SICHERHEITSEMPFEHLUNGEN

Industriegaseverband Schweiz

*(Sicherheitsempfelungen – Safety recommendations)*

# A06 Handling of cryogenic liquefied gases

## General information

A gas or a liquid is in a cryogenic state when its temperature is significantly lower than the surrounding temperature. Some of the gases that are transported, stored and used in a cryogenic state are listed in the table below.

The chemical properties of the gases are generally the same in a cryogenic liquefied state as in a "warm" state. In a cryogenic state, the physical property of "cryogenic" is added. This additional property results in **important information** and **dangers** that **must be observed when dealing with cryogenic liquefied gases.**

### Physical and chemical properties of some gases (reference values)

| | Oxygen | Nitrogen | Argon | Hydrogen | Helium |
|---|---|---|---|---|---|
| Chemical symbol | $O_2$ | $N_2$ | Ar | $H_2$ | He |
| Boiling temperature at 1013 mbar (0°C) | -183 | -196 | -186 | -253 | -269 |
| Amount of gas (l) resulting from 1 l fluid | 855 | 690 | 835 | 845 | 750 |
| Chemical property | flammable | inert | inert | flammable | inert |

Note: At boiling temperature, all listed gases are heavier than air.

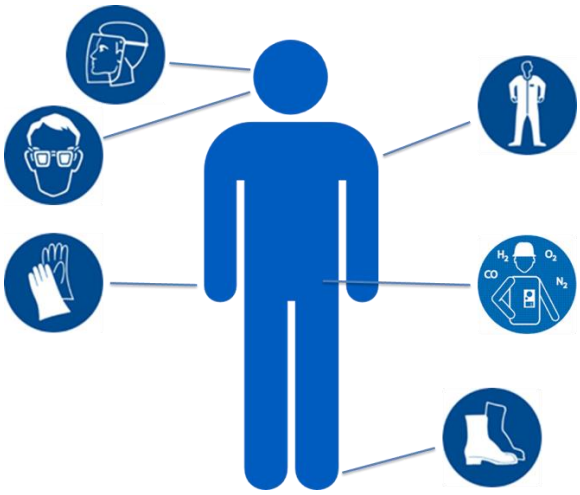
### Precautionary measures

The precautionary measures described in this safety recommendation are applicable to all cryogenic liquefied gases. They are to be applied together with the precautionary measures that are contained in the safety data sheets for gases and additional relevant safety information. It in particular refers to the important information and dangers as regards the handling of **oxygen** and **carbon dioxide**, which are discussed at length in the **IGS [Industrial Gas Association Switzerland] safety recommendations "A04 Oxygen enrichment/deficiency"** and **"A07 Handling of carbon dioxide"**.

## Personal protective equipment (PPE)

If it is worn at all times, personal protective equipment protects against the contact with cryogenic gases, liquids or facility parts to ensure that damages to health are practically ruled out. For this reason **always** wear the correct personal protective equipment (PPE) – in particular when filling / decanting:

- Dry cryogenic gloves
- Face protection and/or protective glasses
- Gas detector
- Dry loosely fitting clothing that covers the body
- Protective shoes
- Respiratory protection (if necessary)



# Important information on handling cryogenic liquefied gases

## Coming into contact

Cryogenic liquefied gases generally find themselves in a boiling state at atmospheric pressure. When transferring such gases into vessels that are still at ambient temperature, the boil initially increases exceptionally violently. Light splashes of the cryogenic liquefied gas may hereby result when cryogenic gas vaporises in large quantities. Face and hands must therefore be protected. The same applies when dipping objects with ambient temperature (or warmer) into cryogenic liquefied gases. Once the vessels or objects have taken on the temperature of the cryogenic liquefied gas the intensity of the vaporisation will subside, the cryogenic liquefied gas however remains in a boiling state.

Being in the presence of undercooled air from cryogenic gases can result in the body undercooling; it can however also lead to a disruption in the lung activity when inhaling the air that has been undercooled due to the cryogenic gas.

## Asphyxiation

The cryogenic gases listed in the table cannot cause poisoning because the named gases are not poisonous. These gases (apart from oxygen) can however oust atmospheric oxygen, which may lead to suffocation if less than approx. 12 vol. % oxygen is in the air.

For rooms in which cryogenic liquefied gases are handled in open or closed vessels, a ventilation system must be available that safely leads off at least the releasable amount of gas. Additionally, a warning device is recommended in case of a lack of oxygen.

## Fire hazard

Besides from an increase in the risk of fire, oxygen enrichment of the air to significantly more than 23 vol. % is not dangerous for the body. Further information on the risk of fire from oxygen enrichment can be found in the **IGS safety recommendations "A04 Oxygen enrichment/deficiency"**.

Risk of fire or explosion can result if flammable cryogenic liquefied gases (e.g. liquid hydrogen) leak out, because they evaporate and thus form an explosive mixture with the air.

## Mist formation and enrichment

If cryogenic gases mix with air, mist can form because of the humidity due to the cooling condenses. In the event of a greater discharge of cryogenic liquefied gases, the mist formation can be so extensive that the reduction in visibility may impair the ability to orientate one's self. In areas where the release of larger quantities of cryogenic liquefied gases must be reckoned with, there may be no sewer entries without a liquid seal, no open cellar windows or other open entry points to lower lying rooms, canals etc., since heavy gases may collect there. There may thus exist a heightened risk of suffocation or fire in such areas.

## Embrittlement

Materials that may come into contact with cryogenic liquefied gases must be suitable for such low temperatures, i.e. they may not become brittle in the cold. Suitable materials are for example copper, austenitic steels and some aluminium alloys. Of the plastics, PTFE is suitable in certain situations. The question of which material is suitable for which application should be clarified with the gas or material supplier.

## Pressure increase with vaporisation

The incursion of warmth causes cryogenic gas to constantly escape from the container if it is open (e.g. Dewar vessels). In sealed vessels the pressure will increase. The better the insulation of the vessel, the slower the increase in pressure is. Substantial gas quantities result from one litre of cryogenic liquefied gas (see table with physical properties).

If cryogenic liquefied gases can for instance be trapped between 2 valves, pressure relief devices with a sufficiently large diameter are to be provided. Even with the best insulation, these liquids will vaporise. The hereby-resulting gas must be led away via the pressure relief devices in order to prevent the piping from bursting for example.

### Condensation

Before cryogenic liquefied gases are used in instruments, containers, piping, fittings etc., these must be dried thoroughly. Due to the cryogenic liquefied gases this would otherwise result in a freezing out of the moisture, which may cause glitches (e.g. of safety valves, manometers...).

## Handling of cryogenic liquefied gases in mobile cryogenic containers

Cryogenic liquefied gases are often transported and stored in mobile cryogenic containers. They are available both as sealable, pressure gas containers suitable for inner excess pressure, or as open, unpressurised operated Dewar vessels. The latter may not be tightly sealed since they may burst.

The cryogenic container user manual is to be observed, and the respective personnel is to be trained / instructed in the safe use and handling of cryogenic containers and cryogenic liquefied gases.

## Road transport of cryogenic containers (in-house / external)

Generally: the “European Agreement on the International Carriage of Dangerous Goods on the Road (ADR)“ and the “Agreement on the Carriage of Dangerous Goods on the Road (SDR)“ apply.

The following is to be observed:

- Load securing and correct positioning of the container
- Open load / cargo space or load / cargo space with aeration and ventilation
- Permissible filling level of the container may not be exceeded

For sealed cryogenic containers:

- Recurring inspection in accordance with ADR is to be ensured, i.e. only inspected and certified containers may be used for transport

For open cryogenic containers:

- Container opening must be equipped with a gas-permeable device that prevents cryogenic liquefied gases splashing out

## Cold burns and frostbite

The following information is in particular aimed towards the provision of first aid. It also however provides the first doctor on the scene with important information. It is advisable to give the injured party these safety recommendations to pass on to the doctor.

### Treatment of cold burns and frostbite

Coming into contact with cryogenic liquids, vapour or gases can cause skin damage – similar to those of burns – the severity of which depends on the temperature and exposure time. Uncovered or insufficiently protected body parts that come into contact with non-insulated supply lines or containers for cryogenic gases can stick due to freezing moisture and can cause lacerations when they are removed.

The wearing of damp clothing is therefore to be avoided. The contact of unprotected body parts with cryogenic liquids or gases results in frostbite.

### First aid (excerpt from doctor’s database “www.uptodate.com“ / “Frostbite“)

- The injured party is to be brought into a warm environment (approx. 22°C) as quickly as possible. If the feet are affected then the injured party should not use them.
- The affected areas are to be protected by extensively covering them with dry, sterile bandages before transport. This may not be applied so tightly as to impair the blood circulation. The affected body part is to be kept still.
- Wet clothing is to be removed. All articles of clothing that could impair the blood circulation at the affected area are to be removed.
- Slowly warm the affected areas in warm water or with body warmth – under no circumstances should the affected areas be rubbed, as this can cause further damage.
- If qualified medical treatment is not available immediately, it must be ensured that the injured party is taken to a hospital straight away.
- The normal form of treatment is to be applied for shock.

### Treatment by a doctor or in the hospital

- If larger parts of the body or individual body parts have been exposed to cryogenic temperatures so as to lower the whole body temperature, the patient must be warmed up again immediately. The patient or the affected part of the body should hereby be brought into a warm water bath of between 37 and 39 °C. In order to warm up the patient as quickly as possible, it is important that the bath temperature is kept constant if at all possible.
- If this is not possible, the patient can be kept still and covered lightly with woollen blankets in a warm location (approx. 22°C).
- Shock may result during the process of being warmed up.
- Frozen skin looks wax-like (pale, yellow colour) and often is not painful. When it thaws it begins to hurt, swells up and is susceptible to infections. Thawing can take 15 to 30 minutes and should continue until the skin colour has changed to pink or red. The thawing process can be very painful depending on the degree of exposure. It may be required to give the patient painkillers.
- If the frozen parts of the body have thawed before medical assistance has arrived, they should not be warmed up further. In this case, the areas are to be protected by extensively covering them with dry, sterile bandages.
- Check for tetanus vaccination.

## Concluding remark

The safe handling of cryogenic liquefied gases is only possible if the specific properties of these gases are known and this knowledge is employed consciously. Used improperly, cryogenic gases can for example cause frostbite, while the proper application of the same effect is employed in cryosurgery.

## Scope / Demarcation

This document replaces the existing IGS safety recommendations “Handling of cryogenic liquefied gases IGS-TS-005/03“, “Cold burns and frostbite IGS-TS-007/03“ and “Handling of cryogenic liquefied nitrogen (LIN) in mobile cryogenic containers IGS-TS-015/03“.

The safety data sheets (SDS) provide information on the safety-relevant properties of the gases. This safety recommendation does not apply to carbon dioxide and dry ice. For further questions on handling cryogenic liquefied gases and cryogenic containers, the gas suppliers are available to provide you with assistance.

## Further documents (not exhaustive)

- The respective safety data sheets (SDS) of the encountered substances
- IGS safety recommendation “A04 Oxygen enrichment / deficiency“
- IGS safety recommendation “A07 Handling carbon dioxide“
- User manuals of the cryogenic containers used
- ADR/SDR
- SVS RG 553

Do you have any questions?
We hold further documents ready.

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