OCDEM, Churchill Hospital, Oxford OX3 7LE

Head of Department: Prof Fredrik Karpe
DSO: Sandy Humphreys
BSO: Prof Patrik Rorsman

SOP number: OCDEM RA 2

Effective date:1st May 2015
Updated: 5th April 2015
Version: 2
Supercedes: 1.1

Risk assessment

Use and Handling of Dry Ice (Solid Carbon Dioxide)

Contents

Introduction

Carbon dioxide (CO_2) is naturally present in the air we breathe at a concentration of about 0.037% and is not harmful to health at low concentrations. At room temperature and atmospheric pressure CO_2 is a colourless and odourless gas and therefore it is not visible, or cannot be smelt, at elevated concentrations. It can cause oxygen depletion and at high concentrations death can be caused by both asphyxiation and poisoning.

The risk of asphyxiation and poisoning is exacerbated by the fact that carbon dioxide is heavier than air which allows it to flow downwards and collect in low lying areas possibly far from its origin. The danger is slightly mitigated by the fact that carbon dioxide in concentrations of about 5% causes a choking sensation which can be used as a warning sign; at concentrations above 10% there would be very little, if any, warning before possible collapse. The choking sensation must not be used as a control measure.

CO_2 is not flammable and will not support combustion.

Solid carbon dioxide or dry ice is available as pellets, flakes or blocks and has a translucent white appearance. It has a boiling point of -78°C and at normal temperatures the solid will sublime* into carbon dioxide gas. One kilogram of dry ice subliming at room temperature produces > 0.5m[3] of the gas.

It is commonly used as a cooling/freezing agent in laboratory procedures and for transportation of samples.

Persons at risk

Persons unpacking parcels shipped on dry ice.

Persons packing samples for shipping on dry ice.

Persons preparing and using dry ice/acetone mixtures for snap freezing of samples.

Persons using dry ice to keep samples frozen during cataloguing or relocation of samples.

Persons transporting samples in dry ice in their cars.

Potential hazards, control measures, recommended action

- Dry ice is a very cold solid that sublimes* to become a toxic asphyxiant gas which will accumulate in poorly ventilated areas.
- Dry ice is capable of inflicting serious burns due to skin contact and frost bite.
- Explosion due to pressure build up if kept in sealed containers.
- Manual handling of large bags of dry ice (10kg is the standard package weight).

Please read Appendix 1 for more information on the assessment of potential for gas release and how it can affect the concentration of carbon dioxide in the air when transporting dry ice in a car.

Toxicity and Asphyxiation

Hazard

On boiling (subliming), one kilogram of dry ice produces approximately $0.5m^3$ of carbon dioxide gas. It is heavier than air and can accumulate at low levels. There is a Workplace Exposure Limit (short term) of 15,000ppm, which is equivalent to a concentration of 1.5%.

When the carbon dioxide concentration in the air is enriched or the oxygen concentration in the air is depleted, a person can become unconscious without sensing any warning symptoms, such as dizziness. There is a risk of death when the carbon dioxide level rises above 10% or the oxygen level falls below 11%. If a cough becomes evident whilst working with dry ice remove yourself from the area immediately until the cough has disappeared. When returning to work, relocate to an area with better ventilation. Working with dry ice in the freezer morgues for greater than 30 minutes is not recommended; it is preferable to work in the main laboratory areas.

The effects and symptoms of exposure to carbon dioxide gas at various concentrations are summarised in table 1 below.

Table 1		
ppm CO_2	**% Vol**	**Effects and Symptoms**
10,000	1	Slight but un-noticeable increase in breathing rate.
20,000	2	Breathing becomes deeper; rate increases to 50% above normal. Prolonged exposure (several hours) may cause headache and a feeling of exhaustion.
30,000	3	Breathing becomes laboured; rate increases to twice normal. Hearing ability reduced, headache experienced with an increase in blood pressure and pulse rate.
40-50,000	4-5	Breathing becomes laboured, rate increase to twice normal. Symptoms as above, with signs of intoxication after half hour exposure and slight choking feeling.
50-100,000	5-10	Characteristic pungent odour noticeable. Breathing very laboured, leading to physical exhaustion. Headache, visual disturbance, ringing in the ears, confusion probably leading to loss of consciousness within minutes.
100,000+	10+	Loss of consciousness more rapid, with risk of death from respiratory failure. Hazard to life increased with concentrations even if no oxygen depletion. Concentrations of 20-30% and above are immediately hazardous to life.

Control measures

- At room temperature dry ices sublimates slowly and in well ventilated areas should not pose a significant risk.
- Store dry ice in well ventilated areas away from direct sunlight and sources of heat.
- When opening lids to storage containers, allow a few seconds for gas to dissipate and do not lean in for longer than necessary.
- Do not store dry ice in a working refrigerator or freezer – it will sublimate at a faster rate than in an insulated storage container and the extremely cold temperature may cause the thermostat to cut out.
- Do not store in walk in freezers or fridges as there is very little fresh air circulation and dry ice will still sublime causing carbon dioxide concentrations to rise.
- Do not pour water onto dry ice; it increases the rate of sublimation and therefore a higher risk of asphyxiation and/or poisoning.
- Do not play games with dry ice.
- Dispose of unwanted dry ice by allowing it to evaporate in a well ventilated area or a fume cupboard– it will sublime leaving no residue.
- Avoid carrying dry ice in the cab of a truck or the passenger compartment of a car. If this is not possible, use as little dry ice as possible, ensure that the container is well

insulated (though not tightly sealed) and ensure that the compartment is well ventilated (open windows, ensure ventilation system is set to draw fresh air from outside).

- Unload the material as soon as possible at the end of a journey.
- Ensure that all users of dry ice are trained and familiar with the hazards and necessary precautions.

Action

If poisoning or asphyxia occurs immediately move the affected person to the open air if it is safe for you to do so. Keep victim warm and rested. Call an ambulance. Apply artificial respiration if necessary.
However, attempts to rescue affected persons from confined spaces, oxygen deficient or carbon dioxide rich atmospheres should only be made by calling the Emergency Services. The only place this is likely to happen in OCDEM would be walk in cold-rooms.

Cold burns and frostbite

Hazard

Skin contact with dry ice may cause severe cold burns and prolonged exposure may result in frostbite. Unprotected skin may freeze onto surfaces cooled by the dry ice causing severe damage on removal.

Control measures

When handling dry ice the following are required:

- Hand protection – non-absorbent, insulated gloves to EN 511 or loose fitting leather gloves must be worn.
- Foot protection – open-toed shoes must not be worn.

Action

First Aid Measures:
Skin Contact - immediately flush thoroughly with water for 15 minutes. A first aider must assess all cold burns; medical assistance needs to be obtained to assess the extent of tissue damage for deep burns or if blistering occurs. In case of frostbite, spray with water for at least 15 minutes, apply a sterile dressing and obtain medical assistance.
Splashes into the eye – flush with running water for at least 15 minutes. Take the casualty to the Eye Hospital for assessment (West Wing, John Radcliffe Hospital; telephone: (2)34800).

Explosion due to trapped gas

Hazard

If dry ice is stored in a sealed container, then expansion on warming may cause an explosion, giving rise to danger from contamination by the vessel’s content or an impact injury from the vessel itself.

Control measures / Action

- Use suitable storage containers (there are commercially available insulated containers with vented seals specifically designed for storing dry ice).
- Do not store or use dry ice in any gas tight container.

Manual Handling

Hazard

The standard size for bags of pellets dry ice is 10 kg. This is the most common form purchased in OCDEM. The bags are heavy, cold and awkward to carry.

Control Measures / Action

- Cryogenic gloves must be used when transporting bags of dry ice from reception to the laboratory.
- A trolley must be used to transport the bags.
- Carry out a manual handling assessment of the bags. Consider whether you are able to lift the bags from floor level on your own; bags of dry ice should not be rested against your body to facilitate handling. Use two people if required.

Appendix 1

Assessment of Potential for Gas Release

It is difficult to evaluate the rate at which the solid form will convert to the gaseous form since this will be dependent on a number of variables:

- The form of the dry ice – pellets or flakes, for instance, will sublime at a faster rate than blocks.
- The ambient temperature – sublimation will proceed faster at higher temperatures.
- The degree of insulation provided by the container.

However, the data below can be used to make some approximate estimates as to what concentration of gas will be generated in particular circumstances.

One kilogram of dry ice subliming at room temperature produces > 0.5m^3 of the gas

Dry ice to CO_2 sublimation rate = approx. 1% of total mass per hour in an insulated container (figure supplied by Gas Safety UK Ltd.).

Dry ice to CO_2 sublimation rate = approx. 14% of total mass per hour at room temperature in the open (figure supplied by Gas Safety UK Ltd.).

Consider the following example:

A number of specimens packed in dry ice are being transported by car from one location to another. The container is well insulated and is positioned on the back seat of the car - the car windows are closed. The journey takes 1 hour. Assuming the interior volume of the car is 2.8 m^3:

Calculating CO_2 in Car Atmosphere		
Quantity of Dry Ice (Kg)	***Volume of Gas Produced in Journey (m^3)***	***Concentration of CO_2 in Car Atmosphere (m^3)***
5	*0.023*	*0.8*

The concentration of CO_2 in the car reaches 0.8% - which is close to the value at which effects start to be noticed (1%). The concentration would be increased by any combination of the following:

- increasing the quantity of dry ice used.
- using a poorly insulated or open container.
- using a smaller car.
- lengthening the journey time.

It can therefore be seen that providing all the factors are taken into account, a reasonable quantitative assessment of risk can be carried out.

Control Measures for carrying dry ice in a car or van.

- Dry ice must only be carried in the boot of a saloon car or the luggage area of an estate car or hatchback; it must not be carried in the passenger compartment.
- Use as little dry ice as possible, but do not exceed 5 kg
- Ensure that the container is well insulated, but not tightly sealed
- Ensure that the passenger compartment is well ventilated (open windows, ventilation system set to draw fresh air from outside).
- Unload the material as soon as possible at the end of a journey.
- Only trained personnel are allowed to carry dry ice in their vehicles.
- Personnel must also adhere to the information contained in University Policy Statements S2/07: Work related Road Safety and S5/07: Safety in Fieldwork.
- A risk-assessment for lone-working must be made if travelling alone.

Review History

Version	Date	Reason for update	Updated/reviewed by :	Date next review due
1	March 2007	New SOP	SMH/Dean Cross(ASO)	March 2009
1	March 2010	Review – no changes	SMH	March 2012
1.1	3rd April 2013	New Header – no other changes	SMH	April 2015
2.0	5th April 2015	HoD added. Changes to text in introduction and hazards section	SMH	May 2017