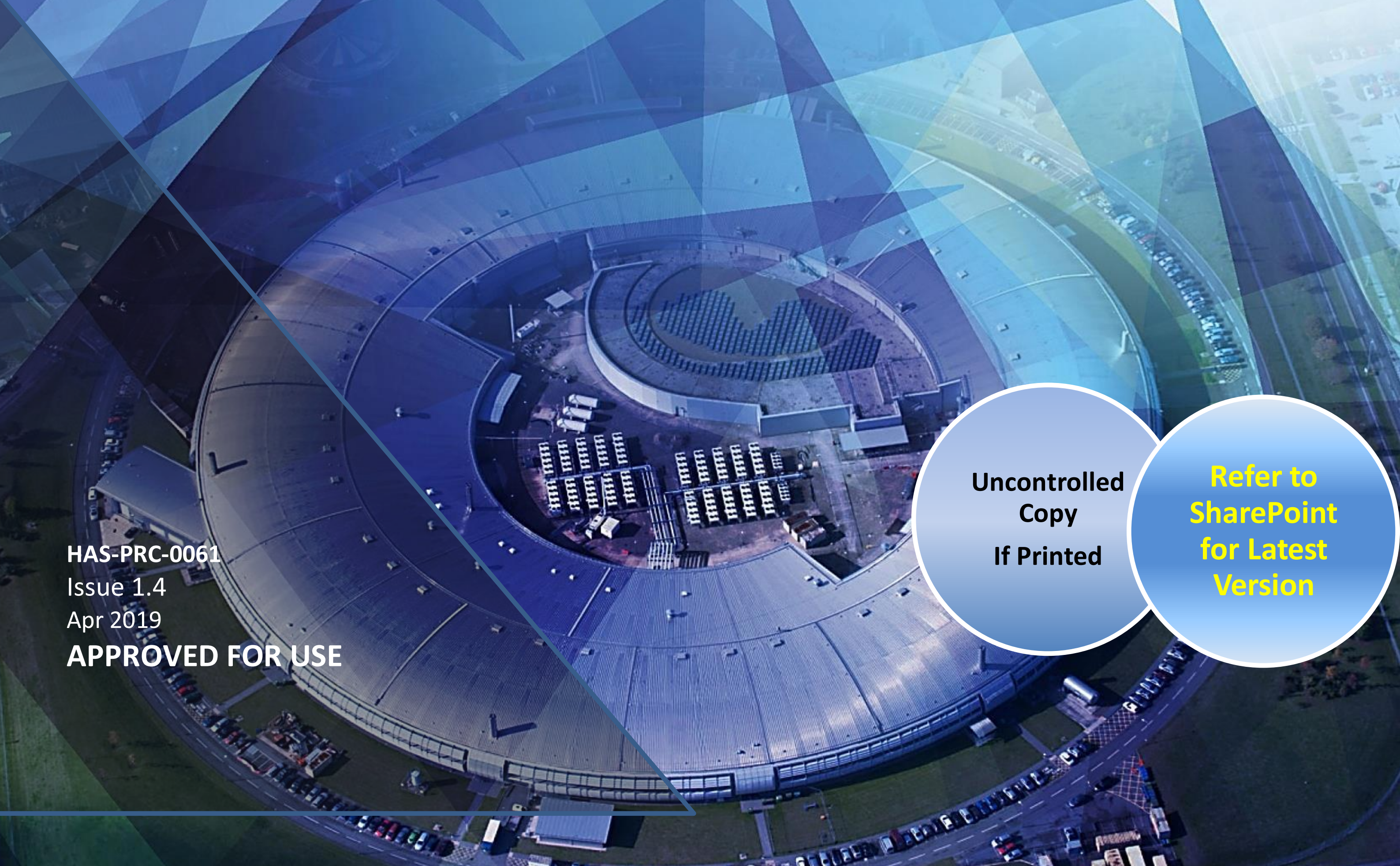
# Oxygen Depletion Policy and Guidance



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**APPROVED FOR USE**

## Contents

## 1. Purpose and Scope

This document sets out the requirements for the risk assessment of work places and work activities which may create oxygen deficient atmospheres that could endanger life. There is guidance on the risk assessment of oxygen depletion, possible control measures and emergency arrangements.

Note: The emergency procedures (page 11) can be displayed as a single page where needed.

The procedure applies to: All activities which present a risk of oxygen deficient atmospheres that could endanger life.

## 2. Definitions

| Term | Definition |
|---|---|
| **Oxygen deficient** | A condition where the level of oxygen is lower than 18%, this results in a risk to life. |
| **Oxygen enrichment** | A condition where the level of oxygen is higher than 23%. Results in an increased risk of fire or explosion. |
| **Asphyxiant** | Any substance which reduces the amount of oxygen available by dilution, displacement or reaction. |
| **Asphyxiation** | The effect on the body of insufficient oxygen. Can lead to unconsciousness and or death. This is also known as suffocation or anoxia. |
| **Inert gas** | A non flammable non toxic gas which may displace or dilute the other constituents of air thus depleting the oxygen content. |
| **Flammable gas** | A gas which has the main hazard of flammability. All flammable gases also act as asphyxiants. |
| **Toxic gas** | A gas which has the main hazard of toxicity. All toxic gases can act an asphyxiants as well as having toxic effects. However the toxic effects will probably occur before asphyxiation occurs. These are controlled by COSHH. |
| **User** | Any individual, contractor, staff, visitor who makes use of or is present when asphyxiants are used; a person at risk. |

## 3. Responsibilities

For general responsibilities which apply, see Safety, Health and Environmental Policy Arrangements (HAS-POL-0001-ARR).

### SHE Group

Responsible for:

Maintenance of the procedure.

Monitoring the effectiveness of the procedure and for provision of information and training to persons who may be affected by asphyxiation - This will generally be given in the SHE induction.

### Process Owner / Area Manager

Responsible for:

Risk assessment.

Application of suitable controls.

Provision of information, instruction and training.

Ensuring that people fully understand the emergency procedures.

Supervising visitors, contractors, young persons and any person not fully trained or authorised for any given area.

Ensuring maintenance of any equipment which is used for the prevention of or warning of asphyxiation hazards to the manufacturer's instructions.

Coordinating with the competent area risk assessor and if necessary, with the SHE group with regards to matters in this area.

### Permit Issuers and Receivers

Responsible for:

Ensuring that all measures have been taken to minimise the risks from using gases.

Ensuring that the persons involved in the work understand the risks and control measures when the work is part of permitted work. The general PTW checklist applies for oxygen depleted atmospheres.

### All Employees

Responsible for: Reading the procedure and ensuring their own understanding of the hazards and risks detailed within.

## 4. Procedure

### Policy

Diamond's policy on oxygen depletion is as follows:

Individual area risk assessors will identify if there is an oxygen depletion hazard in their area.

The area risk assessor will carry out a risk assessment of the hazard and make recommendations based on the risk and severity of the hazard.

The area manager will implement whatever control measures are needed to reduce the risk to life to a level which is deemed as low as is reasonably practicable.

Where a risk of asphyxiation exists, effective oxygen depletion monitoring must be made available.

Where boundaries between areas overlap or have the potential to overlap, the area managers shall cooperate in risk assessment, hazard control and provision of information instruction and training so far is reasonably practicable.

To design risk out of new installations and to manage the risk from current installations.

To maintain and test functionality of safety related equipment which is used to prevent, control or warn operators of asphyxiants.

### Background Composition of Air

The approximate make up of air is as follows:

| Gas | Symbol | Percentage |
|---|---|---|
| Oxygen | $O_2$ | 20.5 |
| Nitrogen | $N_2$ | 78 |
| Argon | Ar | 0.94 |
| Carbon Dioxide | $CO_2$ | 0.039 |

Atmospheric gases are non-toxic but alterations in their concentrations - especially that of oxygen - have an effect upon respiration and combustion.

If good practice is not observed accidents may happen as changes in concentration cannot be easily detected by the human senses.

Oxygen is not flammable but it does support combustion. Nitrogen, Argon and inert gases inhibit combustion. When these gases are liquid, very low temperatures are involved (below -180°C) they can rapidly cause cold burns and make certain materials brittle leading to structural failure.

## Hazards from Oxygen Deficiency

No one should be knowingly exposed to an atmosphere which contains less than 19% oxygen as this may indicate the beginning of a decrease in atmospheric oxygen and thus endanger life.

Oxygen deficiency cannot be detected by human senses, victims are unaware of the danger they are in so are unable to take action. A personal oxygen depletion monitor should be worn if there is a risk of asphyxiation and the area is not covered by a fixed system.

The table below shows possible effects of oxygen depletion created by displacement of air. The effects may vary and symptoms will be different for gases which are also toxic such as carbon monoxide or hydrogen sulphide as these will also have a toxic effect.

**Table 1: Effects of oxygen depletion**

| $O_2$ (% vol) | Effects, Symptoms and Action |
|---|---|
| 18 - 21 | No noticeable effects. Cannot be detected by individuals. |
| 11 - 18 | Reduction of physical and mental performance, not noticeable by the individual |
| 8 - 11 | Possibility of fainting within a few minutes without prior warning. Risk of death when $O_2$ levels drop below 11%. |
| 6 - 8 | Fainting will occur a short time after entering the atmosphere. Resuscitation possible, needs to be carried out immediately |
| 0 - 6 | Fainting almost immediate. Brain damage likely, death will occur within minutes. |

## Causes and Controls of Oxygen Depletion

Any gas other than oxygen can result in the displacement of a normal atmosphere including hydrogen, chlorine, nitrogen, helium, carbon dioxide and ammonia, some of these gases have other properties such as flammability, oxidising character or toxicity; some are lighter than air and will collect in roof spaces, some are heavier than air and will pool in low areas. In all cases a gas release will eventually mix fully with the atmosphere in the room.

For the purposes of risk assessment and general awareness, some sources of release are given as examples:

### Storage

Evaporation from non-pressurised liquid containers, e.g. cryogenic Dewars or flasks. Some cryogenic liquid storage tanks are fitted with a regulated excess pressure spill device.

Dry ice sublimation.

Cylinder leak / damage.

## During Use

Liquid container filling.

Removal of oxygen by corrosion.

Welding (shielding and purge gas venting).

Purging or gas blanketing.

Chilling and freezing operations.

Gases remaining after emptying or purging a tank or vessel.

Combustion processes (e.g. gas welding and cutting; workplace heating / mobile heaters) will consume atmospheric oxygen as well as using the oxygen supply from the cylinder or pipeline and the products of combustion may include carbon dioxide and carbon monoxide. These processes should be carried out in a well-ventilated workplace.

## Unintentional

Magnet quench.

Leaks from pipe work, valves.

Bursting discs and tank relief valves.

Liquid gas / dry ice spillage.

Failure of control system which leads to overflowing of container.

## Notes on Spillage of cryogens

A small amount of cryogenic liquid can lead to the formation of a large amount of gas. For example one litre of liquid nitrogen released into a room, will expand to 700 times the volume (0.7m$^3$) and displace the same amount of air:

| Cryogen (Liquefied gas) | Expansion co-efficient (ratio) |
|---|---|
| Oxygen | 860:1 |
| Argon | 850:1 |
| Nitrogen | 700:1 |
| Hydrogen | 850:1 |
| Helium | 760:1 |

Consequently, liquid spillage or when filling of Dewars can rapidly cause oxygen deficiency in confined spaces, enclosed areas, small rooms, pits, etc.

## Preventive Measures

Equipment used for the generation, distribution and use of asphyxiant gases must be installed by a competent person and leaks must be fixed by a competent person.

Information should be available to all personnel on the actions to be taken by staff and first aiders in the event of an incident involving asphyxiation. This must include protective equipment, detection equipment and isolation procedures.

Detection equipment must be worn when mandated by the risk assessment or method statement and must be maintained in accordance with manufacturer's instructions. Where a risk of oxygen depletion has been identified oxygen monitoring should be in place.

## Control Measures

There are a number of control measures which may be applicable to the management of asphyxiant atmospheres some suggestions are:

> Flow limiting devices (e.g. orifice plate).
>
> Placement of prominent appropriate signs.
>
> Limitation of the amount of boil off in processes.
>
> Use of open spaces, opening doors and windows.
>
> Local exhaust ventilation – local to the source.
>
> Space extract – mechanical ventilation for the entire room.
>
> Air circulation – to dilute.
>
> Attachment of oxygen monitors to gas cylinders or equipment which may cause an inert atmosphere.
>
> Use of a buddy system when filling dewars (one person to operate, one person to remain in a safe place and observe), lone working is not permitted unless justified by risk assessment.

> Wearing an oxygen depletion monitor when filling or using dewars.

Selection and application of control measures will be determined by the risk assessment and will be different for each area and application.

## Risk Assessment

All work which uses or may be affected by the use of oxygen depleting gases or conditions must be risk assessed and controls identified to minimise the risk of asphyxiation to persons.

The risk assessment must be recorded on safety organiser and the findings must also be communicated to the persons undertaking the tasks along with the required control measures.

## Risk Reduction

The control measures taken to mitigate the effects of any hazard should follow the hierarchy of controls:

> Eliminate the hazard by not doing it or using it.
>
> Reduce the hazard by using less (power, pressure, substance etc.), limitation of boil off of gases.
>
> Isolate from the work area, or isolate sources when work is complete (especially comp air guns which vent continuously).
>
> Control by engineering (ventilation or venting

*Use **Appendix 1** to determine potential oxygen concentrations* directed outside).

Protect – ($O_2$ depletion monitoring, Protect persons by provision of air supply – breathing apparatus, escape hood for example).

Discipline; define safe systems and procedures and emergency response and communicate to persons.

## Provision of Information, Instruction and Training

Managers must ensure that suitable and sufficient, information, instruction and training to ensure the health and safety of workers is provided. Information which must be provided to workers and contractors include:

Hazards of the gases

How they are being used and how they should be handled

Precautions required

Additional training which may need to be given

Emergency arrangements and procedures

Testing of emergency procedures by way of drills or exercises should be carried out at a suitable interval which will be determined by the potential frequency of an accident and the severity of the accident – the risk assessment will provide the information for these judgements. The SHE Group will also be able to advise with these activities.

Labelling of gas containers is the responsibility of the supplier; however users should be made aware of the risks associated with the handling of each product. More detailed information should be made available by the supplying company and must be entered onto the Safety Organiser system by the SHE group prior to COSHH assessment.

**Actions in the event of Oxygen Depletion Alarm / Unconscious Person due to Asphyxiation**

In the event that an oxygen depletion alarm should sound or there are “no entry” warning lights (red flashing lights) outside of any area; you should warn others in the area, leave the vicinity and report the occurrence to the experimental hall coordinators **ext 8787** or the control room if in zone 13 **ext 8999**

| Signal | Condition |
|---|---|
| Green light | Normal atmosphere – no action required. |
| Red flashing light and alarm sounding | 19% oxygen in air – evacuate (low alarm) |
| Red flashing light and alarm sounding | <17% oxygen in air – evacuate (low low alarm) |

If any persons are found to be unconscious in an area of possible oxygen depletion or other hazardous gas atmosphere, do not attempt to rescue the person as this will result in making you a casualty. Instead report the occurrence to the control room and the fire service x**8999** or x**2222** for a response.

Personal monitors may have different levels of alarm and differing alarm signals to those above. The alarm levels should be known before use; the alarms must be understood before use and tested as appropriate. It is the responsibility of the wearer to make sure he is familiar with the safety device he is using. It is the responsibility of the line manager of the wearer to ensure that operation of the safety device is understood.

Persons investigating alarms must follow Diamond emergency controller guidance.

## 5. Referenced Documents

| Document Title | Reference | Location |
| --- | --- | --- |
| Hazardous Substances | HAS-PRC-0013 | Sharepoint |
| Permit to Work PTW Procedure | HAS-PRC-0021 | Sharepoint |
| Liquid Nitrogen and Liquid Helium – Code of Practice for Handling | HAS-PRC-0024 | Sharepoint |
| Compressed gas cylinders - code of practice for handling | HAS-PRC-0030 | Sharepoint |
| Diamond emergency controller guidance | HAS-PRC-0050 | Sharepoint |

## 6. Records

| Record | Responsible Person / Group | Statutory | Retention Time |
| --- | --- | --- | --- |
| None | | | |
| | | | |

## 7. Final Approvers

| Name | Position | Approval Type |
| --- | --- | --- |
| **Jean Lane** | **Experimental Hall Manager** | |
| **Jos Schouten** | **Head of Insertion Devices Group** | |
| **Daryl Eves** | **Head of Mechanical Facilities** | |
| **Richard Walker** | **Technical Director** | |
| **Guy Thomas** | **Head of SHE Group** | |

## 8. Document History

| Issue | Date | Comment |
|---|---|---|
| 1 | 15 Feb 2013 | Document consolidates the policy on asphyxiation hazards. |
| 1.1 | 11 Sep 2017 | Reformatted. |
| 1.2 | 04 Oct 2018 | Permit to work document re-numbered |
| 1.3 | 05 Apr 2019 | Referenced documents updated |
| 1.4 | 11 Apr 2019 | Referenced document updated |
| | | |

## Appendix 1: Calculations

For containers of permanent gases (non liquefied gases):

Resulting Oxygen concentration ($C_{ox}$) = (100 x $V_o$) ÷ $V_R$

Where:

$V_o$ = the volume of oxygen, $m^3$, = 0.21($V_R$ – Vol of cylinder)
$V_R$ = the volume of free air in the work place, $m^3$

Volume of gas in the cylinder, $m^3$ = (Water capacity of cylinder, litres x fill pressure, bar) / 1000

For containers of liquefied or cryogenic gases

Resulting Oxygen concentration ($C_{ox}$) = (100 x $V_o$) ÷ $V_R$

Where:

$V_o$ = the volume of oxygen, $m^3$ = 0.21($V_R$ – $V_G$)
$V_R$ = the volume of free air in the workplace, $m^3$
$V_G$ = max volume of liquid in container, litres x $F_g$
$\rho_g$ = density of gas at room temperature and pressure, Kg/$m^3$
$F_g$ = gas expansion ratio

For releases over time

$$C_t = 0.21 + \left[\frac{0.21\,n}{\left(\frac{L}{Vr}\right) + n} - 0.21\right] \times \left[1 - e^{-t/m}\right]$$

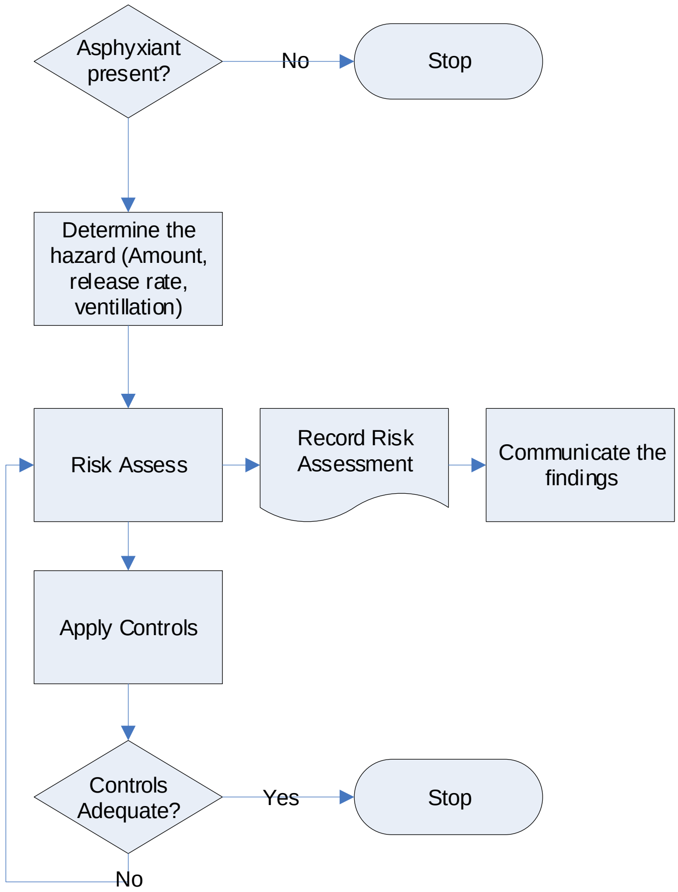
Or for releases over long time periods

$$C_\infty = \frac{(Vr\ \times 0.21\ \times n)}{L + (Vr\ \times n)}$$

Where:
$C_t$ = oxygen concentration after a defined time
$C_\infty$ = oxygen concentration over a long period of time
L = gas release rate, m3 /h
Vr = the volume of free air in the workplace
n = the number of work place air changes per hour
t = time, hours
e = 2.72

$$m = \frac{Vr}{L + n\,Vr}$$

## Appendix 2: Control of Asphyxiant Atmospheres

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