



Transport and storage of CO₂ refrigerated packaging in refrigerated vehicles and climate rooms

Covid-19 vaccines cold chain implementation implies transport by refrigerated vehicles and storage in climate rooms of CO₂ refrigerated packaging containing a large amount of dry ice.

During the transportation as well as the storage phase, dry ice sublimates directly into vapour, leading to the release of a gas of carbon dioxide into insulated truck body and climate room. This phenomenon represents a significant risk of asphyxia for employees likely to get into the vehicles and climate rooms.

It is important to well understand those risks and the related good practices in order to avoid potentially deadly accident.

1. The CO₂ and its use

The CO₂ is almost as twice as heavy than the air as a consequence it accumulates directly at the floor level and cannot be evacuated if there is no opening at a low point such as a bin or a container accessible with a lid. Moreover the CO₂ is odorless and colorless.

Dry ice masses and gas volume

Sublimation of 10 kg of dry ice will produce more than 5 m³ of gaseous CO₂ and only 100 kg of dry ice will be enough to produce a gas volume superior to the insulated body volume of a 26 tonnes truck, or the climate room where the packaging's will be stored.

Charges of dry ice in a refrigerated packaging

The minus 70 °C transport packaging's of Covid-19 vaccines contain several kilograms of dry ice. As a consequence few packaging's transport or storage can lead to very significant gaseous CO₂ volume.

2. CO₂ related risks in transport equipment's and climate rooms

Respiratory risks (asphyxia)

Despite carbon dioxide is a natural air component, at a high level of concentration it is an asphyxiating gas that can result in death.

The significance of the observed effects depends on its concentration level in the atmosphere and some physiological factors (age of the person, vascular state...) but also climatic factors (external temperature, oxygen pressure...).

According to the (French) National Risk and Security Institute (INRS) n° 238 security sheet, : "First manifestations appear when inhaling an atmosphere containing only 2 % CO₂. They result in an increase in respiratory amplitude. From 4 % of CO₂ the respiratory frequency increases and breathing can become complicated for some person. From 5% of CO₂ there are headaches, sensation of dizziness as well as the first cardiovascular and vasomotor effects: increase in cardiac frequency, blood pressure and peripheral vasodilation. At 10 %, visual troubles can be observed sometimes associated with retina degeneration,



tremors, excessive sweating and arterial hypertension with loss of consciousness, for some subjects, if the exposure lasts about ten minutes."

When reaching about 20 %, serious troubles can quickly appear: respiratory depression, convulsion, coma and death. Those intoxications can be complicated by muscular lysis. There is a lot of sudden accidental death cases due to inhalation of high CO₂ concentration accumulated into confined spaces such as silos, wine cellars or even due to environmental disaster.

Risks of burns

Moreover, skin contact with very low temperature CO₂, with dry ice at minus 78.5°C, for instance, can cause cold burns with blisters on the skin.

Risks of explosion

CO₂ sublimation within a completely sealed packaging can lead to an explosion risk of the container, but this risk is far lower than the intoxication and burns risks.

3. Use of CO₂ regulation

ADR regulation and equipment's marking

The agreement on dangerous goods transportation by road (ADR) makes mandatory the marking of transport equipment's containing CO₂. Those obligations also concern CO₂ used as a refrigerant in containers and packaging's.

ADR provides specific provisions for each situation encountered on the field. When a package containing CO₂ as a refrigerant or as a conditioning agent is transported in vehicles or containers without being well-ventilated, their marking is mandatory. This is specially the case when the container is isotherm equipment cooled or refrigerated such as defined in the Agreement on Transport of perishables foodstuffs (ATP).

Within that context, "well-ventilated" means that there is an atmosphere where carbon dioxide is less than 0.5 % by volume and oxygen concentration is greater than 19.5 % by volume.

In the case of vehicles or containers which are not well-ventilated containing dangerous goods used for refrigeration or packaging purpose, a warning mark must be placed at each access point where it will be easily visible by persons opening the doors or entering of the vehicle or container.

The mark must remain placed on the vehicle or container until the following provisions are fulfill

- a) The vehicle or container has been well-ventilated in order to eliminate toxic concentration of refrigerant or conditioning agent; and
- b) The refrigerated or conditioned goods have been unloading.

As long as the vehicle or container bears the warning mark, the necessary precautions must be taken before entering it. The necessity to well-ventilate through the vehicle doors or any other means for instance by forced ventilation has to be assessed and must include in the concerned persons training.

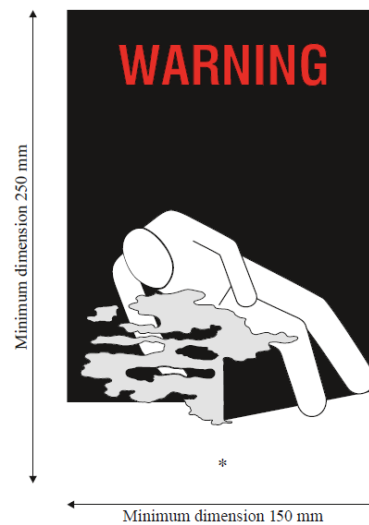


Fig. n° 1: ADR labelling to indicate CO₂ asphyxia risk in refrigerated transport equipment.

This mark can be used for climate rooms or any other storage spaces dedicated to packaging's containing CO₂, but the mark commonly used by the gas industry below can also be used for fixed facilities.



Fig. n° 2: Danger labelling used by gases professionals.

4. Loading and unloading good practices

Loading good practices and air circulation

Transport equipment's or climate rooms loading as well as any other storage space must allow air circulation inside and prevent air pockets. The free air circulation under the load has to be allowed using gratings or pallets, their openings should not be blocked. Putting the load directly on the floor must be avoided as much for product temperature as air circulation.

Ventilation before entering the vehicle or storage space

The vehicle or storage space has to be ventilated before entering. The doors must be opened and kept open long enough depending on the size of the machine to allow CO₂ to escape. In refrigerated equipment, it may be useful, unlike the usual good practices to let the refrigeration unit ventilation run for few minutes in order to expel the air from the equipment. The refrigeration unit will then be switched off before entering the vehicle. Never bend your head into a container that has contained or contains CO₂.

Unused dry ice disposal

In case of dry ice excess upon the package receipt which will be the case for the vaccines in order to keep them at the right temperature until the final destination, care must be taken to remove the dry ice without generating any risk.



The excess of dry ice must be disposed of in an outdoor or ventilated place where it cannot generate any risk of suffocation or burns for people who could to handle it.

Dry ice should not be disposed of in a indoor garbage or an office bin.

Wearing gloves

Handling dry ice should not be done by hands. Skin contact with dry ice or product stored at its temperature should be avoided. Wearing gloves is highly recommended but do not allow handling dry ice by hand.

CO₂ detection

Operators who may enter the vehicle or storage space should be equipped with a portable CO₂ alarm to alert in the case of excessively high CO₂ levels.