact with the skin, to cause an increase in the incidence of cancer or increase its frequency (all the preparations with one or more carcinogenic substances with **overall concentrations above 0.1%** are considered carcinogenic). In a similar way, a substance or preparation is defined as being **mutagenic** if it can, by inhalation, swallowing or contact with the skin, produce hereditary genetic defects or increase their frequency. Finally, a substance or preparation is called **toxic for the reproduction** if it can damage the fertility of human beings.

These are properties that are difficult to demonstrate experimentally, considering the impossibility of carrying out experiments on human beings. According to the data available, European regulations have divided the substances that are carcinogenic, mutagenic and toxic for the reproduction system into the following three categories of decreasing danger:

- substances that have known effects (category 1);
- substances that have probable effects (category 2);
- substances that have possible effects (category 3).

**The use of category 1 and 2 carcinogenic and/or mutagenic substances or preparations implies the obligation of filling in the individual exposition to possible carcinogenic and mutagenic substances card.**

The category 1 or 2 mutagenic and/or carcinogenic substances or preparations can be identified on the basis of their labelling: they are the ones which have the R45, R49 or R46 risk statements.

### Carcinogenic substances and preparations: categories and labelling.

Category	Definition	Labelling	
1	Known substances because of the carcinogenic effects on human beings. Sufficient tests exist to establish a causal connection between exposition of human beings to the substance and the development of tumours.	R45 accompanied by the symbol T or T+; or R49 accompanied by the symbol T	
2	Substances which should be considered carcinogenic as sufficient information exists to consider it probable that exposition to this substance could cause tumours.	R45 accompanied by the symbol T or T+; or R49 accompanied by the symbol T.	
3	Substances that should be considered with suspicion because of the possible effects on human beings for which insufficient information exists.	R40 accompanied by the symbol Xn.	



## Mutagenic substances and preparations: categories and labelling

Category	Definition	Labelling	
1	Substances for which the capacity to induce a mutagenic effect is certain, on the basis of specific investigations.	R46 accompanied by the symbol T or T+.	
2	Substances for which the exposition/mutagenic effect ratio has been ascertained through experimental studies not carried out on human beings.	R46 accompanied by the symbol T or T+.	
3	Substances for which the exposition/mutagenic effect has not been sufficiently proved to place it in category 2:.	R68 accompanied by the symbol Xn.	

## Toxic substances and preparations: categories and labelling

Category	Definition	Labelling	
1	<b>Substances that damage the fertility of human beings.</b> Sufficient evidence exists to establish a cause-effect relationship between human exposition to a substance and the reduction of fertility. <b>Substances that cause toxic effects on development.</b> Sufficient evidence exists to establish a cause-effect relationship between human exposition to a substance and subsequent toxic effects on the development of offspring.	R60 or R61 accompanied by the symbol T.	
2	<b>Substances that could possibly damage the fertility of human beings.</b> Evident evidence exists to presume that human exposition to the substance could reduce fertility, on the basis of evident evidence of reduced fertility from studies conducted on animals in the absence of toxic effects, or on reduced fertility evidence which has been obtained for about the same levels of doses as other toxic effects, but which is not a secondary non specific consequence of such effects.	R60 or R61 accompanied by the symbol T.	
3	<b>Suspected substances for human fertility.</b> In general, on the basis of the results of adequate studies on animals which provide sufficient evidence to have a strong suspicion of toxicity on development in the absence of signs of pronounced maternal toxicity, or for about the same levels of doses as other toxic effects, but which are not secondary non specific consequences of such effects, and the evidence is however insufficient to place the substance in category 2.	R62 or R63 accompanied by the symbol Xn	



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**Risk statements used for carcinogens, mutagens and reproductive toxicants**

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**Carcinogenic substances or preparations**

**Categories 1 and 2**

- R45 May cause cancer.  
R49 May cause cancer by inhalation.

**Category 3**

- R40 Limited evidence of a carcinogenic effect.
- 

**Mutagenic substances or preparations**

**Categories 1 e 2**

- R46 May cause heritable genetic damage.

**Category 3**

- R68 Possible risk of irreversible effects.
- 

**Toxic for the reproduction substances or preparations**

**Categories 1 and 2**

- R60 May impair fertility.  
R61 May cause harm to the unborn child.

**Category 3**

- R62 Risk of impaired fertility.  
R63 Possible risk of impaired fertility
-



## Regulations for the use of carcinogenic and/or mutagenic substances or preparations

These regulations refer to category 1 or 2 carcinogenic and/or mutagenic substances or preparations.

### Care and removal modalities

- Carcinogenic and/or mutagenic substances or preparations should be kept in a **locked storage cabinet** with the necessary hazard indications attached.
- **The removal** of carcinogenic and/or mutagenic substances or preparations should be authorised by the **Person in charge of the Didactic and Research activities**:
- Carcinogenic and/or mutagenic substances or preparations **should not be removed and/or accumulated in the laboratory in larger quantities than those necessary for the experiment.**
- **The modalities for the removal of carcinogenic and/or mutagenic substances or preparations should be defined by the Person in charge of the Didactic and Research activities.**

### Health surveillance and exposition register

- **The health surveillance should be carried out respecting the individual university procedures defined by the doctor in charge.**
- **Only authorised personnel can utilise** carcinogenetic and/or mutagenic substances or preparations.
- **Each worker who utilises a carcinogenic or mutagenic substance should be enrolled in the specific exposition register.**

### Working procedures

- The working procedures should be defined by the **Person in charge of the Didactic and Research activities.**
- The procedures should minimise the quantity of carcinogenetic and/or mutagenic substance or preparation and **reduce the number of people potentially exposed.**
- **The procedures should be based on the material safety data sheet of the substance or preparation and on any other source of information available.**
- The procedures should ensure that the use of carcinogenetic and/or mutagenic substances or preparations takes place with the **absolute certainty of no contamination** of the work surfaces (use of anti-spillage trays, tinfoil, blotting paper with impermeable bottom, etc). The worker, after use, should see to the **systematic cleaning of the premises, of the work bench surfaces and of the apparatus.**
- **The procedures should foresee immediate decontamination interventions in the case of the spread of the carcinogenic and/or mutagenic substances or preparations.**
- The carcinogenic and/or mutagenic substances or preparations should be handled under a **class 3 fume cupboard** (face velocity higher than or equal to 0.7 m/s). **Carcinogenic and/or mutagenic substances or preparations cannot, in no circumstances, be used** in laboratories in which suitable fume cupboards have not been installed.
- In the case of particular requirements and for exceptional reasons for which operations must be conducted outside the fume cupboard (e.g. precise weighing or in an air draught free environment), it is necessary to use **breathing apparatus that offers an adequate protection** (at least a class 3 filtering facepiece or half mask for particles or aerosols according to the type of exposition and to what is reported in the material safety data sheet).



- The exposition of workers who use apparatus (e.g. laboratory reactors, prototypes that use/produce carcinogenic and/or mutagenic substances or preparations) should be reduced to nil.

#### Preliminary actions that should be carried out

- Air the premises and activate the aspiration systems, evaluating their good working order.
- Put on the necessary individual protection devices, having first verified their integrity and good working order. As a minimum, the worker should always wear spectacles, a long sleeved lab coat, gloves and protective sleeves.
- Avoid working with contact lenses.
- Cover any possible skin injuries with specific devices (sticking plasters, gauze etc.).
- Remove the personal effects that could be exposed to contaminating agents.
- Arrange a suitable container for the waste material.

#### Behaviour during the experimental procedures

- Avoid placing the containers on shelves that have no anti-toppling devices or which do not have containing devices for possible spillages.
- Dispose of the waste material according to the indications given the waste disposal procedures.
- Before leaving the laboratory, wash your hands carefully and remove the work clothes which could be contaminated.
- In the case of **unforeseeable exposition**, it is recommended to interrupt the experimental activities, **warn the other workers present of the danger**, leave the area immediately, prevent the entrance of others and finally inform the **Person in charge of the laboratory** and the **Person in charge of the Didactic and Research activities**.



## Cryogenic liquids

Cryogenic liquids, because of their extremely low temperatures, produce **burns** on the skin, while their rapid evaporation can easily make an environment lack oxygen and cause **asphyxia**. It in fact occurs that when the oxygen concentration falls below 16%, a person can lose consciousness, without any warning symptoms. An environment lacking oxygen could be caused, for example, by the accidental spreading of cryogenic liquids on the floor or on other surfaces or even by the unloading of a certain quantity of fluid from the safety valve should a sudden overpressure occur.

The following rules should be followed when using cryogenic fluids:

### Laboratory ventilation

- Ensure that the laboratory is equipped with **vents that guarantee a natural and permanent exchange of the environmental air**; as an alternative, install suitable **mechanical fans located at the ground level or the lower parts of the premises** that should be able to eliminate the vapours that may form.
- When cryogenic liquids are handled and used in **poorly aired environments, the presence of a specific oxygen sensor (oximeter) is indispensable**. This device should have acoustic-light signals that start functioning when the oxygen concentration drops below a level of 18%.

### Containers

- Only use **containers that have been specifically designed and certified** to contain cryogenic liquids.
- **Fill the containers only with those liquids they were meant to contain.**
- The containers (not the storage ones) should be of an **open type or protected by an air valve or another safety device which allows gas to escape**.
- The **unopened large storage containers should be equipped with devices to limit the build up of pressure**.
- When a special **pressure distribution cap with an air valve or with an air hose** is used, for example, as in the case of small portable containers, **check the air valve at regular intervals to ensure there are no blockages caused by frozen atmospheric dampness**.
- Only use **the caps that have been supplied with the containers**.
- **Never put caps on small sized containers**, instead cover them when they are not in use to protect the air valve from dampness.

### Worker protection

- **Protect the eyes using a visor or protection spectacles.**
- **Always wear gloves** to handle any object which is, or could have been, in contact with cryogenic liquids. The gloves should be worn loose so that they can be thrown away immediately should liquid or splashes enter inside them.
- **Always wear closed type shoes**, avoid wearing open type or porous shoes.
- **Wear a long lab coat and trousers or overalls** in order to protect the legs or other parts of the body against splashes.

### Handling of cryogenic liquids

- **Always stay at a safe distance from a liquid that is boiling and splashing** and from the gas it gives off. This always occurs when a “hot” container (e.g. environmental temperature) is filled or when objects are inserted into the liquid.
- **Always carry out these operations slowly** to minimise boiling and splashes.



- **Always avoid putting any part of the body not protected into contact with non isolated tubes or containers** containing liquefied atmospheric gases: extremely cold metal can in fact attach to the skin and lacerate it.
- **Do not remove objects immersed in a cryogenic liquid using your hands, even when they are protected by gloves;** use tongs, for example.
- **Each time it is necessary to pour liquefied gas into a Dewar vase** or other very small sized container, **use a funnel.** When it is dangerous or difficult to tilt the container, use a decanting hose to extract the liquid.
- When using a decanting hose, **insert the decanting hose right down to the bottom of the liquid, until the sealing material, or the cap on the edge of the decanting hose, forms a seal with the neck of the container.** Normal evaporation usually produces an adequate pressure for the extraction of the liquid.
- If one wants to obtain a continuous extraction, the container can be **pressurised with the gas that corresponds to the liquid product,** or with another inert gas without oil. **Do not use a higher pressure than that which is just sufficient to extract the liquid.**
- **The transport of cryogenic liquid containers in lifts** should take place **without personnel inside the lift** (which is used as a hoist). Lifts are small unaired environments; therefore, should an accidental liquid spillage occur or the lift should block, there would be a risk of asphyxia for any personnel present in the lift.



## Summary of the chemical hazard symbols

Symbol and name	Meaning (definition and precautions)	Examples
<p style="text-align: center;">C</p>  <p style="text-align: center;"><b>CORROSIVE</b></p>	<p><b>Classification:</b> substances and preparations which may, on contact with living tissues and/or inert materials destroy them.</p> <p><b>Precautions:</b> do not inhale and avoid contact with the skin, eyes and clothes.</p>	<ul style="list-style-type: none"><li>• Hydrochloric acid</li><li>• Hydrofluoric acid</li></ul>
<p style="text-align: center;">E</p>  <p style="text-align: center;"><b>EXPLOSIVE</b></p>	<p><b>Classification:</b> solid, liquid, pasty or gelatinous substances and preparations which may also react exothermically without atmospheric oxygen thereby quickly evolving gases, and which, under defined test conditions, detonate, quickly deflagrate or upon heating explode when partially confined</p> <p><b>Precautions:</b> avoid bumping, shaking, scraping, flames, or sources of heat.</p>	<ul style="list-style-type: none"><li>• Nitrogen trichloride</li><li>• Nitroglycerin</li></ul>
<p style="text-align: center;">O</p>  <p style="text-align: center;"><b>OXIDANT</b></p>	<p><b>Classification:</b> substances which behave like oxidants towards most other substances or which easily free atomic or molecular oxygen and which therefore facilitate combustible substances catching fire.</p> <p><b>Precautions:</b> avoid contact with combustible materials.</p>	<ul style="list-style-type: none"><li>• Oxygen</li><li>• Potassium nitrate</li><li>• Hydrogen peroxide</li></ul>
<p style="text-align: center;">F</p>  <p style="text-align: center;"><b>HIGHLY FLAMMABLE</b></p>	<p><b>Classification:</b></p> <ul style="list-style-type: none"><li>• substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or</li><li>• solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or</li><li>• liquid substances and preparations with a very low flash-point (below 21 °C), or</li><li>• substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.</li></ul> <p><b>Precautions:</b> avoid contact with ignitable materials.</p>	<ul style="list-style-type: none"><li>• Benzene</li><li>• Ethanol</li><li>• Acetone</li></ul>



<p>F+</p>  <p><b>EXTREMELY FLAMMABLE</b></p>	<p><b>Classification:</b> liquid substances and preparations with an extremely low flash-point and a low boiling-point and gaseous substances and preparations which are flammable in contact with air at ambient conditions.</p> <p><b>Precautions:</b> avoid contact with ignitable materials.</p>	<ul style="list-style-type: none"><li>• Hydrogen</li><li>• Acetylene</li><li>• Diethyl ether</li></ul>
<p>T</p>  <p><b>TOXIC</b></p>	<p><b>Classification:</b> substances and preparations which in low quantities cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.</p> <p><b>Precautions:</b> these substances and preparations must not come into contact with the body.</p>	<ul style="list-style-type: none"><li>• Barium chloride</li><li>• Carbon monoxide</li><li>• Methanol</li></ul>
<p>T+</p>  <p><b>VERY TOXIC</b></p>	<p><b>Classification:</b> substances and preparations which in very low quantities cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.</p> <p><b>Precautions:</b> contact with the body, inhalation and swallowing should be avoided, but also continuous or repetitive exposition to the substances or preparations, even at low doses, should be avoided.</p>	<ul style="list-style-type: none"><li>• Cyanide</li><li>• Nicotine</li></ul>
<p>Xi</p>  <p><b>IRRITANT</b></p>	<p><b>Classification:</b> non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, may cause inflammation</p> <p><b>Precautions:</b> the vapours should not be inhaled and contact with the skin should be avoided.</p>	<ul style="list-style-type: none"><li>• Calcium chloride</li><li>• Sodium carbonate</li></ul>
<p>Xn</p>  <p><b>HARMFUL</b></p>	<p><b>Classification:</b> substances and preparations which may cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin.</p> <p><b>Precautions:</b> the vapours should not be inhaled and contact with the skin should be avoided.</p>	<ul style="list-style-type: none"><li>• Laudanum</li><li>• Dichloromethane</li><li>• Cysteine</li></ul>
<p>N</p>  <p><b>DANGEROUS FOR ENVIRONMENT</b></p>	<p><b>Classification:</b> substances and preparations which, were they to enter the environment, would present or may present an immediate or delayed danger for one or more components of the environment.</p> <p><b>Precautions:</b> these substances must not be dispersed in the environment.</p>	<ul style="list-style-type: none"><li>• Phosphorus</li><li>• Potassium cyanide</li></ul>



## List of the Risk statements (R statements)

- R1 Explosive when dry.
- R2 Risk of explosion by shock, friction, fire or other source of ignition.
- R3 Extreme risk of explosion by shock, friction, fire or other sources of ignition.
- R4 Forms very sensitive explosive metallic compounds.
- R5 Heating may cause an explosion.
- R6 Explosive with or without contact with air.
- R7 May cause fire.
- R8 Contact with combustible material may cause fire.
- R9 Explosive when mixed with combustible material.
- R10 Flammable.
- R11 Highly flammable.
- R12 Extremely flammable.
- R13 Extremely flammable liquefied gas
- R14 Reacts violently with water.
- R15 Contact with water liberates extremely flammable gases.
- R16 Explosive when mixed with oxidizing substances.
- R17 Spontaneously flammable in air.
- R18 In use, may form inflammable/explosive vapour-air mixture.
- R19 May form explosive peroxides.
- R20 Harmful by inhalation.
- R21 Harmful in contact with skin.
- R22 Harmful if swallowed.
- R23 Toxic by inhalation.
- R24 Toxic in contact with skin.
- R25 Toxic if swallowed.
- R26 Very toxic by inhalation.
- R27 Very toxic in contact with skin.
- R28 Very toxic if swallowed.
- R29 Contact with water liberates toxic gas.
- R30 Can become highly flammable in use.
- R31 Contact with acids liberates toxic gas.
- R32 Contact with acid liberates very toxic gas.
- R33 Danger of cumulative effects.
- R34 Causes burns.
- R35 Causes severe burns.
- R36 Irritating to eyes.
- R37 Irritating to respiratory system.
- R38 Irritating to skin.
- R39 Danger of very serious irreversible effects.
- R40 Limited evidence of a carcinogenic effect.
- R41 Risk of serious damage to the eyes.
- R42 May cause sensitization by inhalation.
- R43 May cause sensitization by skin contact.
- R44 Risk of explosion if heated under confinement.
- R45 May cause cancer.
- R46 May cause heritable genetic damage.



- R47 May cause birth defects
- R48 Danger of serious damage to health by prolonged exposure.
- R49 May cause cancer by inhalation.
- R50 Very toxic to aquatic organisms.
- R51 Toxic to aquatic organisms.
- R52 Harmful to aquatic organisms.
- R53 May cause long-term adverse effects in the aquatic environment.
- R54 Toxic to flora.
- R55 Toxic to fauna.
- R56 Toxic to soil organisms.
- R57 Toxic to bees.
- R58 May cause long-term adverse effects in the environment.
- R59 Dangerous to the ozone layer.
- R60 May impair fertility.
- R61 May cause harm to the unborn child.
- R62 Risk of impaired fertility.
- R63 Possible risk of harm to the unborn child.
- R64 May cause harm to breastfed babies.
- R65 Harmful: may cause lung damage if swallowed.
- R66 Repeated exposure may cause skin dryness or cracking.
- R67 Vapours may cause drowsiness and dizziness.
- R68 Possible risk of irreversible effects.

## List of the risk statement combinations

- R14/15: Reacts violently with water, liberating extremely flammable gases
- R15/29: Contact with water liberates toxic, extremely flammable gases
- R20/21: Harmful by inhalation and in contact with skin
- R20/22: Harmful by inhalation and if swallowed
- R20/21/22: Harmful by inhalation, in contact with skin and if swallowed
- R21/22: Harmful in contact with skin and if swallowed
- R23/24: Toxic by inhalation and in contact with skin
- R23/25: Toxic by inhalation and if swallowed
- R23/24/25: Toxic by inhalation, in contact with skin and if swallowed
- R24/25: Toxic in contact with skin and if swallowed
- R26/27: Very toxic by inhalation and in contact with skin
- R26/28: Very toxic by inhalation and if swallowed
- R26/27/28: Very toxic by inhalation, in contact with skin and if swallowed
- R27/28: Very toxic in contact with skin and if swallowed
- R36/37: Irritating to eyes and respiratory system
- R36/38: Irritating to eyes and skin
- R36/37/38: Irritating to eyes, respiratory system and skin
- R37/38: Irritating to respiratory system and skin
- R39/23: Toxic danger of very serious irreversible effects through inhalation
- R39/24: Toxic danger of very serious irreversible effects in contact with skin
- R39/25: Toxic danger of very serious irreversible effects if swallowed
- R39/23/24: Toxic danger of very serious irreversible effects through inhalation and in contact with skin
- R39/23/25: Toxic danger of very serious irreversible effects through inhalation and if swallowed
- R39/24/25: Toxic danger of very serious irreversible effects in contact with skin and if swallowed



R39/23/24/25: Toxic danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed  
R39/26: Very Toxic danger of very serious irreversible effects through inhalation  
R39/27: Very Toxic danger of very serious irreversible effects in contact with skin  
R39/28: Very Toxic danger of very serious irreversible effects if swallowed  
R39/26/27: Very Toxic danger of very serious irreversible effects through inhalation and in contact with skin  
R39/26/28: Very Toxic danger of very serious irreversible effects through inhalation and if swallowed  
R39/27/28: Very Toxic danger of very serious irreversible effects in contact with skin and if swallowed  
R39/26/27/28: Very Toxic danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed  
R42/43: May cause sensitisation by inhalation and skin contact  
R48/20: Harmful: danger of serious damage to health by prolonged exposure through inhalation  
R48/21: Harmful: danger of serious damage to health by prolonged exposure in contact with skin  
R48/22: Harmful: danger of serious damage to health by prolonged exposure if swallowed  
R48/20/21: Harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin  
R48/20/22: Harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed  
R48/21/22: Harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed  
R48/20/21/22: Harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed  
R48/23: Danger of serious damage to health by prolonged exposure through inhalation  
R48/24: Toxic: danger of serious damage to health by prolonged exposure in contact with skin  
R48/25: Toxic: danger of serious damage to health by prolonged exposure if swallowed  
R48/23/24: Toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin  
R48/23/25: Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed  
R48/24/25: Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed  
R48/23/24/25: Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed  
R50/53: Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment  
R51/53: Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment  
R52/53: Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment  
R68/20: Harmful: possible risk of irreversible effects through inhalation  
R68/21: Harmful: possible risk of irreversible effects in contact with skin  
R68/22: Harmful: possible risk of irreversible effects if swallowed  
R68/20/21: Harmful: possible risk of irreversible effects through inhalation and in contact with skin  
R68/20/22: Harmful: possible risk of irreversible effects through inhalation and if swallowed  
R68/21/22: Harmful: possible risk of irreversible effects in contact with skin and if swallowed



R68/20/21/22: Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed

## Listo f the safety statements (S statements)

- S1: Keep locked up
  - S2: Keep out of the reach of children
  - S3: Keep in a cool place
  - S4: Keep away from living quarters
  - S5: Keep contents under ... (appropriate liquid to be specified by the manufacturer)
  - S6: Keep under ... (inert gas to be specified by the manufacturer)
  - S7: Keep container tightly closed
  - S8: Keep container dry
  - S9: Keep container in a well-ventilated place
  - S12: Do not keep the container sealed
  - S13: Keep away from food, drink and animal feeding stuffs
  - S14: Keep away from ... (incompatible materials to be indicated by the manufacturer)
  - S15: Keep away from heat
- Working with Chemicals - 10
- S16: Keep away from sources of ignition - No smoking
  - S17: Keep away from combustible material
  - S18: Handle and open container with care
  - S20: When using, do not eat or drink
  - S21: When using, do not smoke
  - S22: Do not breathe dust
  - S23: Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer)
  - S24: Avoid contact with skin
  - S25: Avoid contact with eyes
  - S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
  - S27: Take off immediately all contaminated clothing
  - S28: After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer)
  - S29: Do not empty into drains
  - S30: Never add water to this product
  - S33: Take precautionary measures against static discharges
  - S35: This material and its container must be disposed of in a safe way
  - S36: Wear suitable protective clothing
  - S37: Wear suitable gloves
  - S38: In case of insufficient ventilation wear suitable respiratory equipment
  - S39: Wear eye/face protection
  - S40: To clean the floor and all objects contaminated by this material use ... (to be specified by the manufacturer)
  - S41: In case of fire and/or explosion do not breathe fumes
  - S42: During fumigation/spraying wear suitable respiratory equipment (appropriate wording to be specified by the manufacturer)
  - S43: In case of fire use ... (indicate in the space the precise type of fire-fighting equipment. If water increases the risk add - Never use water)



- S45: In case of accident or if you feel unwell seek medical advice immediately (show the label where possible)
- S46: If swallowed, seek medical advice immediately and show this container or label
- S47: Keep at temperature not exceeding ... °C (to be specified by the manufacturer)
- S48: Keep wet with ... (appropriate material to be specified by the manufacturer)
- S49: Keep only in the original container
- S50: Do not mix with ... (to be specified by the manufacturer)
- S51: Use only in well-ventilated areas
- S52: Not recommended for interior use on large surface areas
- S53: Avoid exposure - obtain special instructions before use
- S56: Dispose of this material and its container at hazardous or special waste collection point
- S57: Use appropriate containment to avoid environmental contamination
- S59: Refer to manufacturer/supplier for information on recovery/recycling
- S60: This material and its container must be disposed of as hazardous waste
- S61: Avoid release to the environment. Refer to special instructions/safety data sheet
- S62: If swallowed, do not induce vomiting seek medical advice immediately and show this container or label
- S63: In case of accident by inhalation remove casualty to fresh air and keep at rest
- S64: If swallowed, rinse mouth with water (only if the person is conscious)

## List of the safety statement combinations

- S1/2: Keep locked up and out of the reach of children
- S3/7: Keep container tightly closed in a cool place
- S3/7/9: Keep container tightly closed in a cool, well-ventilated place
- S3/9/14: Keep in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)
- S3/9/14/49: Keep only in the original container in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer)
- S3/9/49: Keep only in the original container in a cool, well-ventilated place
- S3/14: Keep in a cool place away from ... (incompatible materials to be indicated by the manufacturer)
- S7/8: Keep container tightly closed and dry
- S7/9: Keep container tightly closed and in a well-ventilated place
- S7/47: Keep container tightly closed and at temperature not exceeding ... °C (to be specified by the manufacturer)
- S20/21: When using do not eat, drink or smoke
- S24/25: Avoid contact with skin and eyes
- S27/28: After contact with skin, take off immediately all contaminated clothing, and wash immediately with plenty of ... (to be specified by the manufacturer)
- S29/35: Do not empty into drains; dispose of this material and its container in a safe way
- S29/56: Do not empty into drains, dispose of this material and its container at hazardous or special waste collection point
- S36/37: Wear suitable protective clothing and gloves
- S36/37/39: Wear suitable protective clothing, gloves and eye/face protection
- S36/39: Wear suitable protective clothing and eye/face protection
- S37/39: Wear suitable gloves and eye/face protection
- S47/49: Keep only in the original container at temperature not exceeding ... °C (to be specified by the manufacturer)