UNIVERSITÀ DI PAVIA

RISKS RELATED TO THE USE OF CRYOGENIC FLUIDS

RISKS RELATED TO THE USE OF CRYOGENIC FLUIDS: BURN, ASPHYXIATION AND SUPEROXYGENATION

Definitions:

Cryogenic liquid: substance with a very low boiling point (< -73 °C) at atmospheric pressure.

Such substances are forced to the liquid state by compression and then transported under pressure; when released, they absorb a large amount of heat in order to evaporate. Because of this characteristic, they are used as powerful **refrigerant** (liquid nitrogen reaches the temperature of - 196°C and liquid helium - 269 °C) in order to keep samples and instruments at very low temperatures.

They are usually stored in cryogenic vessels (Dewar) thermically isolated → able to withstand high temperature variations.

Referring to their chemical nature, they can be put into one of these groups:

inert cryogenic liquids (e.g. nitrogen)

non inert cryogenic liquids (e.g. oxygen, hydrogen).

The latter are more dangerous because they are combustible or combustive substances, which can facilitate the development of combustion.

Those most commonly used are:

nitrogen, oxygen, argon, carbon dioxide.

Inert gas: gas which does not undergo chemical reactions under a set of given conditions. They are not toxic, but they don't sustain human respiration.

The most common are: nitrogen and the rare gases such as:

→ helium, argon, neon, xenon and krypton.

Risks related to the use of cryogenic liquids:

The main risks which can arise while using the cryogenic liquids, are due to:

- *extremely low temperature* → risk of **burn** if a part of the body gets in touch with the cryogenic substance;
- *small amounts of liquid can expand into very large volumes of gas* (e.g., 1 litre of liquid nitrogen expands at standard conditions in about 700 litres of gas)
  → risk of reduction of the concentration of oxygen in the ambient air which results in **asphyxiation;**
- *condensation of oxygen due to low temperatures*
  → risk of **superoxygenation** in close proximity to the cold part.

Risk of burn

The accidental contact of the liquid with surfaces at a cryogenic temperature, provokes in the skin lesions very similar to burns. The extent of damage increases *with the decrease of the temperature* and *with the extension of the time of contact.*

The first aid measures to be performed are the same as in case of burns from high temperatures:

- → de-ice the frozen parts using warm water;
- → don't scratch the part;
- → immediately consult a doctor.

One of the main causes of incident is the friability and the breakage of the containers, due to the low temperature of the liquid, which can provoke friability of low resilience[1] steels and, more generally, it can make friable and break materials of common use in laboratory (e.g. plastic, glass).

Risk of asphyxiation

The cryogenic liquids, once they are vaporized, generate a big amount of inert cold gas which will replace the ambient air causing **shortage of oxygen**, and will tend to accumulate at the **bottom**. In facts, all the cold gases or the gases heavier than air accumulate in the lower zones.

On the contrary, the helium, being lighter than air, **goes up** and accumulates in the most ventilated places, such as the false ceilings and the crawl spaces.

In the spaces where cryogenic liquids are used, situations in which the personnel is exposed to the risk of shortage of oxygen must be avoided.

Examples of such places are:

- indoor locals of buildings where the tanks and/or the cryogenic liquid dewars are filled and/or stored, above all if there is a lot of them;
- elevators used for the transportation of dewars;
- locals where MRI imaging scanners or other devices cooled down with liquid helium are used.

The inert gases are very dangerous because they are **odourless**, **colourless** and **flavourless** and as such not detectable.
The inert gases asphyxiation is not preceded by premonitory symptoms which could alert the victim.

[(1)]Resilience = the ability of a material to absorb energy of elastic deformation and therefore to adapt to the conditions of use in order to guarantee their use.

Symptoms and effects of oxygen shortage

The initial symptoms of oxygen shortage (vertigos, headache, difficulty to speak) are often not recognized by the victim as signs of asphyxia.
The effects of the decrease of oxygen concentration in the atmosphere vary depending on the extent of such decrease **(normal value: 21%).**

O_2 (Vol %)	Symptoms
18-21	Lack of recognizable symptoms
11-18	Reduction of the physical and intellectual performances, even not detectable by the victim
8-11	Possible faint and death
6-8	Faint with quick outbreak. Resuscitation effective only if immediately performed.
0-6	Immediate faint and brain damages.

Risk of superoxygenation:

Increasing of the oxygen concentration could occur close to the cryogenic gas containers, when the low temperatures cause oxygen condensation on their parts.
→ risk of superoxygenation, entailing an increase of the probability of triggering the combustible substances.
In facts, with a concentration of oxygen (a combustive agent that is not flammable but which supports the combustion) in the atmosphere major than 23%, there is a high probability of fire, with a primer.
Many materials burn more violently in presence of oxygen.

In case of emergency

1) First aid in case of:

- **contact with the eyes** → wash profusely with water for at least 15 minutes, keeping the eyelids open. If necessary consult the doctor;

- **contact with the skin** → take immediately the contaminated clothes off. Wash with water the affected part. If necessary consult the doctor;

- **inhalation** → wearing the breathing apparatus, transport the injured person far from the affected zone. If there is shortness of breath, give pure oxygen. Perform CPR if breath stops. Call the First Aid Station.

2) First environmental recovery in case of:

- **Loss and spread** → work on the loss if the operation is not dangerous and anyway wearing the appropriate protection devices. If the loss can't be stopped, it is necessary to evacuate the area and to let the gas drain in the atmosphere. Avoid the gas to enter into the drainage system, basements, digs and the areas where the store can be dangerous;

- **fire** → circumscribe the area. Cool down by water spurting the container exposed to fire because it could break.

Preventive measures in order to prevent the risks

Risk of burn

- Avoid the accidental contact with liquids or vaporized gases that are still at low temperatures;
- don't touch with the unprotected skin pipes or containers with cryogenic fluids: danger of skin frostbite;
- use exclusively hot water to unblock the frozen valves;
- wear the adequate gloves, safety glasses and overshoes in case of pouring.

Risk of shortage of oxygen

- Inform about the potential risk: affix the warning sign (see ''Safety Signage'') and take measures in order to avoid the entry to unauthorized people;
- train the personnel who enter the place or uses the cryogenic fluid or the inert gas about that kind of risk and be sure that they have understood the danger; the personnel must know the symptoms of the shortage of oxygen and of the interventions to carry out in case of emergency;
- operate a permanent ventilation of the local;
- adopt air monitoring systems both personal and fixed; such instruments indicate the percentage of oxygen in the air;
- make periodic controls in order to verify the seal of the dewars with liquid nitrogen (e.g. take note of the frequency of the topping up or of the amount of liquid nitrogen supplied);
- provide the worker inside the local of a portable sound alarm device such as whistle or horn, to advise the colleagues outside;
- define a work procedure which entails the simultaneous presence of two workers: one remains outside the local to spread the alarm in case of necessity;
- avoid to stay for a long time in the place of storage of the dewars;
- DON'T USE the filter masks: they are not effective because they don't replace the lacking oxygen.

Individual Protection Devices (I.P.D.)

According to the D.Lgs. 81/2008, art. 74, comma 1, an Individual Protection Device (I.P.D.) is *any device designed to be worn and held by the worker with the intent that it protects him against one or many risks susceptible to threaten his security or his health during the work, as well as any accessory built at that purpose.*

The D.Lgs. 81/2008 considers the use of IPD only when the adoption of the *technical preventive and/or organisational measures of collective protection* is not enough for the elimination of all the risk factors. In other terms, the IPD must be used only when it is not possible to remove the risk.
The IPD must carry by law the CE brand that indicates the compliance to the fundamental requirements of safety. The safety device must also have a handbook with instructions on conservation, cleaning, maintenance, expiry date, category, and limits of use possibly written in the official languages (Italian and possibly other ones).

IPD that must be worn while using liquid nitrogen:

- long sleeved lab coat;
- cryogenic gloves (made of thick textile, for example leather);
- safety glasses EN 166 with lateral protection;
- safety overshoes.

Safety signage:

Danger signals

Danger of asphyxiation	Low temperature

Duty signals

safety glasses	cryogenic gloves	lab coat

Unique emergency telephone number

112