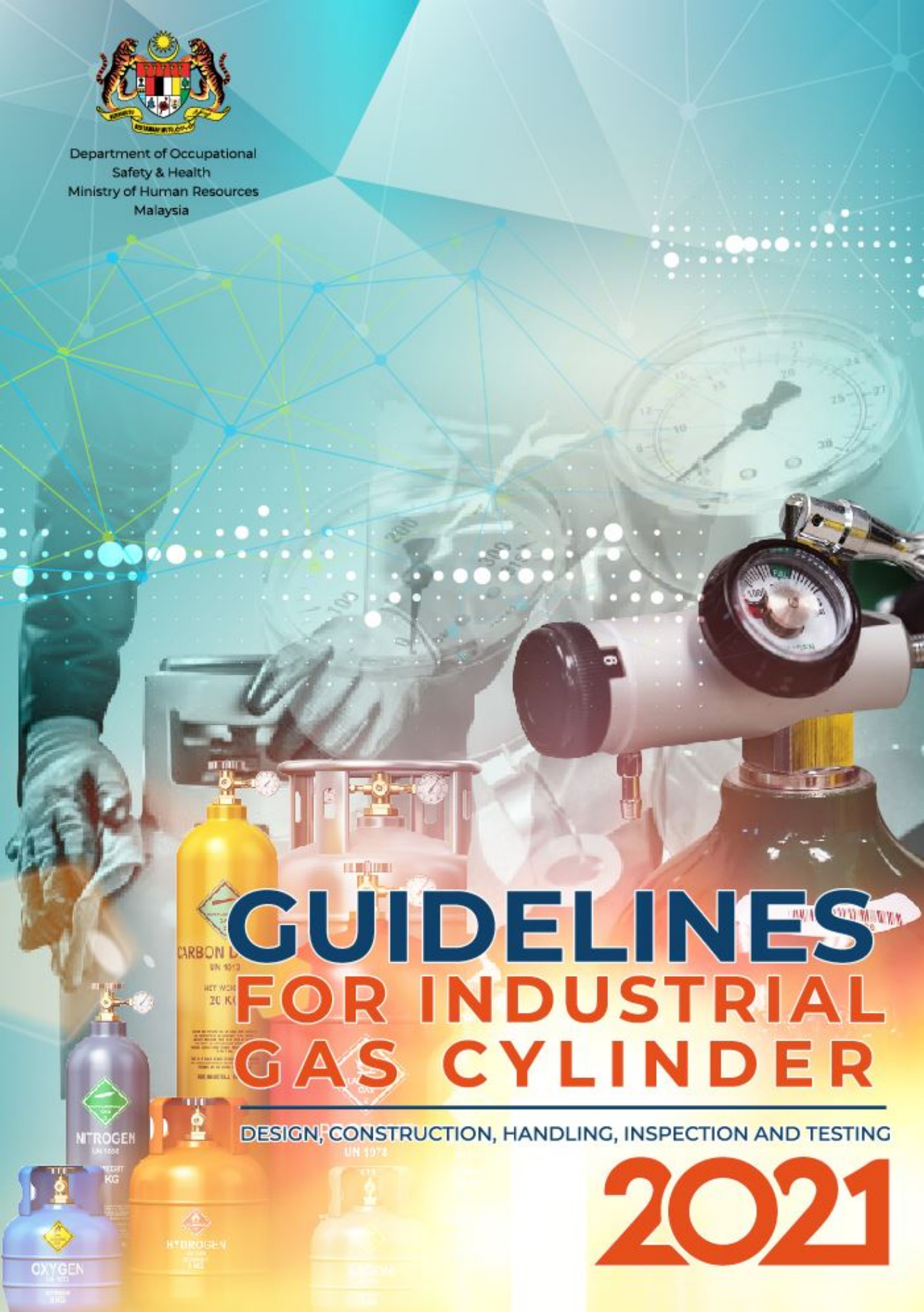
Department of Occupational
Safety & Health
Ministry of Human Resources
Malaysia



GUIDELINES FOR INDUSTRIAL GAS CYLINDER

DESIGN, CONSTRUCTION, HANDLING, INSPECTION AND TESTING

2021

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PREFACE

There are various types of industrial cylinder gas in Malaysia nowadays. However, there is no proper control, neither by the authorities nor agencies, especially at the workplace. In Occupational Safety and Health 1994 (OSHA 1994,) stipulate the duties and responsibilities of the employer, self-employed person or occupier to ensure the use of a plant, in this case, an industrial gas cylinder, is safe and without risks to the health of their employees and persons other than their employees at the workplace.

These guidelines provide advice and guidance to any person or organization that is involved in the design, construction, handling, inspection, testing and disposal of compressed gas cylinders. Hence, the risks can be reduced and helps to prevent accidental damage or injury to people, property and the environment.

These guidelines will be continuously reviewed and improved in order to ensure the safety of the person who are involved in construction, handling, inspection, testing and disposal of gas cylinders.

I would like to thank and acknowledge those who have contributed to the development of the guidelines.

Director General
Department of Occupational Safety and Health
Ministry of Human Resources
Malaysia
2021

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1.0 INTRODUCTION

Gas cylinders are used in a wide variety of industries, including water treatment, food processing and laboratory. They are most commonly used in the medical and manufacturing industries. Medical gas cylinders provide supplemental oxygen, nitrous oxide (anaesthetic functions), nitrogen (surgical tools) and carbon dioxide (to inflate tissue). Whilst in manufacturing, gas cylinders are used for storing fuel for heating systems, vehicles, and torches as well as storing the source of energy for power tools or assembly line machinery.

In these guidelines, unless the context otherwise requires:

Inspecting Authority refers to inspecting authorities as listed in Fourth Schedule, Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970, Factories and Machinery Act 1967 [Act 139];

Consignor means any person, organization or government which prepares a consignment for transport;

Cylinder means a refillable or non-refillable compressed gas container that is commonly used for storing and transporting compressed gases and includes cryogenic receptacle (container). Non-refillable cylinders are designed for one-time use and should never be refilled or reused. Refillable cylinders are designed for refilling and repeated use;

Filling ratio means the ratio of the mass of gas to the mass of water at 15 °C that would fill completely a pressure receptacle fitted ready for use; and

Receptacle means a containment vessel for receiving and holding substances or articles, including any means of closing.

1.1 Compressed Gas

Compressed gas are gases that are stored under pressure in heavy-walled metal cylinders. Compressed gas can be described in the forms stated below: -

i. liquefied gases;

- gases that become liquids at normal temperatures when they are inside cylinders under pressure. They exist inside the cylinder in a liquid-vapour balance or equilibrium. Anhydrous ammonia, chlorine, propane, butane, nitrous oxide and carbon dioxide are examples of liquefied gases.

ii. non-liquefied gases;

- 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 are oxygen, nitrogen, helium and argon.

iii. dissolved gases;

- gases that dissolved in another substance. For example, acetylene. Acetylene is the only commonly used dissolved gas and it is dissolved in acetone or Dimethylformamide (DMF). It is chemically unstable and flammable. Even at atmospheric pressure, acetylene gas can explode. When acetylene gas is added to the cylinder, the gas dissolves in the acetone or Dimethylformamide (DMF) and will be stable.

iv. refrigerated liquefied gases (cryogenic liquids);

- refrigerated liquefied gases or cryogenic liquids are kept in their liquid state at very low temperatures. Refrigerated liquefied gases are extremely cold with boiling points below - 150° C. Refrigerated liquefied gases are heavier than air under cold temperature conditions. The vapours and gases released from refrigerated liquefied gases can be extremely cold and can result in frost bites and blisters. Small amounts of refrigerated liquefied gases liquid can expand into very large volumes of gas. Liquid helium, liquid nitrogen, and liquid argon are the examples of refrigerated liquefied gases.

The pressure of the gas in a cylinder is usually measured in pounds per square inch gauge (psig) or kilopascals (kPa) or bar gauge (barg).

1.2 Compressed Gas Hazardous Properties

Compressed gas can have one or more hazardous properties. It does have inherent pressure hazards and can also create health hazard and flammable atmospheres. Compressed gases may also be flammable, toxic, and corrosive. Examples of hazards related to compressed gas are as follows: -

i. high pressure;

- compressed gases are hazardous due to high pressures inside the cylinders. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder. For example, if unsecured cylinder is knocked over and the cylinder valve breaks, the gas can escape at a high speed resulting in severe injury and property damage.

ii. asphyxiant;

- inert gas such as argon, neon, helium or nitrogen are hazardous because it can displace oxygen in the air and may lead to suffocation. If the oxygen level falls too low, individuals in the affected area can lose consciousness or die from asphyxiation.

iii. pyrophoric;

- some gases, for example non-metal hydrides (diborane, silane, phosphine) or metal carbonyls (nickel carbonyl) are hazardous because it will ignite and burn spontaneously in the air.

iv. cryogenic;

- gases that are kept in their liquid state at very low temperatures and are extremely cold. The main hazards related to the use of cryogenic gases are asphyxiation in oxygen-deficient atmospheres, fire in oxygen-enriched atmospheres and cold burns (hypothermia or frostbite) from intense cold.

v. flammable;

- gases such as acetylene, ethylene and butane can burn or explode in the air when mixed with an oxidizer in a given range of concentrations and provided by the ignition source. Each flammable gas has a specific flammable range. For a gas to be flammable, the concentration should be between its lower flammable limit (LFL) and its upper flammable limit (UFL).

vi. oxidizing;

- gases that contains oxygen above than atmospheric concentrations (23-25%), nitrogen oxides and halogen gases (chlorine and fluorine). These gases can react rapidly and violently with combustible materials and can lead to fires or explosions which are very hard to extinguish and can spread rapidly.

vii. corrosive;

- gases that can burn and destroy body tissues on contact. It can also attack and corroded metals. Common corrosive gases include ammonia, hydrogen chloride, chlorine and methylamine.

viii. poisonous (toxic);

- gases that have the potential to cause adverse health effects depending on the specific gas, its concentration, the length of exposure, and the route of exposure (inhalation, eye or skin contact). Exposure to this type of gas may lead to illnesses, severe respiratory distress, respiratory muscle dysfunction, or immediate death.

1.3 Objective

The objective of this guideline is to provide advice and guidance to any person or organisation that is involved in the design, construction, handling, inspection, testing and disposal of compressed gas cylinders, thereby reducing related risks and helps to prevent accidental damage or injury to people, property and environment.

1.4 Scope

This guideline is intended to specify requirements for the design, construction, operation and handling, inspection, testing and disposal for compressed gas cylinders of sizes from 0.5 litre to 150 litre water capacity.

For specific gas applications such as welding, diving, inerting, etc., additional requirements apply which are not covered in this guideline.

This guideline does not apply to:

i. Cylinders forming part of vehicle e.g NGV cylinder;
ii. Aerosol containers and gas catridges;
iii. Non-refillable cylinders;
iv. Fire extinguishers; and
v. LPG cylinders.

2.0 LEGISLATIVE REQUIREMENTS

Laws and regulations that relates to the use of gas cylinders are as follows: -

i. Factories and Machinery Act 1967 (FMA 1967) [Act 139]; and
ii. Occupational Safety and Health Act 1994 (OSHA 1994) [Act 514].

2.1 Factories and Machinery Act 1967 (FMA 1967) [Act 139]

Section 3 of the Act stipulates the definition of gas cylinders, which means a steel cylinder or bottle used for the storage and transport of compressed, dissolved or liquefied gases. Gas cylinder is also defined as a machinery.

2.2 Occupational Safety and Health Act 1994 (OSHA 1994) [Act 514]

Cylinders that has been defined as a machinery (FMA 1967) are included in the interpretation of 'plant', while gas has been interpreted as a 'substance' under Section 3 of the Act.

- 'plant' includes any machinery, equipment, appliance, implement or tool, any component thereof and anything fitted, connected or appurtenant thereto;
- 'substance' means any natural or artificial substance, whether in solid or liquid form or in the form of a gas or vapour or any combination thereof;

2.2.1 General Duties of Employer, Self-employed Persons and Occupier

Section 15 and 18 of OSHA 1994 stipulate the duties and responsibilities of the employer, self-employed person or occupier to ensure the use of a plant or substance are safe and without risks to health of their employees and persons other than his employees at workplace.

2.2.2 General Duties of Designers, Manufacturers and Suppliers

Section 20 of OSHA 1994 stipulates the general duties of persons who designs, manufactures, imports or supplies any plant for use at work to ensure that the plant is designed and constructed, as to be safe and without risks to health when properly used.

Section 21 of OSHA 1994 stipulates the general duties of persons who formulates, manufactures, imports or supplies any substance for use at work to ensure that the substance is safe and without risks to health when properly used.

2.2.3 General Duties of Employees

Section 24 of OSHA 1994 stipulates the duties of employee while at work to take reasonable care for the safety and health of himself and any other person, to comply with any instruction or measure on occupational safety and health instituted by his employer and to wear any protective equipment to prevent risks to his safety and health.

3.0 DESIGN AND CONSTRUCTION

3.1 General Requirements

Cylinders and their closures shall be designed, manufactured, tested and equipped in such a way as to withstand all conditions, including fatigue, during operation and transportation.

Cylinder shall be designed and manufactured in accordance to current cylinder standard but not limited to the standard as listed below:

i. National Standards such as MS 2542:2013 Gas Cylinder Package [excluding liquefied petroleum gases (LPG) and firefighting] – Code of Practice and International Standards issued by International Organization for Standardization (ISO), European Committee for Standardization (CEN), Transport Canada (TC) or United States Department of Transport (DOT).

ii. Other national standards, subject to the following requirements;

   a. The standard applies to the manufacture of cylinders in the country of origin;
   b. The standard contains equivalent requirements to a standard listed in item (a) for material composition, properties and testing, method of manufacture, testing including type-testing and examination, rejection criteria, marking, documentation and quality assurance.

In no case shall the minimum wall thickness be less than that specified in the design and construction technical standards.

For welded cylinders, only metals of weldable quality shall be used.

Cylinders assembled in bundles shall be structurally supported and held together as a unit. It shall be secured in a manner that prevents movement in relation to the structural assembly and movement that would result in the concentration of harmful local stresses. Manifold assemblies (e.g. manifold, valves and pressure gauges) shall be designed and constructed such that they are protected from impact damage and forces normally encountered in transport. Manifolds shall have at least the same test pressure as the cylinders.

For toxic liquefied gases, each cylinder shall have an isolation valve to ensure that each cylinder can be filled separately and that no interchange of cylinder contents can occur during transport.

Contact between dissimilar metals which could result in damage by galvanic action shall be avoided.

3.1.1 Additional Requirements for the Construction of Closed Cryogenic Receptacles for Refrigerated Liquefied Gases

The mechanical properties of the metal used shall be established for each cylinder, including the impact strength and the bending coefficient.

The cylinders shall be thermally insulated. The thermal insulation shall be protected against impact by means of a jacket. If the space between the cylinder and the jacket is evacuated of air (vacuum-insulation), the jacket shall be designed to withstand without permanent deformation an external pressure of at least 100 kPa (1 bar) calculated in accordance with a recognised technical code or a calculated critical collapsing pressure of not less than 200 kPa (2 bar) gauge pressure. If the jacket is so closed as to be gas-tight (e.g. in the case of vacuum-insulation), a device shall be provided to prevent any dangerous pressure from developing in the insulating layer in the event of inadequate gas-tightness of the cylinder or its fittings. The device shall prevent moisture from penetrating into the insulation.

Closed cryogenic receptacles intended for the transport of refrigerated liquefied gases having a boiling point below -182°C at atmospheric pressure shall not include materials which may react with oxygen or oxygen enriched atmospheres in a dangerous manner, when located in parts of the thermal insulation where there is a risk of contact with oxygen or with oxygen enriched liquid.

Closed cryogenic receptacles shall be designed and constructed with suitable lifting and securing arrangements.

3.1.2 Additional Requirements for the Construction of Cylinders for Acetylene

Acetylene cylinders shall be filled with a porous material, uniformly distributed, of a type that conforms to the requirements and testing specified by the inspection body and which:

i. Is compatible with the cylinder and does not form harmful or dangerous compounds; and
ii. Is capable of preventing the spread of decomposition of the acetylene in the porous material.

In the case of dissolved acetylene, the solvent shall be compatible with the cylinder.

3.2 Materials

Gas cylinders can be made from aluminium, steel, alloys, and composite materials. Mechanical strength, corrosion resistance, and impact resistance are critical factors in determining which material is used.

Construction materials of cylinders and their closures which are in direct contact with dangerous goods shall not be affected or weakened by the dangerous goods intended to be transported and shall not cause a dangerous effect e.g. catalysing a reaction or reacting with the dangerous goods.

Cylinders and their closures shall be made of the materials specified in the design and construction technical standards. The materials shall be resistant to brittle fracture and to stress corrosion cracking as indicated in the design and construction technical standards.

3.3 Service Equipment

Service equipment shall be configured or designed to prevent damage that could result in the release of the cylinder contents during normal conditions of handling and transport. Manifold piping leading to shut-off valves shall be sufficiently flexible to protect the valves and the piping from shearing or releasing the cylinder contents. The filling and discharge valves and any protective caps shall be capable of being secured against unintended opening.

Cylinders which are not capable of being handled manually or rolled, shall be fitted with devices (skids, rings, straps) ensuring that they can be safely handled by mechanical means and so arranged as not to impair the strength of, nor cause undue stresses, in the cylinder (see Figure 1 and Figure 2).

Figure 1
Example of Gas
Cylinder Skid

Figure 2
Example of Gas
Cylinder Trolley

The valves, piping and other fittings subjected to pressure, excluding pressure relief devices, shall be designed and constructed so that the burst pressure is at least 1.5 times the test pressure of the cylinders.

3.4 Approval of Cylinders

The conformity of cylinders shall be assessed at time of manufacture as required by the standards or codes. Cylinders shall be inspected, tested and approved by an inspecting authority. The technical documentation shall include full specifications on design and construction, and full documentation on the manufacturing and testing.

Quality assurance systems shall conform to the requirements of the inspecting authority.

4.0 GAS CYLINDER VALVES AND REGULATORS

The main components of a typical gas cylinder and regulator assembly are shown in Figure 3.

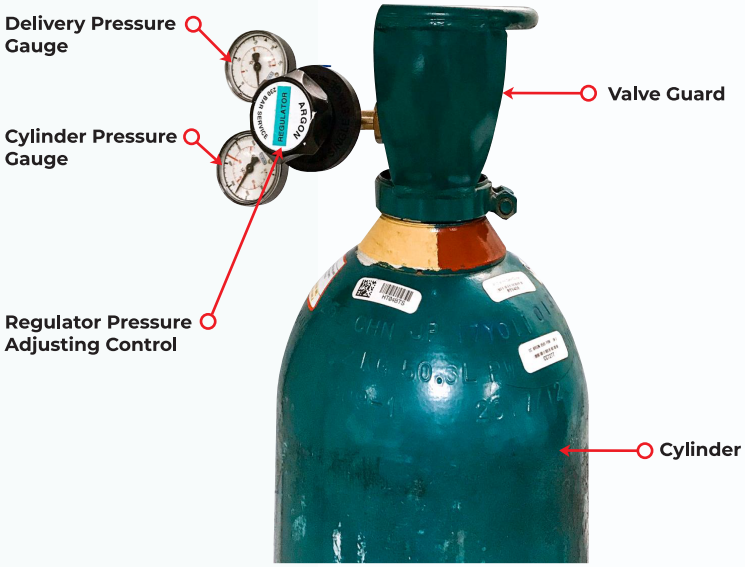

Figure 3
Main components of a compressed gas cylinder and regulator assembly.

The gas cylinder valve is the primary safety mechanism on a gas cylinder and shall not be tampered with. A valve is usually fitted into the open end of the cylinder, normally at the top, or shoulder of the cylinder in order to allow a gas to be contained within a cylinder and to control the release of the gases. A cap, collar, or neck ring commonly protects the valve assembly from damage when the gas is not in use. The valve may have several functions as follows:

- It is a means of closing an opening in a cylinder.
- It provides an inlet port to allow a cylinder to be filled.
- It provides closure to contain the contents within the cylinder.
- It provides an outlet port to allow the gas to be released.
- It can accommodate safety devices, such as non-return valves, pressure relief valves and residual pressure valves.
- It can incorporate an integrated pressure regulator.
- It can incorporate an outlet flow regulating device.
- It can incorporate a contents level (pressure) gauge.
- It can provide a mounting for external components, such as regulators and pipelines.

Valves are designed, constructed, inspected, tested and approved against any national or international standards such as Malaysian Standards or ISO. Due to many properties of the various gases, valves have to be manufactured from compatible materials.

Valves are required to have the same service life and performance as gas cylinders to allow their test pressure and their periodic inspection and test dates to align. Typically, this can mean a minimum service life of at least 10 years for many valves, however, where cylinders have an extended life of up to 15 years, the valve life will need to be taken into consideration. Valves should not be used if their test pressure is below that of the cylinder. Some common valve standards include:

- BS 341, Transportable gas container valves.
- ISO 10297:2014 Gas cylinders - Cylinder valves - Specification and type testing
- BS EN ISO 22435, Gas cylinders. Cylinder valves with integrated pressure
- regulators. Specification and type testing.

4.1 Valve Protection

Valves, especially on larger cylinders, are designed to withstand mechanical impact, and do not need additional protection, but they are often protected from general damage in a variety of ways. The following methods are common:

i. A valve guard - a device that is securely fixed around the valve, but stands higher than the valve hand wheel (see Figure 4). They can be of cast or welded construction or made from non-metallic moulded plastics. They can be attached to either the cylinder shoulder, the cylinder neck (with a Cir-clip), or in some cases, the base of the valve. It does not need to be removed for access to the valve.

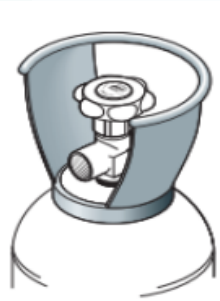

Figure 4
Valve guard

ii. A valve shroud - a type of valve guard but which is an integral part of a welded cylinder or pressure drum, most commonly seen on LPG or refrigerant gas service (see Figure 5).

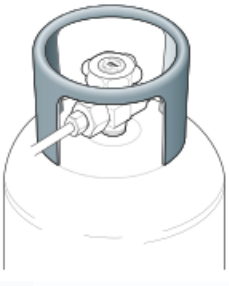

Figure 5
Valve shroud

iii. A valve protection cap - a cover that is securely fixed over the valve during handling, transport and storage which is removed for access to the valve (see Figure 6). It is designed not to contact the valve or the hand wheel.

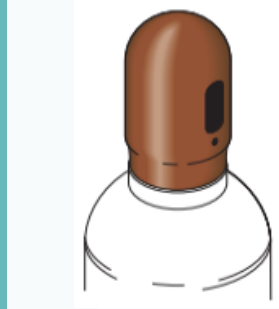

Figure 6
Valve protection cap

The valve outlet port may be protected by:

- A temporary covering, such as a plastic sleeve, often heat shrunk over the outlet port.
- A specialist security cap, typically manufactured from plastic, which requires a small amount of effort to break open. Once open it cannot be refitted.
- A removable (plastic) plug, that screws onto the thread in the outlet port.
- A re-useable fill port plug, (which may be gas-tight) particularly for very high value, risk or purity gases.

This type of protection is fitted once a cylinder has been filled and is used to prevent contamination of the outlet port, but it also provides an indication that the gas cylinder has not been used or tampered with.

4.2 Valve Outlets

A variety of different valve outlets exist. Whilst modern standards have attempted to standardise valve outlets such that there is an international system to prevent the interconnection of non-compatible gases, there remain many outlets in use which are based on traditional national standards. Care should therefore be taken to ensure that only appropriate connections are made.

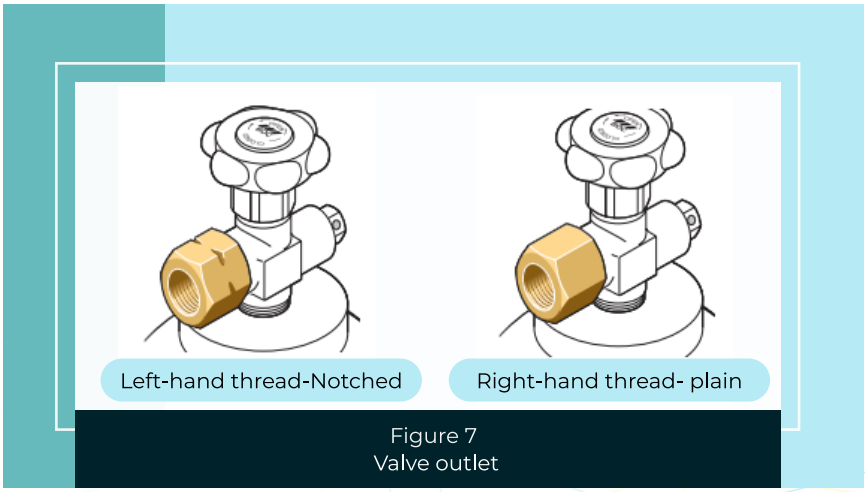

Figure 7
Valve outlet

The valve outlet is designed for a specific gas, or a specific hazard group. For example, valves for non-flammable gases are fitted with right-hand threaded valve outlets, whereas valves used for flammable gases are fitted with left-hand threaded valve outlets (see Figure 7). Components that fit into valve outlets with a left-hand thread are often identified by having a notch cut into the hexagonal connecting nut.

Some common valve outlet standards include:

- BS 341, Transportable gas container valves.
- BS EN ISO 407:2004 Small medical gas cylinders. Pin-index yoke-type valve connections.
- BS ISO 5145:2017 Cylinder valve outlets for gases and gas mixtures. Selection and dimensioning.

Valve outlets may be configured as a top outlet or as a side outlet. More complex valves may have more than one type of valve outlet.

- DO NOT use an adaptor to connect equipment to the valve outlet if it is not compatible.
- DO NOT over-tighten or use excessive force to connect equipment.

4.3 Valves with a Dip Tube

Some gas cylinders that are used to contain liquefied gases incorporate valves fitted with dip tubes. These may be identified by a white line painted on the side of the cylinder, and / or an 'indicator' ring under the valve (see Figure 8).

Figure 8
Valves with a dip tube

Dip tubes can be of various length and design and are fitted to the inlet of the valve. They can have several functions in use, such as, allowing liquid to be withdrawn, enabling a homogenous gas mixture during filling, and maintaining an adequate ullage space within the cylinder.

Some valves may also have twin outlets, allowing a choice between gas or liquid delivery.

4.4 In Use

Remove any valve outlet protection which may be fitted. Carry out a visual inspection of the gas outlet. Ensure it is clear of any contaminants. Any visible material or moisture should be removed by cleaning with a clean, dry, lint-free cotton cloth. Do not apply any oils or greases. For advice on connecting gas cylinders refer to BCGA TIS22: Connecting Gas Cylinders.

The cylinder valves on all gas cylinders are opened by turning the spindle anti-clockwise and then closed by turning the spindle clockwise. Some valves are permanently fitted with hand wheels to rotate the spindle, but others rely on the use of an external cylinder valve key. The key is available from the gas supplier (see Figure 9).

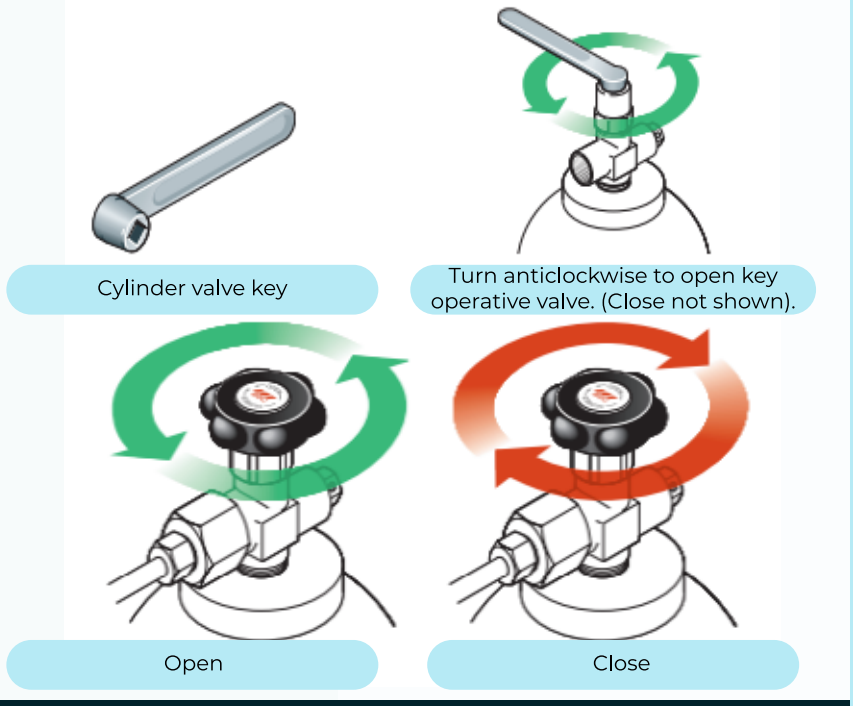

Figure 9
Operating a cylinder valve

Before opening a valve, point the outlet away from personnel. Valves are only to be opened slowly. An opened spindle should NEVER be left against the backstop, but should be turned back at least half a turn to avoid seizure in an open position.

NOTE:

Whilst this applies to the majority of valves, there are valves with a specific operating requirements. It is therefore important that the correct operating procedures are fully understood before attempting to operate a valve.

When the cylinder is in use and the valve is open, keep the cylinder valve key inserted into the valve. In-use a cylinder should always be secured to prevent it from toppling over. Be aware that a loose cylinder falling over with a cylinder valve key inserted can act as a lever, causing damage.

Valves should be checked for leaks using an appropriate leak detection fluid. Care needs to be taken regarding the choice of leak detection fluids. Many valves are manufactured from non-ferrous material such as a brass or bronze, but as copper-based materials they are susceptible to stress corrosion cracking if exposed to amines or ammonia, yet many leak detection fluids contain these chemicals. For reference, refer to EIGA Document 78, Leak detection fluids cylinder packages.

4.5 Regulator

The regulator is the next most important safety device to be fitted to a gas cylinder before operation or use. It allows for the high pressure of the cylinder contents to be brought down to a usable working pressure. Regulators come as single stage for short term applications and two stages for long term applications. Regulators are also constructed from different materials, mainly brass or stainless steel.

The application will define the required regulator. Consult the gas supplier to confirm which kind of regulator to use.

Regulators are designed to be fitted directly to the cylinder valve. No other fittings, connections or lubricants shall be used to connect a regulator to a gas cylinder valve. Regulators for flammable gases are left hand threaded and have a notch cut out of faces on the securing nut to distinguish them from non-flammable gas regulators.

Typical single stage regulator
1. Regulator Outlet Connection
2. Cylinder Valve
3. Inlet Spigot (re-gulator)
4. Regulator Multi-Spanner (Inlet Spigot)

Figure 10
Example of single stage regulator

Always connect a gas cylinder to the item being charged via a regulator and any appropriate pressure system components. Note that some valves are designed complete with a regulator, such as a Valve with Integrated Pressure Regulator (VIPR) (see Figure 11), which include pressure and sometimes flow regulation, making them suitable for connection directly to devices.

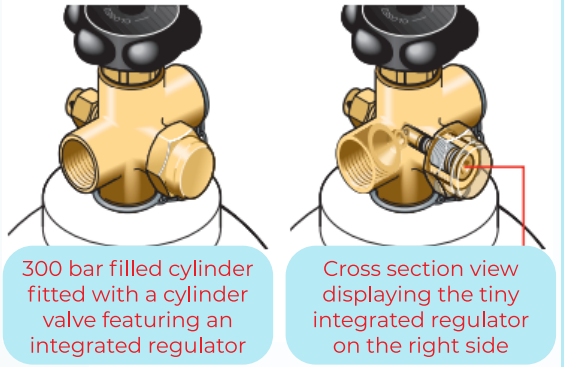

Figure 11
Example of integrated pressure regulator

Where the gas cylinder valve assembly has a residual pressure valve and/or a non-return valve fitted, the user shall not interfere with or remove these devices. A residual pressure valve retains a positive gas pressure inside the cylinder. This pressure prevents the possible ingress of contaminants into the cylinder should the valve be left open. The non-return feature prevents back flow whenever the cylinder is at a lower pressure than the application (involving a fluid) to which it is connected. The use of these devices will have been assessed by the cylinder owner (usually the gas supplier) and will form part of the construction requirements of the cylinder and valve assembly.

4.6 Pressure Relief Devices

Most cylinders or manifolded cylinder packs are fitted with a relief device. In a situation where excess pressure is encountered, this is designed to discharge cylinder contents either completely or only discharge the excess pressure. Discharge of a pressure relief device will be accompanied by a high pitched noise and a jet of gas at high speed. There are three types of commonly used pressure relief devices:

- Burst disc (most common)
- Fusible plug (e.g. acetylene)
- Pressure relief valve

4.6.1 Burst Disc

In the event of overpressure, this is designed to burst, leaving an open passage for gas contents to escape completely (see Figure 12).

e.g. Carbon Dioxide (CO2) cylinders are fitted with a burst disc which operates at approximately 207 bar and is fitted on the cylinder valve.

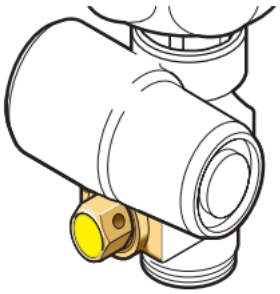

Figure 12
Burst disc

4.6.2 Fusible Plug

This is designed to melt when the cylinder is exposed to high temperatures and will completely release the cylinder contents (see Figure 13).

e.g. Acetylene cylinders are fitted with fusible plugs which melt at approximately 100°C.

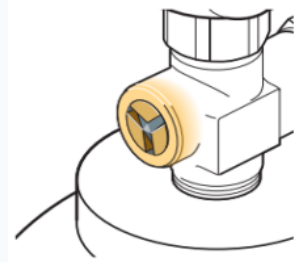

Figure 13
Fusible plug

4.6.3 Pressure Relief Valves

This valve is designed to relieve excess pressure and close again after relieving the excess pressure (see Figure 14). Cylinders containing liquefied compressed gases are usually protected by pressure-relief valves.

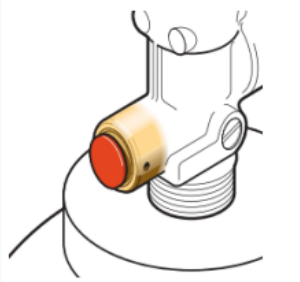

Figure 14
Pressure relief valves

4.7 Connecting a Valve to a Cylinder

There are a variety of threaded connections available for connecting a valve to a gas cylinder. The choice of valve will be determined by the gas supplier. Before fitting a valve, it should be inspected to ensure it is serviceable, it is suitable for the gas contained within the cylinder, and it has sufficient life remaining, for example, to allow its use until the gas cylinder is due its next inspection and test.

The type of threaded connection used is important in terms of achieving a seal without causing valve material strain. There are two common types:

Tapered thread – this seal through the use of a sealant on the threads, such as PTFE tape, and the application of a specified torque. European examples include 17E, 18T and 25E.

Parallel thread - this seal against a captured 'O' ring seal to the shoulder of the valve body, as the valve is clamped down on to the flat face of the cylinder. For this type of seal an additional sealant should not be used. European examples include M18, M25 and M30.

4.8 Disconnecting a Valve from a Cylinder

Cylinders contain gases under pressure. Valves should only be removed under the authority of the cylinder owner taking all necessary precautions to do so safely. In-use, valves should never be removed or exchanged by customers.

4.9 Valves in Operation

There are two main types of valve design for controlling the flow of gas.

The simplest design makes use of an 'O' ring. This operates in a similar manner to a domestic water tap. The wetted area is sealed against the spindle by an 'O' ring(s) located around the spindle. This type of valve is acceptable for general use.

A more comprehensive design utilises a diaphragm. The spindle is connected to a flexible diaphragm, which it moves up and down to open and close the flow. This design prevents any possible gas flow past the spindle. This type of valve is used to control high value or high risk gases, where even small leaks are undesirable, for example in laboratory situations.

4.10 Storage and Transport

When a gas cylinder is not in use, for example when in storage or being transported, the valve should always be closed. This will not only stop gas escaping, but on a nominally empty cylinder it will also prevent contamination entering the cylinder and helps to maintain its integrity.

Where provided, valve protection caps should always be fitted.

4.11 Damaged Valves

If you have a gas cylinder with a damaged valve, do not use the cylinder and seek the advice of gas supplier. If safe to do so, move the gas cylinder to a secure place and quarantine it until appropriate action is taken.

5.0 MARKING AND LABELLING

Every cylinder and their contents must be identified for the clear benefit of all users, fillers, periodic testers, transporters, emergency responders as well as any other persons coming into contact with the cylinder and/or its contents. These requirements are shown in Table 1.

Table 1 Identification of cylinders and their contents

ITEM	FORM OF MARKING
Cylinder identification (manufacture, standards, test dates, approval number, etc)	Stamped or permanently marked
Valves and fittings identification	Stamped or permanently marked
Gas identification	Adhesive or attached labels
User warning identification	
Filling station identification	

5.1 Cylinder Marking

Different countries have different colour coding systems that are used to classify different gases and types of cylinders. In order to provide the information of the cylinders, these identification markings are used to indicate important data about the capabilities, ownership, and inspection history of the cylinder. More information can be seen in Figure 15.

The ISO 13769:2018 Gas Cylinders – Stamp Marking is the standard which apply to the marking of compressed gas cylinders.

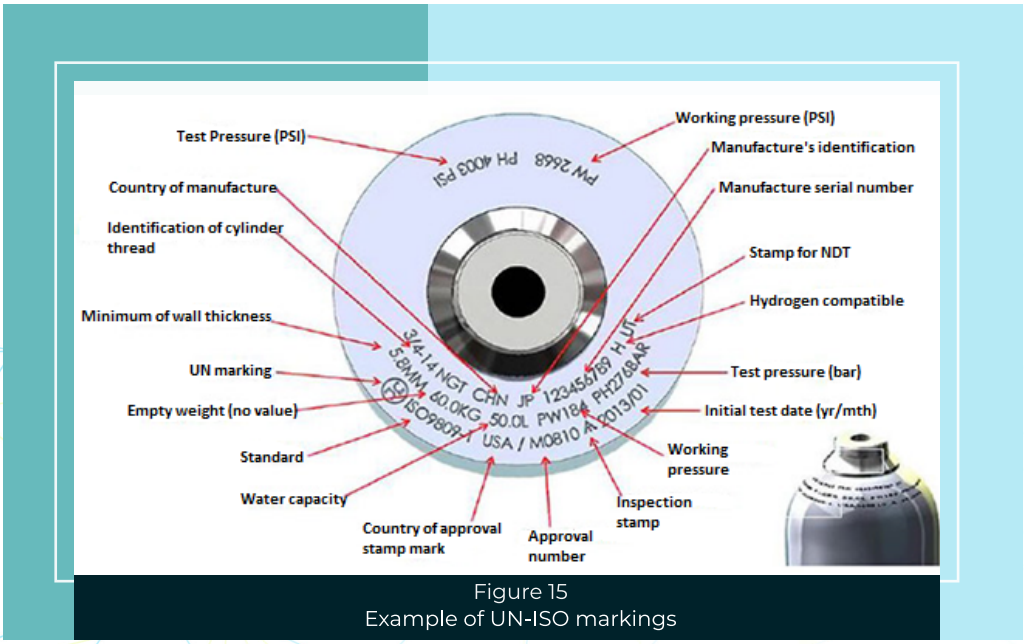

Figure 15
Example of UN-ISO markings

Legend:

Top row:
Contains manufacturing marks such as the cylinder thread type, the country of manufacture, and the serial number.

Middle row:
Contains operational marks such as the minimum wall thickness, the tare or empty weight, water capacity in liter, working pressure (PW) in bar, and test pressure (PH) in bar.

Bottom row:
Contains certification marks such as the UN packaging symbol, the ISO standard, the country or countries of approval, the manufacturer's approval mark, the approved third party independent inspection agency identification stamp, and the initial inspection year and month separated by a slash.

Additional information: -

- ✓ Never rely on the colour of the cylinder for gaseous chemical identification. Color-coding is not reliable because colours can vary with the supplier.
- ✓ Never rely on the colour of the cylinder cap for gaseous chemical identification.
- ✓ Never rely on the label affixed on the cap, if any. Caps can be easily interchanged.
- ✓ Never use a cylinder whose contents cannot be positively identified.
- ✓ Do not remove or deface any marks or tags attached to the cylinder by the supplier.
- ✓ If the labelling or the attached tag on a cylinder becomes unreadable or is missing, the cylinder should be marked "contents unknown" and returned to the supplier.

5.2 Gas Cylinder Content Labelling

Where a gas cylinder contains a hazardous substance, it must be identified and labelled to the classifications of the hazardous substance, the adverse effects and the general precautions that need to be taken in order to prevent the adverse effects.

It is the filler's responsibility to ensure that all cylinders they fill are correctly labelled as to the cylinder's contents.

Before using any gas, read the label and safety data sheet information associated with the specific gas. Gas cylinder with more than one hazard label carry contents with more than one hazardous property. The labelling shall be in accordance with the National Occupational Safety and Health Regulation (Chemical Classification, Labelling and Safety Data Sheets) 2013, OSHA 1994.

6.0 HANDLING AND STORAGE

The contents of a cylinder store the energy that has gone into compressing them, and if the cylinder is weakened, this mechanical energy may be released violently. Some gases store a considerable amount of chemical energy, and may react chemically with the environment. In either case, the chemical energy will augment the mechanical energy and increase the violence of the release.

Cylinders should be stored, handled and used in an upright attitude wherever possible, unless they have been specifically designed for horizontal use. Most general purpose gas cylinders are designed for use in the upright (vertical) attitude. Cylinders such as vehicle cylinders and forklift cylinders are designed for use in the horizontal attitude although forklift cylinders may normally be handled and stored vertically.

Acetylene cylinders contain acetone as a solvent for the gas, and must be used, stored and transported upright to avoid the possibility of acetone being discharged with the acetylene. In the event if the acetylene cylinders are found in horizontal, they must be stood upright for at least one hour before use.

6.1 References on Handling of a Gas Cylinder

The following standards may apply for the handling of a gas cylinder;

a. MS 2560:2014 Gas Cylinders – Safe Handling (First Revision); and

b. ISO 11625:2007 Gas Cylinders – Safe Handling.

6.2 Transportation

This section should be read in conjunction with any rules and regulation in Malaysia which set out the requirements for things such as load segregation, documentation, placarding and load security.

Cylinders should be secured when being transported. Examples of preferred methods include:

a. cylinder(s) suitably supported in bins, racks or suitably approved transportation devices; or

b. cylinders in customised supporting 'cradles' or chocks that are designed to prevent the cylinder(s) from rolling; or

c. cylinder(s) restrained in the upright attitude by way of tie-down straps or ropes

Flammable and toxic gas cylinders should not be stored in the same compartment or in the same part of the vehicle as the driver or passengers. No part of the cylinder or valve should project beyond the dimensions of the vehicle that is transporting them.

6.3 Care and Maintenance

Adequate precautions should be taken at all times to prevent damage to the cylinder during transportation, handling, storage or use.

Protective coatings on cylinders should also be maintained in good condition.

6.4 Gas Cylinder Storage

Irrespective of the type of gas or the quantity stored, gas cylinders should be stored in a location that:

a. is suitable for the type and quantity stored;

b. is secured;

c. is well ventilated;

d. in the case of flammable gases, is of fire resisting construction;

e. in the case of flammable gases or oxidising gases, is suitably separated from potential sources of ignition;

f. in the case of flammable or toxic gases, is not in a person's work area and the quantities stored meet the required separation distances from areas of high and low intensity land use (note that use of such gases);

g. may need to be in a person's work area – such as medical gases in a hospital;

h. in the case of flammable or oxidising gases, has portable fire extinguishers available;

In addition to the above, it is good practice for the cylinders to be protected from the weather.

7.0 FILLING CYLINDERS

Cylinders should be filled by a trained person, namely filler. To become a filler, a person should know and be familiar with:

a. the different forms of compressed gases, namely –

   i. low pressure liquefied gas;
   ii. high pressure liquefied gas;
   iii. permanent gas; and
   iv. cryogenic gas;

b. the factors that can trigger failure of a cylinder;

c. the potential adverse effects associated with the different forms of compressed gas;

d. the requirements of relevant standards or codes covering the visual inspection and safe charging of a cylinder including:

   i. an approved cylinder design;
   ii. cylinder filling terminology, e.g., tare weight, empty weight, ullage, filling ratio, water capacity, working pressure, test pressure;
   iii. cylinder safety devices;
   iv. test periods for types of cylinders the filler will be charging;
   v. cylinder markings;
   vi. valve markings;
   vii. the different types of valves fitted to cylinders the filler will be charging;
   viii. external visual inspection of cylinders for general condition; and
   ix. in the case of a liquefiable gas cylinder, how to correctly calculate the maximum filled weight using the formula:

MAXIMUM FILLED WEIGHT = (WATER CAPACITY x FILLING RATIO) + TARE OR EMPTY WEIGHT

"tare weight" in relation to -

1. acetylene cylinder means the weight of the cylinder together with any fittings, permanently attached and includes the weight of valve any safety device, porous mass, requisite quantity of solvent for dissolving acetylene, and the weight of acetylene gas saturating the solvent at atmospheric pressure and temperature of 150 ^{o}C;
2. liquefiable gas cylinder means the weight of the cylinder together with any fittings permanently attached thereto and includes the weight of valve;
3. permanent gas cylinder means the weight of the cylinder together with any fittings permanently attached thereto and excludes the weight of valve;

7.1 Filler Responsibility

The filler is responsible to record the movement of each cylinder and the date of the cylinder to be re-qualified. Only cylinders with a valid requalification date can be refilled.

7.2 Pre-filling Checks

Before filling a cylinder, the filler should ensure that:

a. the cylinder is marked according to standard followed;
b. the cylinder is within its required test period;
c. the cylinder is in good external physical condition;
d. the cylinder markings and labelling are clear and correspond to the gas to be filled;
e. the valve is suitable and in good condition; and
f. where required, an over-pressure protection device is fitted, e.g., pressure relief valve, burst disc.

Prior to filling, the filler shall perform an inspection of the cylinder and ensure that the cylinder is authorized for the gas. Shut-off valves shall be closed after filling and remain closed during transport. The consignor shall verify that the closures and equipment are not leaking.

7.3 Checks During Filling

Once a cylinder has commenced being filled, the filler should ensure that:

a. the cylinder valve is not leaking via its neck threads, or valve spindle;
b. the rate of filling does not exceed the manufacturer's recommendation for the cylinder design; and
c. the filler remains in attendance at the filling point at all times while the cylinder is being filled.

7.4 Post Filling Checks

After filling a cylinder, the filler should ensure that:

a. the cylinder is correctly labelled in accordance with section 5.2 of this guidelines;
b. the cylinder is labelled with the name or other suitable identification of the filling station;
c. the cylinder has been checked for leaks by:

    i. leak detection fluid (LDF);
    ii. immersing the cylinder and valve in a water bath; or
    iii. electronic leak detector;

d. the final fill pressure or filled weight has not exceeded the marked fill pressure or the calculated maximum filled weight respectively.

7.5 Decant Filling

Decant filling by weight control is the only permitted method that can be used to fill cylinders having a water capacity less than 5 litres. Decant filling is a controlled delivery using only the pressure from the supply cylinder or tank to transfer the gas, and is not pump assisted.

7.6 Consequences of Over-filling

If a liquefied gas cylinder is over-filled, then the expansion of the liquid phase as the temperature increases may cause the cylinder to become 'liquid-full' with no remaining ullage space. If the temperature continues to rise, the pressure in the cylinder will rise disproportionately. At the very least, liquid will be forced out of the pressure relief valve risking malfunction of attached appliances and a fire. If there is no pressure relief valve, or it fails to operate, the cylinder may burst after only a small rise in temperature.

7.7 Cylinders Prohibited From Filling and Transport

Cylinders shall not be offered for filling and transport:

a. When leaking;
b. When damaged to such an extent that the integrity of the cylinder or its service equipment may be affected; or
c. When the cylinder is beyond its requalification time limit.

Cylinder may be offered for filling and transport when:

a. the cylinder and its service equipment has been examined and found to be in good working order; and
b. the required certification, retest, and filling markings are legible.

7.8 Filling Stations

The occupier of the site is normally the person with day to day responsibility for its operation. The occupier is responsible for ensuring that the requirements of the relevant Act and regulations are met at all times. This person must ensure a high standard of filler competence and that filling station equipment is well maintained.

7.8.1 What are the Requirements?

The occupier must ensure that:

a. all persons filling cylinders are trained for the gas traffic and cylinder types filled;
b. all equipment necessary to safely fill cylinders is provided and maintained; and
c. the cylinder filling and cylinder storage areas are separated by the required distances and are kept orderly and tidy.

7.8.2 What Equipment is Required?

The occupier must ensure that the following items of equipment are provided and maintained:

a. Cylinder filling instructions;
b. Filling hoses of a suitable pressure rating and suitable for the gas being filled;
c. All required cylinder filling connections;
d. Soapy water solution or a water bath, for leak checking;
e. For filling liquefied gases, calibrated weighing scales of a type suitable for the gas being filled;
f. For filling of flammable gases, a portable fire extinguisher is provided;
g. All hand tools necessary for fitting and removing filling connections, e.g. adjust able spanner, flat bladed screwdriver, etc;
h. Filling station identification labels;
i. All other labels required for identification of cylinder contents;
j. Leather gloves;
k. Eye protection;
l. First-aid kit on site; and
m. Warning signage.

7.8.3 Location and Infrastructure Requirements of the Filling Plant

The area where the filling operation is to take place shall:

a. be an external area or inside a structure which has been assessed to assure there is a high ventilation rate. Filling shall not take place in an enclosed area;
b. be constructed primarily of non-flammable materials;
c. be constructed using compatible materials, for example, when filling with oxygen avoid the use of oil, greases and bitumen products;
d. have fire-fighting equipment / facilities;
e. have an electrical installation adequately rated for the area in which it is installed;
f. have adequate lighting;
g. be exclusively for the filling operation;
h. have no other hazardous products stored within the filling area;
i. take into account human factors in the design of the filling equipment and the operations around it;
j. be ergonomically designed and laid out, for example, to ensure visibility of pressure gauges and access to valves;
k. be subject to regular housekeeping, including the collection and removal of all combustible products, such as packaging, which are no longer required; and
l. have multiple independent escape routes available. Emergency exits shall not require a key, card, or code to operate. All exits shall be able to be opened from the inside, for example, by the use of a push bar.

During the site risk assessment, the hazard from oxygen depletion and enrichment shall be assessed, as well as the hazard due to any other properties of the gases on-site. This may require an assessment for the use of gas detection equipment. The use of monitoring equipment, such as close-circuit television (CCTV), is recommended during filling plant operation.

7.9 References on Filling of a Gas Cylinder

The following standards may apply for the filling of a gas cylinder;

a. ISO 24431:2016 Gas Cylinders -- Seamless, Welded and Composite Cylinders for Compressed and Liquefied Gases (Excluding Acetylene) -- Inspection at Time of Filling;
b. ISO 11755:2005 Gas Cylinders -- Cylinder Bundles for Compressed and Liquefied Gases (Excluding Acetylene) -- Inspection at Time of Filling
c. MS 2239:2009 (CONFIRMED:2015) Gas cylinders - Cylinders for compressed and liquefied gases (excluding acetylene) - Inspection at time of filling (ISO 24431:2006, MOD) (First revision)

8.0 INSPECTION, TESTING, REQUALIFICATION AND DISPOSAL

New cylinders shall be subjected to testing and inspection during and after manufacture in accordance with the applicable design standards.

The following standards or documents may apply to the periodic inspection, testing and requalification of compressed gas cylinders:

a. MS 1720:2003 Welded Carbon Steel Gas Cylinders – Periodic Inspection and Testing

b. MS ISO 10461:2011 Gas cylinders - Seamless aluminium-alloy gas cylinders - Periodic inspection and testing (ISO 10461:2005, AMD. 1:2006, IDT)

c. ISO 18119:2018 Gas cylinders -- Seamless steel and seamless aluminium-alloy gas cylinders and tubes -- Periodic inspection and testing

d. ISO 10460:2018 Gas cylinders -- Welded carbon-steel gas cylinders -- Periodic Inspection and Testing

e. ISO 11623:2015 Gas cylinders -- Composite Construction -- Periodic Inspection and Testing

f. AIGA090/14: A Reference Guide for Requalification of Gas Cylinders

8.1 Cylinder Requalification

A cylinder shall be due for periodic inspection and tests on its first receipt by a filler following the expiry of the interval established in national and international standards.

Provided that the cylinder has been subjected to normal conditions of use and has not been subjected to abusive and abnormal conditions that would render the cylinder unsafe, there is no general requirement for the user to return a gas cylinder before the contents have been used even though the periodic inspection and test interval may have lapsed.

It is the responsibility of the owner or user to submit the cylinder for periodic inspection and test within the interval specified by relevant cylinder design standards. Reference shall be made to the manufacturer or inspection body if there is a question on the re-test period for specific gases.

No cylinder shall be refilled beyond the expiry date of requalification.

Requalification period of a cylinder shall follow any national and international standards recognised by the countries.

For compressed gases service, the United Nations recommended period for requalification is a 5-year interval. A 10-year interval may be used if the dryness of the product and that of the filled cylinder are such that there is no free water. This condition shall be proven and documented within a quality system of the filler. If these conditions cannot be fulfilled, alternative or more frequent testing may be appropriate, according to the recommendations.

For UN 1001 acetylene, dissolved, the test period is 10 years.
For UN 3374 acetylene, solvent free, the test period is 5 years.

Under certain conditions, a shorter time interval for requalification may be required at all times, e.g. the dew point of the gas, polymerization reactions and decomposition reactions, cylinder design specifications, change of gas service, etc.

Failed cylinders cannot be repaired and must be disposed of in a safe manner.

8.2 Cylinder Disposal

Other than the end of life cylinders, there are normally four other possible reasons for disposing of cylinders:

a. External condition - the cylinder shell could have been subjected to fire or physical damage and failed the inspection at time of filling (see EN 12754 Transportable gas cylinders. Cylinders for dissolved acetylene. Inspection at time of filling);

b. Internal condition e.g. contamination by water, carbon black, broken mass etc.;

c. Commercial decision - e.g. the cylinder design has been superseded by a more recent design etc.; or

d. Periodic inspection - failed to satisfy the prevailing periodic inspection requirements.

Cylinder disposal methods are as follows:

a. Release the gas content contained in the cylinder in a safe manner;

b. Removing the valve located on the cylinder;

c. Make sure there is no gas in the cylinder;

d. The thread neck cylinder shall be completely damaged and shall not be used again;

e. Cylinder must be cut and destroyed; and

f. For acetylene cylinders, please refer AIGA 036/16 - Revision of AIGA 036/06, Asia Industrial Gases Association (Guidelines for the Management of Waste Acetylene Cylinder) or other relevant international standards.

9.0 REFERENCES

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