GAS CYLINDER SAFETY MANUAL

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

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Scope

This manual is applicable for all research activities in the Institute which use gas cylinders.

This manual contains safety precautions to be adopted in handling, storage and usage of gas cylinders. The properties and physiological effects of gases used in research activities are also covered.

Introduction

Research laboratories in the Institute make use of a wide variety of gases. These include gases that are flammable, irritants, inert, oxidants, pyrophoric and toxic.

While a few gases can be detected by odour, many are colourless and odourless. In addition to these, there are hazards involved in handling and usage of gas cylinders. The properties of gases are such that we need to handle them with care and caution to prevent accidents.

Definitions

Threshold Limit Value (TLV) Air-borne concentration of toxic substances which nearly all personnel involved may by repeatedly exposed day after day without adverse effect.

TLV values are expressed in ppm (parts per million) or mg/m^3.

Time Weighted Average (TLV-TWA) is the time weighted average concentration for a normal eight hour day or 40 hr week. Nearly all persons can be exposed day after day to airborne concentrations at these limits without any adverse effect.

Asphyxiant is a gas, exposure to which leads to a morbid condition caused by the failure of the tissues to receive or utilize oxygen, the fault occurring in the lungs, blood or tissues or caused by dilution of atmospheric oxygen.

Simple asphyxiants are physiologically inert substances that dilute oxygen in the air. Examples are nitrogen, hydrogen, helium, methane and carbon dioxide.

Chemical asphyxiants are substances that interfere with the supply or utilisation of oxygen in the body by chemically reacting with blood, e.g., carbon monoxide and hydrogen cyanide.

Flammable Limit - A flame can propagate in a mixture of flammable gas and air (or oxygen) only if the concentration of the gas is between two limits known as the lower and upper flammable limits.

Lower Flammable Limit (LFL) - The minimum percent by volume of flammable vapour in air below which flame will not propagate in the mixture.

Upper Flammable Limit (LFL) – The maximum percent by volume of flammable vapour in air above which flame will not propagate in the mixture.

Types of gases

Flammable gas burns or explodes if it is mixed with air, oxygen or other oxidant, in the presence of a source of ignition.

Oxidant gas is non flammable but supports combustion. Materials that burn in air, burn more vigorously and/or explosively in oxygen and other oxidants.

- Sources of ignition must be eliminated while handling oxidants.

- Oxidants must not be stored with combustible materials.

- Oil, grease or other combustible substances must not be brought into contact with oxidants.

Corrosive gas can corrode materials with which they come in contact.

- Some gases, which are non corrosive in their anhydrous form become corrosive in presence of moisture.

- Corrosivity of a gas must be taken into consideration while selecting components and piping for handling the gas.

Irritant gas causes inflammatory reactions after immediate, prolonged or repeated contact.

- Protective clothing must be used to minimize exposure to corrosive or irritant gases.

Pyrophoric gas burns spontaneously upon exposure to air.

Inert/Asphyxiant gas does not react with other materials under normal temperature and pressure.

- If released in a confined area, these gases may displace oxygen of the air below the level necessary to sustain life.

Receiving Gas Cylinders

- Wherever possible order the minimum number of gas cylinders for research work.
- If a cylinder of lesser capacity can be used, avoid procuring a larger one.

- Upon receiving the cylinder, it must be visually inspected for any signs of damage.
- Every cylinder must contain a label affixed on it with the name of the gas. Gas cylinders without labels must not be accepted.

- The type of the gas must not be determined based on the colour of the gas cylinder alone, as different manufacturers may use different colours for the same type of gas.
- Ensure that cylinders are received with valve caps. The valve cap offers protection to gas cylinder valve in case the cylinder falls.

- Sealed gas cylinder valves help to prevent accumulation of dirt in the valve outlet.

- The received gas cylinders must be shifted to the laboratory or to the storage area.
- The cylinders must not be allowed to stand free in passages or areas where they could be knocked down.
- The MSDS (Material Safety Data Sheet) must be referred before the usage of gas cylinder.
- Personnel handling gas cylinders must be well aware of the hazards and properties associated with the gas before use.
- Contact the gas supplier for clarifications, if any.

Gas cylinder storage outside the laboratory

- Store gas cylinders in a separate storage area outside the building which is protected from weather.
- Do not expose gas cylinders to temperatures above 45^{o}C.Overheating of cylinders can result in build up of pressure and explosion.
- Do not store gas cylinders with other combustible materials.
- The storage area must be well ventilated to prevent accumulation of gas in case of leakage.
- Flammables and oxidisers must be stored separately in the storage area. The cylinders must be separated by a distance of 6 meters or must be separated by a fire wall of 30 minutes fire resistance.
- The empty and full cylinders must be stored separately and clearly labelled/marked.

- Chain the gas cylinders during storage to prevent fall.
- Flammable substances, such as oil and other solvents, must not be stored in the same area.
- The floor used for storing gas cylinders must be dry, to prevent the corrosion of gas cylinders.

Gas cylinder storage in the laboratory

- The cylinders must be chained or supported to a firm surface to prevent fall.
- Do not store gas cylinders near the exits.
- Empty cylinders must be clearly marked. And cylinders which are not connected with regulator must be stored with their valve caps.

- Cylinders must be used on a first come first use basis.
- Keep cylinders away from any source of heat and ignition.
- Gas cylinders must be stored in a manner that permits quick removal in case of an emergency. Do not store materials over or around the cylinders.

- Ensure proper ventilation in the room where gas cylinders are stored, to prevent accumulation of the gas in case of a leakage.
- Store toxic, pyrophoric and corrosive gases inside ventilated gas cabinets.

- Cylinders must not be exposed to continuous dampness and must not be stored near corrosive chemicals.

Handling and use of gas cylinders

- Gas cylinders must not be dropped or dragged.

- Move gas cylinders only on trolleys meant for the purpose. While moving, the valve cap must be fixed and the cylinder chained to the cart.

- Improper handling of gas cylinders can cause sprains or fractures.
- The regulator selected must be the one appropriate for the type of gas used.
- Never use oxygen regulator for flammable gases. An adaptor must not be used for connecting regulators. Cross contamination of internal parts can result in rapid oxidation and fire. Same is applicable for other oxidising gases.

- Attach the regulator carefully; the valve must be opened slowly. While opening the valve, do not stand by the side of valve outlet or in front of regulator.
- The regulators must not be subjected to rough handling. Repairs should be done only by authorised personnel.
- Always use safety glasses while working with gas cylinders.

- Check for gas leakage with a compatible leak detection solution on the joints of regulators. In case of leakage the area will be indicated by the formation of bubbles.

- Do not use cylinders without a regulator.

- Never use a hammer or mallet in attempting to open or close a valve. Get the help of the supplier if there is difficulty in opening the valve.

- Close the valve after usage or when the equipment is not in use.

- Flexible hoses used for connecting the cylinder to manifold under pressure can get loose and whip off and strike personnel nearby.

- Place the spindle key near the gas cylinder, so that the valve can be quickly closed in case of an emergency.

- The gas cylinder valve must be closed at the end of the operation. The pressure in the regulator shall be released before removing the regulator from the cylinder.

- If a cylinder falls it may break off the regulator, causing the cylinder to pin-wheel causing serious injury. In addition to this danger, the valve could shear off and the cylinder can become a projectile due to sudden release of pressure.

- Do not roll or drag the cylinder, since it is easy to lose control of a cylinder while rolling or dragging and if the cylinder falls it can result in serious injury.

- Never use oil or grease as a lubricant on valves or attachments of oxygen cylinders. Keep oxygen cylinders and fittings away from oil and grease, and do not handle such cylinders or apparatus with oily hands, gloves or clothing.

- If the cylinders are returned to the supplier without closing the valve, the interior of the cylinder can get contaminated with atmospheric air and moisture.

- The metal/non metal gas lines used must be compatible with the gas used. Incompatible material used can result in gas leaks.

- Inform the supplier in case of contamination of the gas cylinder.

- Install gas detectors for detecting leaks.

- Liquefied gas can get trapped in parts of the system and can result in the rupture of the pipe line due to pressure build up.

Handling gas leakages

A gas leak can occur from any of the following points.

- Valve threads, where the valve is attached to the cylinder.

- Safety devices on the cylinder.

- Valve spindle

- Valve outlet

- Joints in pipeline or from the pipeline due to corrosion.

- Do not attempt to repair a leak at the valve threads (at the base of the valve) or from the safety device on the cylinder.

- In case of a flammable gas leak extinguish any open flame if any quickly. Do not operate electrical switches in the room or laboratory where a flammable gas leak is suspected as electric arcing can ignite the gas. Evacuate the area.

- Do not attempt to deal with a toxic/corrosive/pyrophoric gas without proper personal protective equipment. Contact emergency support personnel for the same.

- An uncontrollable leak from a flammable/pyrophoric/toxic/corrosive gas from a cylinder requires immediate evacuation of the building.

- Use self contained breathing apparatus while dealing with leaks of toxic, corrosive gases or if an oxygen deficient atmosphere is suspected in case of other gases.
- If the leaking gas is toxic or corrosive and the same is inside the gas cabinet, do not take the cylinder out.
- Any gas leaking inside a non ventilated confined space can displace atmospheric oxygen impairing respiratory function.
- An oxygen gas leak can form an oxygen enriched atmosphere which can cause a fire to burn violently. Extinguish any open flames in the vicinity of an oxygen gas leak.

First aid measures

- In case of contact of corrosive/toxic gas with eyes-flush with water for at least 15 min.
- In case of skin contact, remove contaminated clothing and flush the affected part with water. An emergency shower can be used for the same.
- In case of inhalation of gas, remove the person to fresh air.
- Get immediate medical attention.
- Do not give anything to drink if the person is not conscious.

Properties and physiological effects of gases used in research laboratories

Acetylene

Type of gas: Flammable gas

Colour: Colourless

Specific gravity: 0.91 (slightly lighter than air)

Odour: Acetylene gas of ordinary commercial purity has a garlic odour, while 100 % pure gas is odourless.

Flammability limits: 2.5 - 80%

- Acetylene gas in cylinders is dissolved in acetone and absorbed in a porous solid material.
- Do not store or inject acetylene gas into any vessel or enclosure. Improperly stored acetylene is unstable.
- Acetylene must never be used in equipment outside the cylinder at pressures exceeding 15psi.
- Under certain conditions, acetylene forms explosive metallic compounds of copper, silver, and mercury called acetylides.

Physiological effects

- It is a simple asphxiant if present in concentrations high enough to deprive the lungs of oxygen and produce suffocation.

Ammonia

Type of gas: Toxic gas and flammable gas

Colour: Colourless

Specific gravity: 0.59 (lighter than air)

Odour: Pungent

Flammability limits: 16 -25 %.

TLV-TWA (Threshold Limit Value – Time Weighted Average): 25 ppm

- The concentration of ammonia vapour in air can be reduced by the use of adequate volumes of water applied through spray or fog nozzles, as ammonia is readily soluble in water.

- Ensuring good ventilation in the storage area helps to dissipate the gas into the atmosphere as ammonia is lighter than air.

Physiological effects

- Ammonia has a severe irritating effect on the mucous membranes of the eyes, nose, throat and lungs due to its caustic action.

- Inhalation of high levels of ammonia can lead to pulmonary edema (filling of fluids in the lungs) which can be fatal.

Argon

Type of gas: Non flammable gas

Colour: Colourless

Specific gravity:1.38 (heavier than air)

Odour: Odourless

Flammability limits : NA

Physiological effects

- Argon is non toxic. It is a simple asphyxiant as it can displace oxygen in the air in confined areas.

- It is extremely inert and is slightly soluble in water.

Boron trichloride

Type of gas: Toxic and corrosive gas

Colour: Colourless

Specific gravity: 4.1 (heavier than air)

Odour: Pungent

Flammability limits: NA

TLV-TWA (Threshold Limit Value – Time Weighted Average): 1 ppm

Physiological effects

- The gas is extremely corrosive, and can burn and damage eyes, skin, mucous membranes, and any other exposed tissue.
- If inhaled, irritation of the respiratory system may occur, with coughing, and breathing difficulty. Overexposure to this gas may be fatal.
- Exposures to high concentrations can lead to symptoms such as coughing, labored breathing, sore throat, and pulmonary edema.
- When released to moist air, boron trichloride immediately decomposes to form a mist of Hydrochloric Acid, which is very corrosive.

Carbon dioxide

Type of gas: Non flammable gas

Colour: Colourless

Specific gravity: 1.5 (heavier than air)

Odour: Odourless

Flammability limits : NA

- Being denser than air, carbon dioxide gas can accumulate in low or confined areas.

Physiological effects

- Carbon dioxide is relatively non toxic.
- It acts as a simple asphyxiant.

Carbon monoxide

Type of gas: Toxic and flammable gas

Colour: Colourless

Specific gravity: 0.96 (slightly lighter than air)

Odour: Odourless

Flammability limits: 12.5 - 74%

TLV-TWA: 25 ppm

Physiological effects

- Carbon monoxide is a chemical asphyxiant, which combines with haemoglobin in the blood forming carboxy haemoglobin.
- It thus prevents the haemoglobin from taking up oxygen and reduces the oxygen carrying capacity of blood.
- The affinity of carbon monoxide for haemoglobin is about 300 times more than that for oxygen.
- Carbon monoxide gives no warning of its presence, and inhalation of high concentrations can cause sudden, unexpected collapse.

Chlorine

Type of gas: Toxic gas

Colour: Greenish yellow

Specific gravity: 2.5 (heavier than air)

Odour: Pungent

Flammability limits: Non flammable

- Chlorine is non flammable but is capable of supporting the combustion of certain substances, e.g., hydrogen.
- Many organic chemicals react readily with chlorine, in some cases explosively.
- Mixtures of chlorine and hydrogen can react with explosive violence, forming hydrogen chloride.

TLV-TWA: 1 ppm

Physiological effects

- Chlorine gas is primarily a respiratory irritant.
- In sufficient concentration it can cause irritation of the mucous membranes, the respiratory system and the skin.
- Large amounts cause irritation of eyes, coughing and labored breathing, which can be fatal.
- Chlorine combines with moisture forming hypochlorus and hydrochloric acids.

Diborane

Type of gas: Toxic and flammable gas

Colour: Colourless

Specific gravity: 0.95 (slightly lighter than air)

Odour: Repulsive

Flammability limits: 0.8 to 98%

Diborane usually autoignites in moist air.
TLV-TWA: 0.1 ppm

Physiological effects

Is a pulmonary irritant.

Exposure to high concentration can result in a sensation of tightness in the chest, shortness of breath, eye irritation and nausea. Exposure can lead to pulmonary edema.

Ethane

Type of gas: Flammable gas

Colour: Colourless

Specific gravity: 1.05 (almost same as that of air)

Odour: Odourless

Flammability limits: 3.0 - 12.4%

Physiological effects

- Inhalation of higher concentrations has an anesthetic effect.
- It can act as a simple asphyxiant by displacing oxygen in the air.
- Ethane is non corrosive.

Ethylene (Ethene)

Type of gas: Flammable gas

Colour: Colourless

Specific gravity: 0.98 (slightly less than air)

Odour: Faint odour that is sweet and musty

Flammability limits: 3.1 - 36%

Physiological effects

- Is a simple asphyxiant.
- Is non toxic and used as anesthetic.
- Prolonged inhalation of substantial concentration of the gas can lead to unconsciousness.

Germane

Type of gas: Flammable and toxic gas

Colour: Colourless

Specific gravity: 2.7 (heavier than air)

Odour: Pungent

Flammability limits: Not available

TLV-TWA - 0.2 ppm

Physiological effects

- Germane is a hemolytic agent (breaks open the red blood cells and releases haemoglobin into the surrounding fluid).
- Exposure to high concentrations can cause discomfort, headache, breathing problems,

nausea, tightness in the chest and abdominal pain. This can lead to unconsciousness and possible death.

- Long term exposure can lead to kidney and neurological damage.

Helium

Type of gas: Non flammable gas

Colour: Colourless

Specific gravity: 0.14 (lighter than air)

Odour: Odourless

Flammability limits: NA

Physiological effects

- Helium is non toxic.
- Is a simple asphyxiant that can deprive the lungs of oxygen.

Hydrogen

Type of gas: Flammable gas

Colour: Colourless

Specific gravity: 0.07 (lighter than air)

Odour: Odourless

Flammability limits: 4.1-74%

Hydrogen burns in air with a pale blue, almost invisible flame.

Physiological effects

- Hydrogen is non toxic, but it can act as a simple asphyxiant by displacing the oxygen in the air.
- Unconsciousness from inhaling air which contains a sufficiently large amount of hydrogen can occur without any warning.

Hydrogen sulfide

Type of gas: Toxic and flammable gas

Colour: Colourless

Specific gravity: 1.2 (heavier than air)

Odour: Rotten egg smell

Flammability limits: 4.0 - 44.0%

- It burns in air producing sulphur dioxide and water.
- H_2S reacts readily with all the metals.
- It dissolves in water and alcohol.

TLV-TWA – 10 ppm

Physiological effects

- In low concentrations can cause irritation of the eyes and upper respiratory tract.
- Exposure to higher concentrations can affect central nervous system and cause pulmonary edema.
- It is instantly fatal if inhaled in very high concentrations.

Liquefied Petroleum Gases

- They are flammable, colourless, non corrosive and non toxic.
- Prolonged inhalation of high concentrations has an anesthetic effect.

- Due to their ability to displace oxygen in the air, they can act as simple asphyxiants.

Methane

Type of gas: Flammable gas

Colour: Colourless

Specific gravity: 0.55 (lighter than air)

Odour: Odourless

Flammability limits: 5.0 - 15.0%

Physiological effects

- Methane is considered as non toxic.
- Inhalation of higher concentrations causes a feeling of pressure on the forehead and eyes, but is reversible once returned to fresh air.
- Methane is a simple asphyxiant.

Nitrogen

Type of gas: Non flammable gas

Colour: Colourless

Specific gravity: 0.97 (slightly lighter than air)

Odour: Odourless

Flammability limits: NA

Physiological effects

- Nitrogen is non toxic and largely inert.

- It can act as a simple asphyxiant by displacing needed oxygen in the air.
- Inhalation of it in excessive concentrations can result in unconsciousness.

Oxygen

Type of gas: Oxidiser

Colour: Colourless

Specific gravity: 1.1 (slightly heavier than air)

Odour: Odourless
Flammability limits: NA

- Pure oxygen is nonflammable, but it supports combustion.
- All materials that are flammable in air, burn much more vigorously in oxygen.
- Combustibles such as oil and grease, burn with nearly explosive violence in oxygen if ignited.

Physiological effects: Nil

Phosphine

Type of gas: Toxic and flammable gas

Colour: Colourless

Specific gravity: 1.2 (heavier than air)

Odour: Garlic or rotting fish

Flammability limits: 1.6 – 98%

- Phosphine is pyrophoric. It can autoignite.

TLV-TWA: 0.3 ppm

Physiological effects

- Phosphine causes irritation of the lungs and the upper respiratory tract.
- Symptoms are shortness of breath, chest tightness, headache, fatigue and nausea.

Silane

Type of gas: Pyrophoric gas

Colour: Colourless gas

Specific gravity: 1.1

Odour: Choking

Flammability limits: 1.4 - 96.0%

TLV-TWA - 5 ppm

Physiological effects

Short term exposure to high concentration of the gas can cause headache, nausea, and irritation of the respiratory tract.

Sulphur dioxide

Type of gas: Toxic gas

Colour: Colourless gas

Specific gravity: 2.3

Odour: Pungent odour

Flammability limits: NA

TLV-TWA - 5 ppm

Physiological effects

- Sulphur dioxide is an extremely irritating gas.
- At low concentrations sulphur dioxide produces an irritating effect on the mucous membranes of the eyes, nose, throat and lungs due to the formation of sulfurous acid, when gas comes in contact with moisture.
- Exposure to higher concentrations produces a suffocating effect due to the closing of the glottis which can be fatal.

Sulphur hexafluoride

Type of gas: Non flammable gas

Colour: Colourless gas

Specific gravity: 5.1 (heavier than air)

Odour: Odourless

Physiological effects

- Sulphur hexafluoride is completely non toxic and non flammable.
- It can act as a simple asphyxiant by displacing the amount of oxygen in the air necessary to support life.

References

- Gas Cylinders Rules 2004
- Indian Standard 13490:1992 - Code of practice for handling speciality gases.
- Encyclopedia of Occupational Health and Safety (Part–II) – International Labour Office.
- Handbook of Laboratory Safety- Norman V. Steere