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Compressed Gas Cylinder Safety in Industries

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Abstract:
Many industrial and Laboratory operations require the use of compressed gases for a variety of different operations. Compressed gases are necessary and serve a variety of purposes in industries. If not treated correctly, however, they can pose serious hazards. They can present chemical hazards and the cylinder themselves present a physical hazard and also those hazards must be prohibited in industries. My aim of this project is to be developed to cover general procedures for the safe handling and storage of all cylinders and provide recommended safety practices for the handling, storage and transportation of compressed Gas cylinder and take the general precautions to prevent injuries caused by asphyxiation, Fire, explosion, High pressure and improper handling of compressed gas cylinders.

Key words: compressed gases, industries, hazards, asphyxiation, Fire, explosion, High pressure, improper handling.

1. INTRODUCTION

Compressed gases used in a variety of industrial, laboratory,clinical areas, for welding, powering industrial trucks and a variety of less common tasks situations.Compressed gases are necessary and serve a variety of purposes. If not treated correctly, however, they can pose serious hazards or unique hazard. Depending on the particular gas, there is a potential for simultaneous exposure to both mechanical and chemical hazards Compressed gas cylinder contents can be toxic, flammable, oxidizing, corrosive, and/or inert. Chemicals that are in gaseous form and pressurized, can quickly spread throughout a space. Pressurized cylinders can become high speed projectiles if the cylinder valve is broken off. This procedure applies to all WHOI personnel that are involved in handling, storing, and using compressed gas cylinders. All users of compressed gas cylinders should review this procedure and the applicable Material Safety Data Sheet (MSDS) and implement applicable hazard control measures.

1.1 THREE MAJOR GROUPS OF COMPRESSED GASES

There are three major groups of compressed gases stored in cylinders: liquefied, non-liquefied and dissolved gases. In each case, the pressure of the gas in the cylinder is commonly given in units of kilopascals (kPa) or pounds per square inch gauge (psig).
Gauge pressure = Total gas pressure inside cylinder - atmospheric pressure
Atmospheric pressure is normally about 101.4 kPa (14.7 psi). Note that compressed gas cylinder with a pressure gauge reading of 0 kPa or 0 psig is not really empty. It still contains gas at atmospheric pressure.

1.1.1 Liquefied Gases

Liquefied gases are gases which can become liquids at normal temperatures when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Initially the cylinder is almost full of liquid, and gas fills the space above the liquid. As gas is removed from the cylinder, enough liquid evaporates to replace it, keeping the pressure in the cylinder constant. Anhydrous ammonia, chlorine, propane, nitrous oxide and carbon dioxide are examples of liquefied gases.

1.1.2 Non-Liquefied Gases

Non-liquefied gases are also known as compressed, pressurized or permanent gases. These gases do not become liquid when they are compressed at normal temperatures, even at very high pressures. Common examples of these are oxygen, nitrogen, helium and argon.

1.1.3 Dissolved Gases

Acetylene is the only common dissolved gas. Acetylene is chemically very unstable. Even at atmospheric pressure, acetylene gas can explode. Nevertheless, acetylene is routinely stored and used safely in cylinders at high pressures (up to 250 psig at 21°C).This is possible because acetylene cylinders are fully packed with inert, porous filler. The filler is saturated with acetone or other suitable solvent. When acetylene gas is added to the cylinder, the gas dissolves in the acetone. Acetylene in solution is stable.

1.2 TYPES OF GAS CYLINDERS

In general, there are three types of gas cylinders:

1.2.1 High Pressure Cylinders

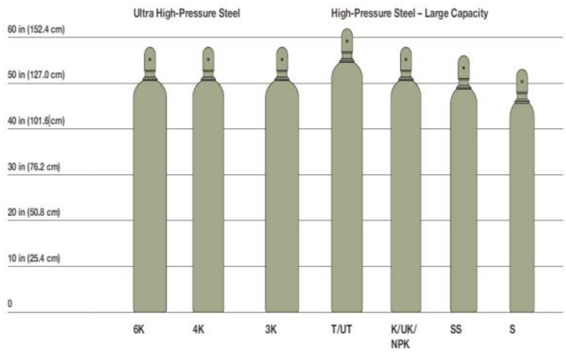


Figure 1.1 High Pressure Cylinders

High pressure cylinders come in a variety of sizes, see Figure.Air Liquid offers a variety of packaging options for both specialty gases and industrial gases. We provide numerous sizes of high-pressure compressed gas cylinders with various volume capacities for any application. Cylinder packs are also available for applications requiring multiple cylinders of compressed gas. In addition, Air Liquid offers liquid gas mixtures in high-pressure piston cylinders. For larger quantities of hydrogen and helium, high-pressure tube trailers are available. Some examples of gases supplied in High pressure cylinders include Nitrogen, Helium, Hydrogen, Oxygen and Carbon Dioxide.

1.2.2 Low Pressure Cylinders

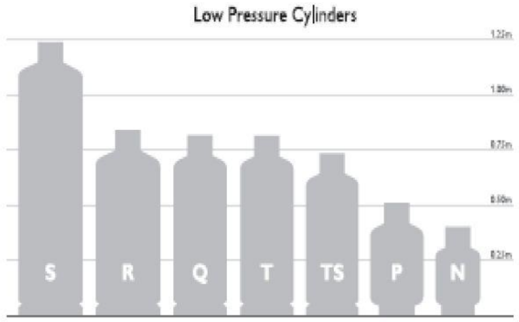


Figure 1.2 Low Pressure Cylinders

Low pressure cylinders come in a variety of sizes, see Figure. Air Liquid provides numerous packaging options for specialty gases and industrial gases, including low-pressure compressed gas cylinders in a variety of sizes and volume capacities for any application. While most of our gas cylinders remain the property of Air Liquid, we also fill customer-owned cylinders provided they meet all appropriate safety requirements.

1.2.2 Acetylene Cylinders

Aggregate filled and acetylene is dissolved in acetone to get sufficient product into the cylinder.

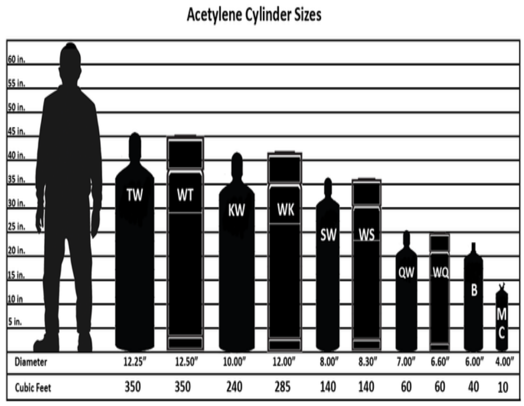


Figure 1.3 Acetylene Cylinders

Unlike most industrial gases, Acetylene is a type of gas that is dissolved into a solvent to keep it safer and more stable. Due to its chemical composition it is an extremely useful gas for the chemical industry but for commercial cylinder applications, is mainly used in cutting and welding processes. It has a burning temperature up to 5,700°F (3,148°C), when burnt with oxygen. Also, pure samples of the gas can decompose violently. Due to all these reasons, critical understanding and steps need to be taken when handling and storing acetylene gas cylinders. This post provides information you need to know on the topic. While many people may logically conclude that acetylene is stored in standard high pressure cylinders which are hollow in construction and gas storage use, this point is not true. Acetylene cylinders are a separate, dedicated and special type of cylinder that is used to store and transport the gas above pressures of 5 psi (.3 bar). A standard acetylene cylinder has a length of 30" (76.2 cm) and has a 10" (24.4 cm) diameter. The cylinder's construction comprises the following materials and components:

1. The exterior of the cylinder is all steel in construction.
2. The interior of the cylinder body is constructed of either a fire resistant or monolithic filler material known as the 'porous masses.
3. The porous material is saturated with acetone or dimethyl form amide (DMF).
4. Older cylinders have fuse plugs in the bottom of the cylinder.
5. The top of the cylinder comprises brass valves, a metal cap, and often safety fuse plugs.

Knowing the composition and traits of an acetylene cylinder will help a user understand and safely handle and store acetylene cylinders. Some examples of gases supplied in low pressure cylinder are **LPG and refrigerant gases.**

2. PROBLEM IDENTIFICATION

Gas cylinders are widely used across NERC for activities ranging from providing special gases for laboratory equipment through engineering uses to field and medical applications. The main hazard from gas cylinders arises from the large amount of stored energy they contain due to the pressure of the compressed gas within them. If the pressurized gas is released in an uncontrolled manner this can cause considerable damage. Uncontrolled release and flying particles (including the cylinder itself) can occur from failure of the cylinder or its fittings and may arise if it is involved in a fire or it suffers damage in a collision. Gas cylinders also present a hazard from their contents which, even if not directly hazardous by nature of their flammable, toxic, corrosive or oxidizing properties, can still cause an asphyxiant hazard by displacing oxygen. The inherent weight and size of cylinders may also present a physical hazard during transport and manual handling or if they topple.

3 HAZARDS IN GAS CYLINDER USAGE

3.1 HAZARDS IN GAS CYLINDER USAGE

- Oxygen deficient atmosphere resulting in asphyxiation.
- Formation of flammable gas air mixtures in case of leakage of flammable gas.
- Oxygen enriched atmosphere in case of leakage of oxygen gas.
- Injury caused by fall of gas cylinders during handling. Hazards in gas cylinder usage (contd.)
- Exposure to high concentrations of toxic or corrosive gases in case of leakage.
- Gas cylinders can explode when exposed to high temperatures, e.g., in case of fire.
- If the valve breaks, the sudden release of compressed gas can turn it into a lethal projectile

3.2 CHEMICAL HAZARDS

Compressed gases can be toxic, flammable, oxidizing, corrosive or inert. In the event of a leak, inert gases such as nitrogen or helium can quickly displace air in a large area creating an oxygen-deficient atmosphere. Toxic gases (e.g. carbon monoxide, ammonia) can create poisonous atmospheres. Flammable, oxidizing or reactive gases such as acetylene, ethylene and vinyl chloride can result in fire and exploding cylinders.

3.3 PHYSICAL HAZARDS

All compressed gas cylinders are hazardous because of the high pressures inside the gas cylinders. Cylinders can become damaged from falling, heat, electric circuits, motion, vibration or anything that can cause a weakness or crack in the cylinder wall or shell. There have been many cases in which damaged cylinders have ruptured, exploding sharp metal pieces throughout the area. The most common hazard associated with cylinders occurs when cylinders tip or fall over. Falling cylinders have broken bones and caused multiple contusions at the University.

3.4 SAFE HANDLING OF COMPRESSED GASCYLINDERS

Safe handling of compressed gas cylinders is not complicated but is extremely important. Safety measures include:

- Store cylinders with their cylinder valves in the closed position;
- Securely attach cylinder valve caps when the cylinder is not in use, is stored, or being moved;
- Transport cylinders securely on a cart designed for cylinder use;
- Secure all cylinders during transport;
- Turn all cylinder valves off;
- Separate cylinders according to their contents.

4 STORAGE AREA AND NEAR BY AREA

1. Cylinders shall be stored in a dry, cool, well ventilated place under cover, away from boilers, open flames, steam pipes or any potential source of heat and such place of storage shall be easily accessible.
2. The storage room or shed shell is made of fire resistant construction.
3. Thin wall cylinders such as liquid petroleum gas and dissolved gas shall not be stacked in a horizontal position.
4. Cylinder containing flammable gas and toxic gas shall be kept separated from each other and from cylinders containing other type of gas by an adequate distance or by a suitable partition wall.
5. Cylinder shall not be stored under condition, which will them cause to corrode
6. Cylinder shall not be stored along with any combustible material
7. Empty cylinder shall be segregated from the filled ones and care shall be taken that all the valves are tightly shut.

Because of the high internal pressure in compressed gas cylinders, they can become projectiles if stored in a manner that could damage the valve. Leaking cylinders can also cause an atmospheric hazard or create an oxygen deficient atmosphere. Due to the hazards associated with compressed gas cylinders, the following rules for storing compressed gas cylinders shall be followed at all times:

4.1 GENERAL STORAGE REQUIREMENTS

All cylinder storage areas must be prominently marked with the hazard class or name of the gases to be stored, e.g. flammable gas storage area, and “No Smoking” signs posted where necessary,

- Always secure gas cylinders upright (with valve end up) to a wall, cylinder hand truck, cylinder is specifically designed to be stored otherwise. An upright position shall include conditions where the cylinder is inclined as much as 45 degrees from the vertical. If being secured to laboratory bench, cylinder bench clamps can only be attached to a bench that is adequate to support the weight of the cylinder.
- Cylinder with a water volume less than 1. Gallons are allowed to be stored in a horizontal position;

4.2 RISK ASSESSMENT

All gas cylinders contain gases under pressure and may present a risk of explosion if not safely handled and stored. UK legislation requires that a site specific risk assessment is required for each gas cylinder store; refer to The Management of Health and Safety at Work Regulations (6) and The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) (9). Every storage situation must be considered on its merits and special circumstances may necessitate variations on the recommended requirements.

The HSE provide a wide range of guidance on carrying out risk assessments on their website. Guidance on the preparation of Risk Assessments under DSEAR (9) is contained in BCGA Guidance Note (GN) 13 (49), DSEAR Risk Assessment.

4.3 LEGAL AND PERMIT REQUIREMENTS

The Planning (Hazardous Substances) Regulations (13) requires that consent from the local authority is obtained to store quantities of dangerous substances over certain thresholds. The regulations contain thresholds for both named substances, such as oxygen and hydrogen, and for generic categories of substances (flammable, toxic). For example the threshold for oxygen storage is 200 tonnes, for flammables 50 tonnes, but for hydrogen only 2 tonnes. In some cases the percentage / partial faction of thresholds (for example, flammables and oxidants) are additive when determining if consent is required. It is unlikely that small quantities of cylinder gas storage will trigger these thresholds and there is a ‘de minimus’ rule for small quantities (<2 % of the threshold). However as the thresholds include all dangerous substances held on the site, for example product, raw material or water treatment chemicals in bulk tanks, and as thresholds for toxic gases are lower, it is recommended that an evaluation is carried out to determinate if the site needs consent. For sites that currently have consent the addition of cylinder gases storage may require modification of the existing consent. Planning permission may be required for significant cylinder storage facilities under the Town and Country Planning Act (1). Contact your local authority for advice.

4.4 LOCATION OF THE STORAGE AREA

The majority of gas cylinders are designed so that they can be stored in the open air and, as such, they will not be adversely affected by inclement weather. Storage areas should be located in an external area where there is good natural ventilation. Adjacent buildings, structures and geographical features may adversely affect natural ventilation and their effect should be taken into account during the risk assessment. The store should not be located in low lying areas; where gases may accumulate.

4.5 STORAGE AREA LAYOUT AND SEPARATION DISTANCES

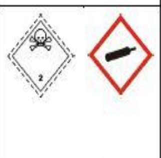
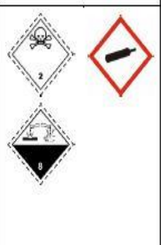
The physical dimensions of the storage area shall take into account the storage requirements , for example, grouping by hazard classification, full/empty or unserviceable cylinders and providing adequate space for access and egress, for safe manual handling operations and the use of mechanical handling equipment.

Means shall be provided to secure cylinders to prevent them falling over, for example, pallets, chains, lashing, etc.

4.5.1 Minimum Recommended Separation Distances

The minimum recommended separation distances between cylinders, the store(s) and other features. Where there are space restraints a permanent physical partition may be used to help achieve the required minimum recommended separation distances. The required minimum recommended separation distance can include the length of the sides of the partition, as shown in Figure. Such partitions should be imperforate and constructed of suitable materials, for example, solid masonry or concrete. Approved Code of Practice and Guidance, and BS 476 (27), Fire tests on building materials and structures. Where the wall separates vulnerable populations from the cylinders (not including inert gases), the fire resistance provided should be a minimum of 60 minutes.

Table 4.1 Gas classifications

Category	Hazard pictograms	Signal word	Hazard statement Precautionary statement for storage	Notes
Class 2 Division 2.1 Flammable		Danger	Extremely flammable gas. Contains gas under pressure; may explode if heated. Store in a well-ventilated place.	Will burn if a source of ignition is present. Example: Hydrogen
Class 2 Division 2.2 Non-flammable Non-toxic Oxidizing		Danger	May cause or intensify fire; oxidizer. Contains gas under pressure; may explode if heated. Store in a well-ventilated place.	Strongly support combustion but do not, themselves burn. Example: Oxygen.
Class 2 Division 2.2 Non-flammable Non-toxic Asphyxiant		Warning	Asphyxiant in high concentrations. Contains gas under pressure; may explode if heated. Store in a well-ventilated place.	Do not in general react with other materials, but can cause asphyxiation by replacement of the oxygen in the atmosphere. Example: Nitrogen.
Class 2 Division 2.3 Toxic		Danger	Contains gas under pressure; may explode if heated. Toxic if inhaled. Store in a well-ventilated place. Store locked up.	Gases which, when inhaled, are known to produce injurious or fatal effects. Example: Hexafluoroisobutene
Class 2 Division 2.3 Corrosive		Danger	Contains gas under pressure; may explode if heated. Causes severe skin burns and eye damage. Toxic if inhaled. Corrosive to the respiratory tract. Store in a well-ventilated place. Store locked up.	Can cause severe burns to the skin and irritation to eyes and respiratory system. Example: Sulpher dioxide

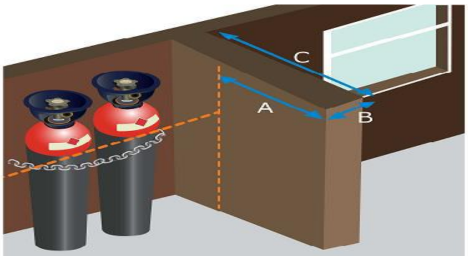


Figure.4.1. Use of a partition to achieve the minimum recommended separation distances

Within Figure the minimum recommended separation distances may include the distance measured around the sides of the partition by determining the sum of A + B + C. If flammable gas cylinders are stored against a building wall the area up to 2 m either side of the storage area and up to 9 m above ground should be imperforate and of a minimum of 30 minutes fire resisting construction. When planning the gas cylinder storage facility, adequate handling space shall be allowed. The total amount of floor space required will depend on the quantity and the size of the cylinders; and the handling equipment to be used during their movement.

5. GAS DETECTORS

5.1 GAS DETECTOR

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.

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Figure 5.1 Gas Detector

Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacture processes and emerging technologies such as photovoltaic. They may be used in firefighting

5.2 GAS LEAK DETECTION

Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Exposure to toxic gases can also occur in operations such as painting, fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc. Common sensors include combustible gas sensors, photoionization detectors, infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and semiconductor sensor. More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries, pharmaceutical manufacturing, fumigation facilities, paper pulp mills, aircraft and shipbuilding facilities, hazmat operations, waste-water treatment facilities, vehicles, indoor air quality testing and homes.

5.3 TYPES OF DETECTORS

Gas detectors can be classified according to the operation mechanism (semiconductors, oxidation, catalytic, photoionization, infrared, etc.). Gas detectors come packaged into two main form factors: portable devices and fixed gas detectors. Portable detectors are used to monitor the atmosphere around personnel and are either hand-held or worn on clothing or on a belt/harness. These gas detectors are usually battery operated..

Figure 5.2Gas Leak Detection

5.3.1 Electro chemical gas sensor

Electrochemical gas detector work by allowing gases to diffuse through a porous membrane to an electrode where it is either chemically oxidized or reduced. The amount of current produced is determined by how much of the gas is oxidized at the electrode, indicating the concentration of the gas. Manufactures can customize electrochemical gas detectors by changing the porous barrier to allow for the detection of a certain gas concentration range. Also, since the diffusion barrier is a physical/mechanical barrier, the detector tended to be more stable and reliable over the sensor's duration and thus required less maintenance than other early detector technologies. However, the sensors are subject to corrosive elements or chemical contamination and may last only 1–2 years before a replacement is required.[4] Electrochemical gas detectors are used in a wide variety of environments such as refineries, gas turbines, chemical plants, underground gas storage facilities, and more.

5 .3.2Catalytic Bead Sensor

Catalytic bead sensors are commonly used to measure combustible gases that present an explosion hazard when concentrations are between the lower explosion limit (LEL) and upper explosion limit (UEL). Active and reference beads containing platinum wire coils are situated on opposite arms of a Wheatstone bridge circuit and electrically heated, up to a few hundred degrees C. The active bead contains a catalyst that allows combustible compounds to oxidize, thereby heating the bead even further and changing its electrical resistance

5.3.3 Photoionization Detectors

Photoionization Detectors (PIDs) use a high-photon-energy UV lamp to ionize chemicals in the sampled gas. If the compound has ionization energy below that of the lamp photons, an electron will be ejected, and the resulting current is proportional to the concentration of the compound. Common lamp photon energies include 10.0 eV, 10.6 eV and 11.7 eV; the standard 10.6 eV lamp lasts for years, while the 11.7 eV lamps typically last only a few months and is used only when no other option is available. A broad range of compounds can be detected at levels ranging from a few ppb to several thousand ppm. Detectable compound classes in order of decreasing sensitivity include: aromatics and alkyl iodides; olefins, sulfur compounds, amines, ketones, ethers, alkyl bromides and silicate esters; organic esters, alcohols, aldehydes and alkanes; H2S, NH3, PH3 and organic acids. There is no response to standard components of air or to mineral acids. Major advantages of PIDs are their excellent sensitivity and simplicity of use; the main limitation is that measurements are not compound-specific. Recently PIDs with pre-filter tubes have been introduced that enhance the specificity for such compounds as benzene or butadiene. Fixed, hand-held and miniature clothing-clipped PIDs are widely used for industrial hygiene, hazmat, and environmental monitoring

5.3.4Infrared Point

Infrared (IR) point sensors use radiation passing through a known volume of gas; energy from the sensor beam is absorbed at certain wavelengths, depending on the properties of the specific gas. For example, carbon monoxide absorbs wavelengths of about 4.2-4.5 μm.The energy in this wavelength is compared to a wavelength outside of the absorption range; the difference in energy between these two wavelengths is proportional to the concentration of gas present.This type of sensor is advantageous because it does not have to be placed into the gas to detect it and can be used for remote sensing. Infrared point sensors can be used to detect hydrocarbons and other infrared active gases such as water vapor and carbon dioxide.

5.3.5 Infrared Imaging

Infrared image sensors include active and passive systems. For active sensing, IR imaging sensors typically scan a laser across the field of view of a scene and look for backscattered light at the absorption line wavelength of a specific target gas. Passive IR imaging sensors measure spectral changes at each pixel in an image and look for specific spectral signatures that indicate the presence of target gases. The types of compounds that can be imaged are the same as those that can be detected with infrared point detectors, but the images may be helpful in identifying the source of a gas

5.3.6 Semiconductor

Semiconductor sensors detect gases by a chemical reaction that takes place when the gas comes in direct contact with the sensor. The dioxide is the most common material used in semiconductor sensors, and the electrical resistance in the sensor is decreased when it comes in contact with the monitored gas. The resistance of the tin dioxide is typically around 50 kΩ in air but can drop to around 3.5 kΩ in the presence of 1% methane. This change in resistance is used to calculate the gas concentration. Semiconductor sensors are commonly used to detect hydrogen, oxygen, alcohol vapor, and harmful gases such as carbon monoxide. One of the most common uses for semiconductor sensors is in carbon monoxide sensors. They are also used in breathalyzer. Because the sensor must come in contact with the gas to detect it, semiconductor sensors work over a smaller distance than infrared point or ultrasonic detectors.

5.3.7 Ultrasonic

Ultrasonic gas detector use acoustic sensors to detect changes in the background noise of its environment. Since most high-pressure gas leaks generate sound in the ultrasonic range of 25 kHz to 10 MHz, the sensors are able to easily distinguish these frequencies from background acoustic noise which occurs in the audible range of 20 Hz to 20 kHz. The ultrasonic gas leak detector then produces an alarm when there is an ultrasonic deviation from the normal condition of background noise. Ultrasonic gas leak detectors cannot measure gas concentration, but the device is able to determine the leak rate of an escaping gas because the ultrasonic sound level depends on the gas pressure and size of the leak. Ultrasonic gas detectors are mainly used for remote sensing in outdoor environments where weather conditions can easily dissipate escaping gas before allowing it to reach leak detectors that require contact with the gas to detect it and sound an alarm. These detectors are commonly found on offshore and onshore oil/gas platforms, gas compressor and metering stations, gas turbine power plants, and other facilities that house a lot of outdoor pipeline.

5.3.8 Holographic

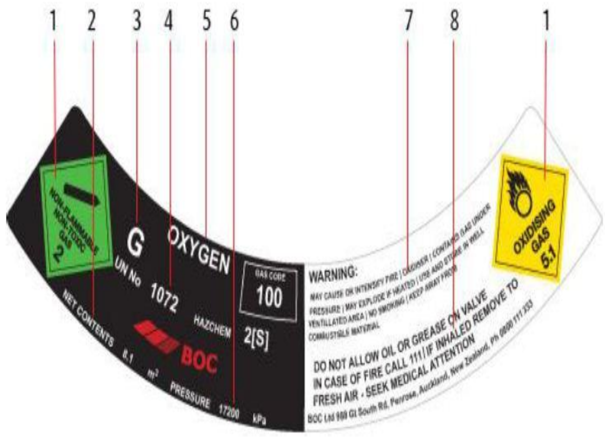
Holographic gas sensor use light reflection to detect changes in a polymer film matrix containing a hologram. Since holograms reflect light at certain wavelengths, a change in their composition can generate a colorful reflection indicating the presence of a gas molecule. However, holographic sensors require illumination sources such as white light or Lasers. and an observer or CCD detector.

6.IDENTIFICATION OF COMPRESSED GAS CYLINDER

6.1 LABELING

All compressed gases received, used or stored must be labeled according to the Gas cylinder rules, 2004. Each cylinder must be marked by label or tag with the name of its contents. Such identification should be stenciled or stamped on the cylinder or placed on a label. Do not accept cylinders without the appropriate labels. The primary identifier of cylinder contents is the label.

- Never rely on the color of the cylinder for identification. Cylinder colors may vary depending on the supplier. Labels on caps have little value because caps are interchangeable.
- All gas lines leading from a compressed gas supply shall be clearly labelled to identify the gas.
- When a cylinder becomes empty, it must be marked EMPTY and stored apart from full cylinders while waiting to be removed.
- Storage areas shall be prominently posted with the hazard class or the name of the gases stored.



1. Dangerous Goods Classification (Hazard Class)
2. Contents of cylinder at standard temperature and pressure (15°C @ 101.3 kPa)
3. Cylinder size
4. United Nations numbering system for safe handling, transport and storage
5. Gas name and grade
6. Nominal filling pressure at standard conditions (for permanent gas)
7. Caution - indicated major hazards
8. General safety information

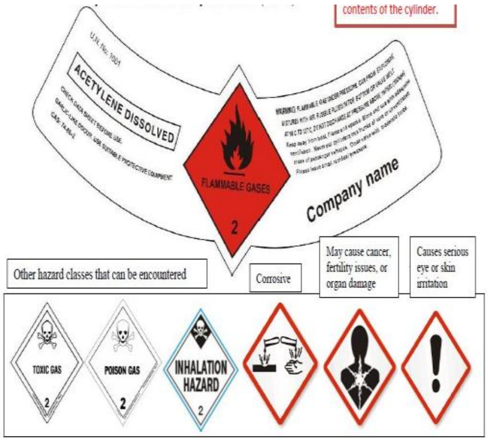


Figure 6 .1 labeling

7. SAFE HANDLINGANDHEALTH EFFECT OF GAS CYLINDER

Many industrial and Laboratory operations require the use of compressed gases for a variety of different operations. Compressed gases are necessary and serve a variety of purposes in industries. If not treated correctly, however, they can pose serious hazards. They can present chemical hazards and the cylinder themselves present a physical hazard and also those hazards must be prohibited in industries. This aim of this research is to be developed to cover general procedures for the safe handling and storage of all cylinders and provide recommended safety practices for the handling, storage and transportation of compressed Gas cylinder and take the general precautions to prevent injuries caused by asphyxiation, Fire, explosion, High pressure and improper handling of compressed gas cylinders. Certain specific properties of compressed gases make them highly useful in various research activities. These gases, however, can be dangerous if not handled in an appropriate manner. Many of the odourless and colourless gases are highly toxic and flammable and this calls for utmost care while handling them.

7.1 GASES USED ROUTINELY IN COMPANYS

- **Inert gases** – Argon and Nitrogen
- **Flammable gases**- Hydrogen and Acetylene.
- **Toxic gases**- Ammonia
- **Cryogenic liquids** - Pegasol
- **Oxidisers** - Oxygen

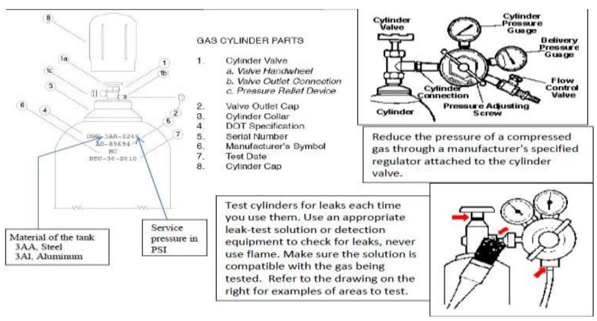


Figure 7.1 compressed gas cylinder parts

7.2 ACETYLENE

The hottest and most efficient of all fuel gases, acetylene (C_2H_2) provides high levels of productivity thanks to good localised heating with a minimum of thermal waste. It also requires the least amount of oxygen to ensure complete combustion. This flammable, colourless gas is lighter than air so does not accumulate at low levels, where it could cause a potential hazard. It is generally supplied dissolved in acetone or DMF (dimethylformamide) in specially designed cylinders to prevent decomposition.

In cutting, oxy-acetylene gives the fastest preheating and piercing times of any fuel gas combination.

Benefits include:

- Improved cut quality
- Higher cutting speeds
- Faster cut initiation time
- Reduced oxygen use.

In atomic absorption flame spectroscopy, acetylene is combined with high-purity synthetic air or nitrous oxide as a fuel for the flame.

7.3 HYDROGEN

- Hydrogen (H2) is an odourless, colourless and tasteless gas that is produced through natural gas steam reforming or the electrolysis of water. Lighter than air, it burns with an invisible, clean (carbon-free and soot-free) flame. It is the only fuel gas that does not contain any carbon atoms. H2 has the highest thermal conductivity of all gases. Combined with oxygen, the hydrogen flame reaches a temperature of 2834°C.

Figure 7.2 safe handling

FIRST AID:

INHALATION Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

SKIN CONTACT: In case of contact, immediately flush skin with plenty of water for at least 10 minutes while removing contaminated clothing and shoes. To avoid risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it.

EMERGENCY RESPONSE:

- In case of fire, use water spray (fog), foam or dry chemical. Apply water from a safe distance to cool container and protect surrounding area.
- Keep unnecessary personnel away. Use suitable protective equipment. Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.
- Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers
- Inert gas is resistant to chemical action under normal temperature and pressure conditions. Non-reactive gases that do not cause a change or reaction when they come in contact with another gas and/or humans. Inert gases are asphyxiants

7.4 ARGON

- Argon is an inert gas, which is colourless and odourless.It is also the third most common gas in the earth's atmosphere, after Nitrogen and Oxygen.
- **SUPPORTING A WIDE RANGE OF SHIELDING, BLANKETING AND INERTING APPLICATIONS WITH ARGON IN THE DESIRED COMMERCIAL PURITY GRADES**
- In high concentrations, it has an asphyxiating effect. As argon is an atmospheric gas (0.93% vol.), it is generally sourced by separating air. A crude argon stream containing up to 5% oxygen is removed from the main air separation column and purified to produce the commercial purity grade required. Argon can also be recovered from the exhaust streams of certain ammonia plants.

7.5 NITROGEN

Nitrogen (N_2) makes up the major portion of the earth's atmosphere, accounting for 78.08% of total volume. It is a colourless, odourless, tasteless, non-toxic and almost totally inert gas. It can be an asphyxiant in high concentrations. Nitrogen is produced in high volumes at air separation plants. A second purification process may be necessary if very high purity levels are required. Membrane techniques can also be used to recover nitrogen in lower purities. Pressure swing adsorption (PSA) techniques are suited to medium-to-high purities. One of the main applications of nitrogen is blanketing, purging and sparging in the food and chemical industries. It can also be found in modified atmosphere packages (MAP) for foodstuffs. In liquid form, it is an agent to shock-freeze food, store biological material, perform cryosurgery and cryogenically grind plastics and rubbers, for instance. In the semiconductor industry, N_2 is used in large quantities as a purge and carrier gas. In electronics, it acts as an inerting agent for epitaxial reactors. It is also useful as a carrier, zero and balancing gas in laboratory analysis. Other common applications include heat treatment, the production of ammonia, fire extinguishing in mines, tyre filling, shrink-fitting and cold traps, where nitrogen can help to increase vacuum efficiency.

7.6 OXYGEN

Oxygen (O_2) is a colourless and odourless gas. It is vital for most life forms on earth. We absorb oxygen through the air we breathe. Medical oxygen is essential in hospital and clinical care for resuscitation and surgery and for various therapies. It is also mixed with nitrogen or helium to create underwater diving mixtures. Oxygen is obtained on a commercial scale through the liquefaction and distillation of ambient air at air separation plants. A second purification process may be necessary if ultra-high purity levels are required. High-purity oxygen can also be produced through the electrolysis of water. Membrane techniques are suited to lower-purity requirements.

7.7 AMMONIA

It is used as refrigerant gas, raw material in Fertilizers, cleaning agent, manufacturing of nitric acid, cyanide, urea and fibers etc. Ammonia Gas – Usage, Health Effects, First Aid and Response Ammonia Gas is an irritating, flammable and colourless liquefied compressed gas packaged in cylinders.

7.8 CRYOGENIC LIQUIDS

Cryogenic liquids and their boil-off vapors rapidly freeze human tissue and cause embrittlement of many common materials which may crack or fracture under stress. All cryogenic liquids produce large volumes of gas when they vaporize (at ratios of 600:1 to 1440:1, gas: liquid) and may create oxygen-deficient conditions. Examples of common cryogenic liquids include liquid nitrogen, oxygen, hydrogen, and helium. The following information applies to the use and handling of cryogenics: Wear face shield and chemical safety goggles when dispensing from cylinder or dewar; Wear appropriate insulated gloves to protect from the extreme cold when handling cryogenic containers. Gloves need to be loose fitting so that they can be readily removed in the event liquid is splashed into them. Never allow an unprotected part of the body to touch uninsulated pipes or containers of cryogenic material; Keep liquid oxygen containers, piping, and equipment clean and free of grease, oil, and organic materials; Do not store cylinders or dewars in environmental chambers that do not have fresh air ventilation.

8 RISK ASSESSMENT REPORT

8.1 FOR DRUM/CARBOY STORAGE AREA

- Proper ventilation will be provided in go down.
- Proper label and identification board /stickers will be provided in the storage area.

8.2 RISK ASSESSMENT REPORT

- Drum handling trolley / stackers/fork lift will be used for drum handling.
- Separate dispensing room with local exhaust and static earthing provision will be made.
- Materials will be stored as per its compatibility study and separate area will be made for flammable, corrosive and toxic chemical drums storage.
- Smoking and other spark, flame generating item will be banned from the Gate.

8.3 FOR CYLINDER STORAGE AREA:

Handling of Cylinder

Gas Cylinders shall be handled only by properly trained persons. Training must include the contents of this guideline as well as any specific information relevant to the gas being used. While handling cylinders, the cylinder shall not be dragged or rolled. Instructions shall be issued to all suppliers for mandatory affixing of cap guards, providing color coding and warning sticker as per Gas Cylinder Rules, 1981. In addition, supplier shall issue Test and Inspection Certificates.

9 SAFETY MEASURES

9.1 DETAILS OF SAFETY MEASURES

It is practically impossible to reduce the risk to zero. However, effective measures can certainly reduce the risk considerably. The safety measures intend to reduce the risk related to various hazards present at the work place.

Safety Measures for Hydrogen Gas Cylinder

- Hydrogen cylinders will be stored in cylinder storage area
- Cylinder storage license will be obtained from PESO as per Gas cylinder rules.
- Hydrogen cylinder storage area will be made well ventilated and safe distance will be maintained as per gas cylinder rule.
- Sprinkler system provision will be made in cylinder storage area.

Figure 9.1 Safety Measures for Hydrogen Gas Cylinder

Safety measures for Acetylene Gas Cylinder

- Safety devices will be provided in the acetylene cylinder storage area to ensure that the pressure, temperature and flow levels are maintained within safe limits.
- The equipment shall be designed, operated and maintained in such a way that during normal operation air or oxygen entry to the equipment is prevented, under pressure shall be prevented ,air acetylene mixtures shall be safely eliminated by purging and excessive rise in temperature and pressure is prevented.
- Regulators shall conformed to ISO-7291 and high pressure hoses shall conform to ISO-14113.Hoses for high pressure acetylene shall have burst pressure not less than 1000 bar (100 MPa).

Figure 9.2Safety measures for Ammonia Gas cylinder

10 HAZARD IDENTIFICATION, RISK ASSESSMENT AND DETERMINING CONTROLS

10.1 HAZARD IDENTIFICATION, RISK ASSESSMENT AND DETERMINING CONTROLS (HIRA&DC)

- Cover all activities at all location of the storage area.
- Identify all the hazards related to activities- what can go wrong?
- Identify all the risk associated with hazards
- Classify the risks as source, situation or Act.
  - Source: Hazard due to inbuilt of property of the equipment, material etc.

○ Situation: Circumstances leading to hazardous exposure.
○ Act: Exposure to hazards due to human negligence or other human factors.

Risk Matrix
The seriousness of a risk is rated in the following risk matrix:

3	6	9
2	4	6
1	2	3

-Probability

-Severity

11 RECOMMENDATIONS

- Carbon Dioxide fire extinguishers shall not be used for extinguishing flammable gas fires due to the risk of static electricity generation. Dry Chemical Powder type fire extinguishers shall be installed at all the strategic locations in the acetylene filling and storage plant.
- Methyl acetylene pro padiene (MAPP) gas, propylene, propane or mixtures of liquefied petroleum gas can be substituted for acetylene as fuel gases for cutting, welding and brazing. These gases are more stable and can be stored in normal cylinders. Their flammable limits are much narrower than those of acetylene (e.g., 3.4 to 10.8 percent for MAPP versus 2.5 to 82 percent for acetylene), so they represent a reduced fire hazard.

	Gas Generator	Gas Cylinder
Convenience	Produce gas on demand with consistent purity Compact stackable solution available providing up to 3 gases (Precision Series) Once installed, the system needs only infrequent maintenance	Cylinder must be monitored to avoid running out of gas Difficult to manoeuvre and requires frequent handling A large cylinder bank can take up valuable work space Depending on usage, cylinders can require frequent changeovers
Consistency	Consistent purity	Inconsistent purity from cylinder to cylinder
Economical	Fast payback/return on investment Low ongoing costs 24/7 gas production	Increasing delivery and rental costs year-on-year Instrument down-time during cylinder changeovers Can run out at inconvenient times
Safe	Minimal gas storage volume Low pressure storage	Health and safety risk during transportation and handling Gas stored at high pressures in large volumes potential for undetected leaks from pipework from cylinder banks
Environmental	No more deliveries or collections Energy efficient Reduced carbon footprint	High energy requirements for compression and purification of gas Cylinders must be transported, often long distances by road
	Gas Generator	Gas Cylinder

12 TRAINING

12.1 TRAINING

- All people engaged in the storage and handling of gases in cylinders shall receive suitable training.
- Training should be carried out regularly under a formalized system and records kept.

Training should be reviewed and / or up-dated following:
a) A related accident or incident.
b) The purchase of gases which have not previously been used on site.
d) The appointment of new and/or transferred employees.
Training should include, but not be necessarily confined to the following subjects:

1. Identification of the cylinder contents
- Cylinder labels, tags, stenciling.
- Color coding.

2. Properties of Gases
- Meaning of flammable, toxic and non-flammable non-toxic gases classification.
- Potential hazards as given in Section 3.
- Contents of each product safety data sheet.
- Fire triangle.
- The different properties and hazards of compressed and liquefied gases.

3. Construction of cylinders
- Materials of construction.
- Difference between welded and seamless cylinders.
- Valve operation and valve types.
- Cylinder information on data plate or stamped into cylinder shoulder.
- Use of guards, caps on valves where fitted.
- Checks on cylinder condition.
- The importance and operation of relief devices.

4. Handling of cylinders
- Cylinder weights full and empty.
- Safe handling techniques for individual cylinders.
- Safe movement of cylinders into or out of pallets.
- Safe movement of palletized cylinders.
- Use of trolleys or other handling devices.
- Use of mechanical handling devices e.g. Fork Lift Truck.

- Operation and maintenance of securing devices for cylinders.
- Personal protective equipment as identified by the risk assessment.

5. Stock management

- Examination of cylinder storage conditions.
- Separation of different categories of cylinders e.g. full and empty cylinders.
- Stock rotation of cylinders.
- Reporting of cylinder defects to line management/supplier.

6. Storage compound

- Need for removal of debris and good housekeeping.
- Need for security.
- Identification by the appropriate signage.

7. Emergency situations

- Action to be taken in cases of:
- Leaking cylinder valve.
  - Fire.
  - Fire impact on cylinders in storage.
  - Emergency contact details for supplier.
  - Location of emergency equipment.
  - Links to emergency services

MOCK DRILLS

To evaluate the effectiveness of emergency preparedness and to spread the awareness among employees mock drill shall be carried out at the interval of every three months. After completion of the mock drill, summary report shall be made and corrections shall be done if any weakness has been observed.

Frequency of mock drills:

- On-site emergency: Once every 6 months
- Off-site emergency: Once every year

13. CONCLUSION

Personnel who handle compressed gases should be familiar with potential hazards before using the gas. In addition to the chemical hazards of compressed gases, hazards accompanying high pressure or low temperature may also be present due to the physical state of the gas, i.e., liquefied or non-liquefied. All compressed gases must be labelled packaged and transported in accordance with local and national requirements and industrial standards. The vehicle /container used for transporting the compressed gases must use respective Hazchem code, TREM cards and MSDS, regardless of color codes used for the cylinders. Prepare safe operating procedures to complete any given job. The supervisor or responsible person shall designate and train employees and workers who are required to handle and use compressed gases and ensure that compressed gases are handled in accordance with safe working practices. It is the supervisor's responsibility that employees and workers using compressed gases understand the proper procedures. Address potential emergencies and corresponding measures necessary to safely avoid such emergencies. Consider scenarios that could result in gas leaks or other emergencies in order to be fully prepared to react appropriately.

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