Compressed Gas Cylinder Safe Handling, Use and Storage

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Safety Resources

University of Saskatchewan

College/Unit:	**Safety Resources**
Procedure Title:	**Compressed Gas Cylinder Safe Handling, Use and Storage**

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Revision History

Revisions to this procedure are to be documented in Table 1, Revision History.

Table 1: Revision History

Document Section	Details of Amendments	Date	Author (Initials)

Contents

1 Purpose

The guide is intended to provide information on the safe handling, use and storage of compressed gases at the University of Saskatchewan.

2 Applicable to

This guide is applicable to all faculty, staff, students, and visitors at the university who will be using and handling cylinders of compressed gases.

3 Definitions

Bonding: Bonding is connecting two or more conductive objects with a conductor, such as a copper wire, that equalizes the potential charges between them.

Compressed Gas: Any contained mixture or material with either an absolute pressure exceeding 275.8 kPa at 21ºC or an absolute pressure exceeding 717 kPa at 54ºC, or both, or any liquid having an absolute vapour pressure exceeding 275.8 kPa at 37.8ºC.

Flashback Arrestor (or Flame Arrestor): A device commonly used with oxy-fuel welding or cutting activities to prevent the flame from burning back into the hose or gas cylinders thereby preventing damage to equipment. The arrestor is placed between the torch (or flame source) and the hoses, although there are arrestors that attach directly to the gas regulator.

Grounding: Grounding is connecting one or more conductive objects directly to the earth using ground rods, cold water copper pipes, or building steel. Unlike bonding, grounding drains the static charges away as quickly as they are produced.

Lecture Bottle: A small compressed gas cylinder that is typically 2-3 inches (5-8 cm) in diameter and 12-18 inches (30-45 cm) in length. These smaller cylinders are used for holding calibration gases or in applications where large quantities of gases are not required.

LEL – Lower Explosive Limit: The lowest concentration of a gas, in air, that will burn or explode when exposed to an ignition source.

Liquefied Gas: 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.

MSDS: Material Safety Data Sheets.

Odour Threshold: The odour threshold is the lowest concentration of a chemical in air that is

detectable by the human sense of smell. Odour thresholds should only be regarded as estimates as the ability to detect odours in a work environment varies from person to person.

Olfactory Fatigue: Olfactory fatigue, also known as odor fatigue or olfactory adaptation, is the temporary, normal inability to distinguish a particular odour after a prolonged exposure to that airborne compound.

PPE: Personal protective equipment.

PPM: Parts per million, a unit of concentration.

PSI: Pounds per square inch, a unit of pressure.

PSIG: Pound force per square inch gauge, a unit of pressure relative to the surrounding atmosphere.

Supervisor: A person who is authorized by the university to oversee or direct the work of employees and students. The authority to supervise employees and students is inherent in their job function. Although the university recognizes the ultimate responsibility of performing work in a safe manner lies with the individual employee, supervisors have additional responsibilities, which arise from their role as persons responsible for providing competent supervision and managing the workplace under their authority.

TC/DOT: Transport Canada/Department of Transport.

UEL – Upper Explosive Limit: The maximum concentration of a gas, in air, that will burn or explode when exposed to an ignition source.

4 Responsibilities

Supervisors are responsible to:

- Ensure staff, students and visitors in their charge receive appropriate training specific to the compressed gases they are handling and using;
- Ensure that compressed gases are used only for their intended purpose and in accordance with defined procedures and rules;
- Ensure that applicable Material Safety Data Sheets (MSDS), or other relevant literature is made readily available to staff and students;
- Provide staff, students and visitors with appropriate personal protective equipment (PPE);
- Maintain appropriate records pertaining to the handling and use of compressed gases including an up-to-date inventory, training records, and reported incidents;
- Provide appropriate supervision of staff and students;
- Ensure staff, students and visitors adhere to applicable occupational health and safety regulations for the use of compressed gases; and

- Investigate reported incidents to determine the cause and to develop appropriate preventative measures to minimize a recurrence.

Staff, students and visitors are responsible to:

- Adhere to defined procedures and rules, and applicable occupational health and safety regulations for the use of compressed gases;
- Wear and maintain PPE provided;
- Notify their supervisor of identified hazards related to the use of compressed gases; and
- Notify their supervisor of any incident related to the use of compressed gases.

Safety Resources is responsible to:

- Provide information and advice in health, safety and environmental protection including on the safe use of compressed gases;
- Develop and administer health, safety and environmental programs;
- Provide health and safety training;
- Provide hazardous waste disposal services;
- Respond to reported incidents and spills of hazardous materials; and
- Support regulatory compliance.

5 Training Requirements

Only trained personnel shall use compressed and liquefied gases. Training must include all relevant safety training courses offered by Safety Resources. This includes, but is not limited to:

- Safety Orientation for Employees;
- Safety Orientation for Supervisors;
- Laboratory Safety and/or Workplace Hazardous Materials Information System (WHMIS); and
- Transportation of Dangerous Goods training.

Staff, students and visitors must also receive site-specific training on the particular activities they will be engaged in including known hazards and how to protect themselves from those hazards. Training must also be provided on work procedures, rules and emergency response associated with the work to be performed.

It is the responsibility of the supervisor to maintain appropriate records pertaining to staff, student and visitor training.

To register for a safety course, please visit our website at http://safetyresources.usask.ca/. For further information on training requirements or assistance with training, please contact Safety Resources at 306-966-4675.

6 Hazards Associated with Working with Compressed Gases

There are a number of hazards associated with the handling, use and storage of compressed gases. Following is a summary of known hazards.

Pressure Hazards: All compressed gases are hazardous due to the high pressure inside the cylinder. Damage to the cylinder valve can result in a rapid release of the high pressure gas propelling the cylinder causing personal injury and damage to property.

Fire and Explosion Hazards: Flammable gases such as acetylene, butane and hydrogen can burn or explode under certain conditions. If flammable gases are allowed to accumulate until their concentration is between their defined Lower Explosion Limit (LEL) and Upper Explosion Limit (UEL), an explosion may occur if there is an ignition source present.

Health Hazards: Many gases are toxic and can cause serious health problems dependent upon the specific gas, its concentration, length of exposure, and route of entry. Health symptoms of exposure to gases can be immediate, or delayed.

Chemical Burn Hazards: Some compressed gases are corrosive. They can burn or damage skin on contact, burn the eyes or lungs if inhaled, as well as attack and corrode metals.

Asphyxiation Hazards: Asphyxiation is the main hazard associated with inert gases such as helium, argon, and nitrogen. If these gases escape undetected into the atmosphere, they can quickly reduce the oxygen levels below concentrations necessary to support consciousness and life.

Physical Hazards: Compressed gas cylinders are large, heavy and awkward to handle. Improper handling, or not properly securing cylinders while in use, can cause cylinders to fall causing injury to workers.

7 General Gas Cylinder Information

Many manufacturers colour code their cylinders of compressed gases. These colour coding systems are not standardized and should not be used to verify the contents in a compressed gas cylinder. Manufacturers are required, by law, to label their cylinders to identify the gases they contain and the label should be used to positively identify the contents of a cylinder.

Gas cylinders are available in a variety of sizes to suit a particular need or application. Common cylinder sizes are presented in Table 1.

Figure 1: Examples of compressed gas cylinders. Image courtesy of netcylinders.com.

Table 1: Dimensions of common compressed gas cylinders.

Approximate Dimensions (Diameter × Height) (inches)	**Material**
9 x 55	Steel
9 x 51	Steel
7 x 46	Steel
7 x 31	Steel
10 x 54	Aluminum
8 x 48	Aluminum
7 x 33	Aluminum
2 x 12 (lecture bottle)	Steel

8 Compressed Gas Regulators

Gas regulators are used to reduce the high pressure of a compressed gas cylinder to safe and useable pressures. They are designed for use with a specific gas, within prescribed pressure ranges. The main components of a typical gas cylinder and regulator assembly are shown in Figure 2.

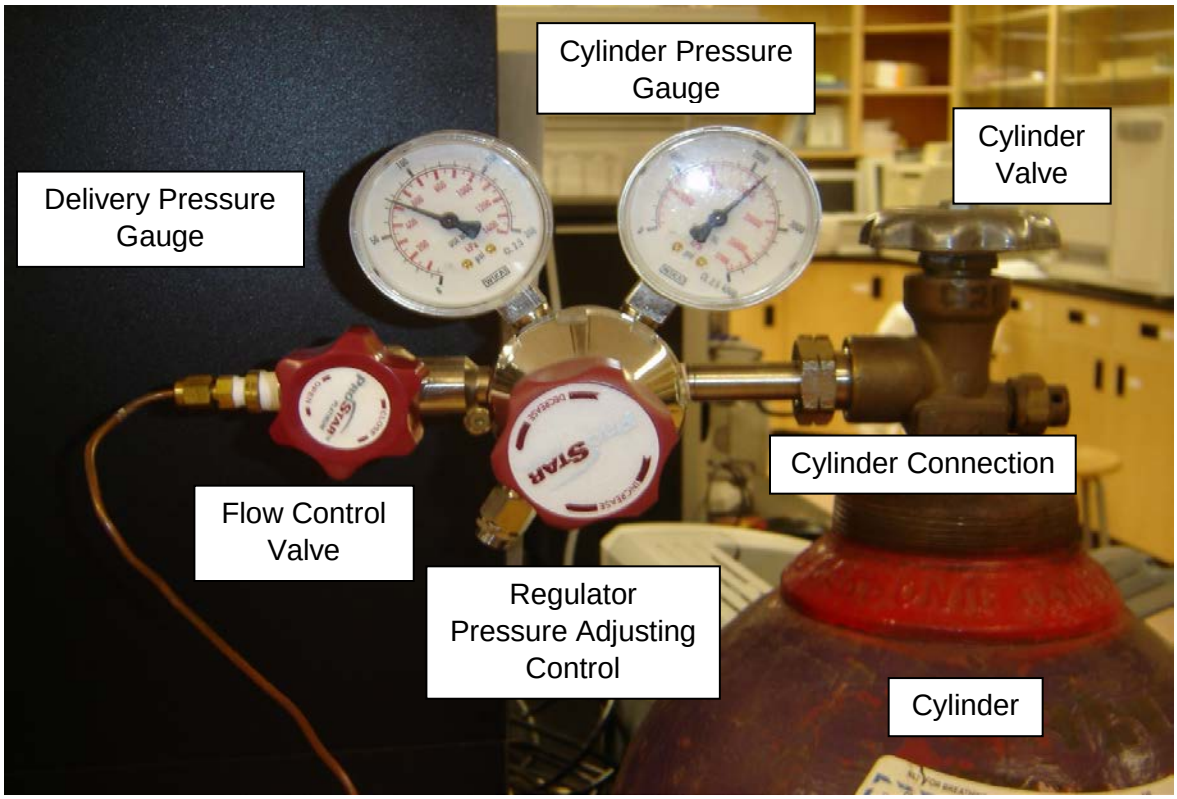

Figure 2. Main components of a compressed gas cylinder and regulator assembly. Image courtesy of Safety Resources.

Cylinder regulators have a relief device to prevent excessive pressure from developing. High pressure cylinder regulator gauges have a solid-front, safety-back construction. When subject to excessively high pressure, the light-metal safety back will blow off to relieve the pressure.
Always use the proper regulator for the gas in the cylinder as they are designed to provide the correct flow rate for that particular gas. Using the wrong regulator may cause some gases to react with the materials inside the regulator. For example, materials used in some regulators are not designed for oxygen and could ignite causing a fire or explosion.

Plaques, decals or engraved numbers on the regulator may indicate which gas the regulator is designed for. Cylinder valve connections on regulators are also designed to minimize the chances of using the wrong regulator. Always verify that you have the correct regulator for your application.
There are regulators that are left hand threaded (the connection is tightened by turning the nut counterclockwise). These Compressed Gas Association (CGA) connectors will have an identifying notch in them or a line inscribed around the circumference.

The CGA has developed a system to help prevent using the incorrect regulator on a compressed gas cylinder. Each cylinder and regulator has a connection fitting that is designated by a CGA number. Some common CGA numbers are presented in Table 2.

Table 2: CGA connection numbers for compressed gas cylinder regulators.

Gas	CGA Connection	Gas	CGA Connection
Acetylene	510	Hexafluoroacetone	330
Air (breathing air)	346	Hexafluoropropylene	660
Air (industrial grade)	590	Hydrogen	350
Allene	510	Hydrogen bromide	330
Ammonia	705/240	Hydrogen chloride	330
Argon	580	Hydrogen fluoride	670
Arsine	350	Hydrogen iodide	330
Boron trichloride	660	Hydrogen selenide	350
Boron trifluoride	330	Hydrogen sulfide	330
Bromine pentafluoride	670	Iodine pentafluoride	670
Bromine trifluoride	670	Isobutane	510
Bromotrifluoroethylene	510	Isobutylene	510
1,3-butadiene	510	Krypton	580
Butane	510	Methane	350
Butenes	510	Methylacetylene	510
Carbon dioxide	320	Methylbromide	330
Carbon monoxide	350	3-Methylbutene	510
Carbonyl fluoride	750	Methylchloride	510
Carbonyl sulfide	330	Methyl mercaptan	330
Chlorine	660	Monoethylamine	705
Chlorine trifluoride	670	Monomethylamine	705
Chlorotrifluoroethylene	510	Natural gas	350
Cyanogen	750	Neon	580
Cyanogen chloride	750	Nickel carbonyl	660
Cyclopropane	510	Nitric oxide	660
Deuterium	350	Nitrogen	580
Diborane	350	Nitrogen dioxide	660
1,2-Dibromodifluoromethane	668	Nitrogen trioxide	660
Dimethylamine	705	Nitrosyl chloride	330
Dimethylether	510	Nitrous oxide	326
2,2-Dimethylpropane	510	Oxygen	540
Ethane	350	Perfluoro-2-butene	660
Ethyl acetylene	510	Perfluoropropane	660
Ethyl chloride	510	Phosgene	660
Ethylene	350	Phosphine	350
Ethylene oxide	510	Phosphorous pentafluoride	330
Fluorine	679	Propane	510
Freon 12 (dichlorodifluoromethane)	660	Propylene	510
Freon 13 (chlorotrifluoromethane)	660	Silane	350
Freon 13B1 (bromotrifluoromethane)	660	Silicon tetrafluoride	330
Freon 14 (tetrafluoromethane)	580	Sulfur dioxide	660

Gas	CGA Connection	Gas	CGA Connection
Freon 22 (chlorodifluoromethane)	660	Sulfur hexafluoride	590
Freon 114 (1,2- dichlorotetrafluoroethane)	660	Sulfur tetrafluoride	330
Freon 116 (hexafluoroethane)	660	Sulfuryl fluoride	660
Freon RC318 (octafluorocyclobutane)	660	Tetrafluoroethylene	350
Genetron 21 (dichlorofluoromethane)	660	Trimethylamine	705
Genetron 23 (fluoroform)	660	Vinyl bromide	510
Genetron 115 (monochloropentafluoroethane)	660	Vinyl chloride	510
Genetron 152A (1,1-difluoroethane)	510	Vinyl fluoride	350
Genetron 1132A (1,1-difluoroethylene)	350	Vinyl methylether	510
Germane	350	Xenon	580
Helium	580		

Figure 3: Example gas cylinder connector (Industrial Air Grade, CGA-590). Image courtesy of Rakuten.

9 Safety Handling and Use of Gas Cylinders

9.1 General Safety Guidelines

When using gas cylinders, there are a number of general safety measures that should be adhered to.

- Individuals working with the gas cylinders are appropriately trained;
- Gas cylinders are only to be used for their intended purpose;
- Wear PPE appropriate for the hazard potential of the material being worked with. Refer to the MSDS for details on the safe handling of the material. At a minimum, wear a lab coat, safety glasses, gloves, long pants and closed toed, closed heeled shoes;
- Ensure that the proper regulator and fittings are used for the particular gas in the cylinder;

- Each time a compressed gas cylinder is used, the cylinder, regulator and connections should be visually inspected for disrepair or damage;
- When working with toxic gases the installation of permanent gas detectors or carrying personal detectors for leak detection is required. Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained;

Figure 4: Permanent toxic has detector. Image courtesy of Det-Tronics.

- Never refill a gas cylinder;
- Never use cylinder gas as a source of compressed air;
- Never heat the cylinder to raise the pressure of the gas as this may defeat the safety mechanisms built in by the supplier;
- Never use copper fittings or tubing on acetylene tanks as an explosion may result;
- Remove all pressure from regulators not currently in use;
- Bond and ground all flammable compressed cylinders, lines and equipment;
- Keep the cylinder clear of all sparks, flames and heat sources;
- Gas cylinders should never become part of an electrical circuit; and
- Ensure the cylinder, regulator and associated equipment are properly maintained.

9.2 Receiving Gas Cylinders

Following, are guidelines for safely receiving gas cylinders. Only individuals trained in the transportation of dangerous goods may receive dangerous goods including gas cylinders.

- Read the cylinder label to confirm the gas received is the gas purchased. Never identify the product by the color of the cylinder (see figure 5);

- Check the Transport Canada/Department of Transportation (TC/DOT) cylinder markings to confirm the pressures contained in the cylinders (see Figure 6);

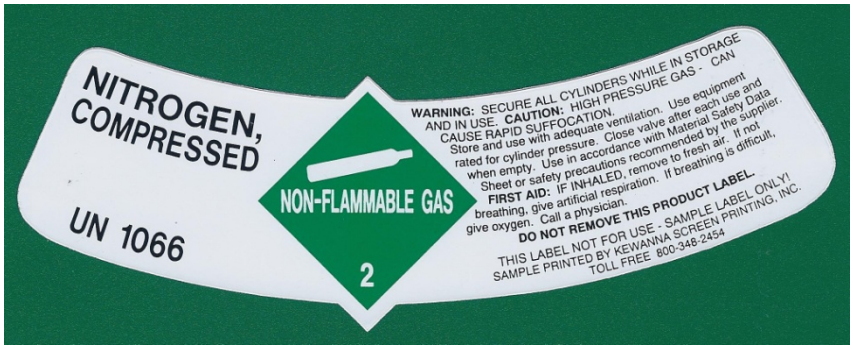

Figure 5: Example of a gas cylinder label. Image courtesy of Safety Resources.

- Thoroughly inspect the cylinders for any obvious damage such as cuts, gouges, burn marks, and obvious dents. The cylinder surface should be clean;
- Cylinders with neck threads should have a cap in place over the valve. Remove the cap by hand. Never use a screwdriver, crowbar, or other leverage device to remove the cap;
- Check the cylinder valve to be sure it is not bent or damaged. A damaged valve could leak, fail, or not provide a tight connection;
- Ensure the valve is free of dirt and oil, which could contaminate the gas. Dirt particles propelled in a high-velocity gas stream could cause a spark, igniting a flammable gas. Oil and grease can react with oxygen and other oxidizers, causing an explosion; and
- The MSDS for the contents of each cylinder must be provided with the gas cylinder.

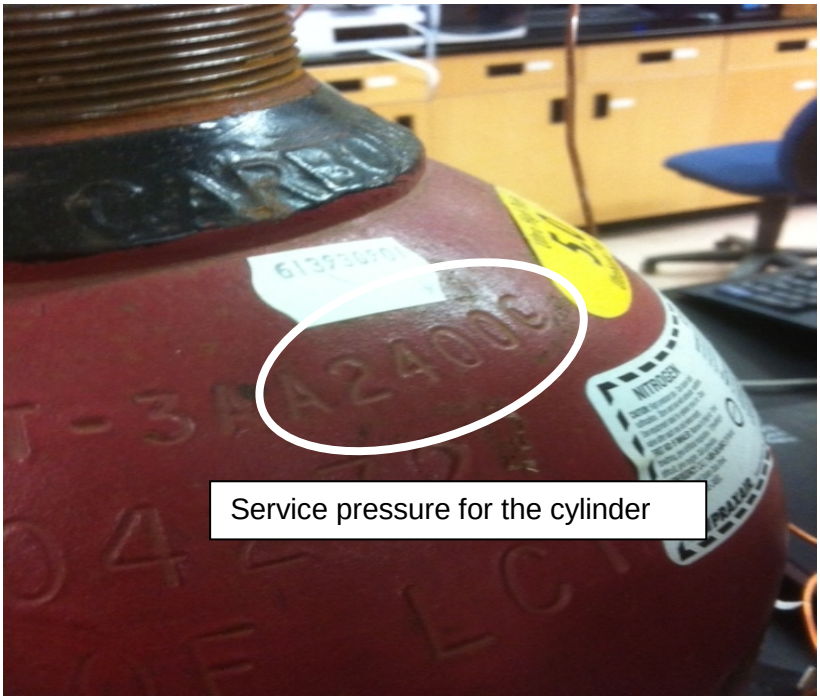

Figure 6: Service pressure for the compressed gas cylinder. Image courtesy of Safety Resources.

If any cylinder is received with missing or unreadable labels and markings, has visible damage, do not use the cylinder. Contact your supplier and ask for instructions.

9.3 Moving Cylinders

Before moving a cylinder to a storage area, a point of use, or before returning the cylinder to the supplier, ensure the following:

- The outlet valve is fully closed;
- Remove the regulator. Never move a cylinder with the regulator attached;
- The outlet valve dust plug or pressure cap is on tight for cylinders equipped with these protection devices; and
- The valve protection cap is properly secured in place on cylinders with neck threads.

When moving compressed gas cylinders:

- Always use a cart or hand truck designed for this purpose. Ensure the cylinder is secured to the cart during transport with a chain or strap. Cylinders should not be dragged, rolled or manually carried;

Figure 7: Example of a cylinder cart. Image courtesy of Safety Resources.

- Never drop cylinders or allow them to strike each other violently;
- Cylinders shall not be lifted by the valve cap;

- Magnets shall not be used for lifting cylinders; and
- Ensure the pathway is clear prior to moving cylinder. Be aware of flooring grade changes and use an elevator, if available.

After moving a cylinder to its point of storage or use, secure the cylinder in place. Use cylinder stands, clamps, chains, or other securing devices. Cylinders should be placed so that the valve handle at the top is easily accessible at all times.

9.4 Placement and Storage of Gas Cylinders

The following safety measures should be adhered to when storing gas cylinders.

- Only store cylinders in designated areas and segregated by hazard class;
- All cylinders must be secured in place to prevent accidental knock over;
- Cylinders must be secured in an upright position by a cylinder stand, clamp, chain or cable at a point approximately 2/3 of the height of the cylinder;

Figure 8: Compressed gas cylinder storage area. Image courtesy of Safety Resources.

- Cylinders used in laboratories must be secured individually (one restraint per cylinder);
- Store small cylinders in a box or crate that will keep them upright and large enough to prevent cylinders from falling out;
- Do not store cylinders in high traffic areas;
- Do not store cylinders near the edges of platforms;
- Do not store cylinders in areas where there are activities that could damage or contaminate the cylinders;
- Do not store cylinders under overhead hoists that can drip oil or grease on cylinders, contaminating them;
- Do not store gas cylinders with flammable materials;
- Propane cylinders are not to be stored in laboratories, or used indoors;
- Gas cylinders shall not be stored or allowed to come in contact with heat sources;

- As with any hazardous material, gas cylinders can not to be stored in public hallways or other unprotected areas;
- When the cylinder is not in use the valve protection cap shall be in place to protect the valve (see Figure 9); and
- Clearly mark empty cylinders and store separately from full cylinders.

Figure 9: Cylinder cap. Image courtesy of Safety Resources.

Figure 10: Outdoor cylinder storage facility. Image courtesy of Safety Resources.

Contact Safety Resources at 306-966-4675 for assistance with proper placement and storage of gas cylinders.

9.5 Attaching a Regulator

When attaching a regulator to a cylinder certain procedures should be followed in a specific sequence. Refer to the manufacturer's specifications when in doubt. Following, is a general outline of the steps to follow when connecting a regulator to a cylinder.

1. Always wear appropriate PPE such as safety glasses or goggles.

2. Before attaching the regulator, perform a visual inspection of the regulator. Check the condition of the inlet and outlet, look for worn threads and inspect gauges for damage.

3. Visually inspect the cylinder before each usage to detect for any damage, cracks, corrosion or other defects.

4. Wipe the outlet with a clean, dry, lint free cloth. The threads and mating surfaces of the regulator and hose connections should also be cleaned before the regulator is attached. A connection problem caused by dirty or damaged threads could result in leaks when the cylinder is used.

5. Always use a cylinder wrench or other tight fitting wrench to tighten the regulator nut and hose connections. Using an oversized wrench, adjustable wrench, pliers or a pipe wrench may damage the fittings and make it impossible to tighten them properly.

6. Attach the proper regulator to the cylinder of compressed gas (see Figure 2). Do not use Teflon TM tape on fittings when the seal is made by metal-to-metal contact. Under no circumstances is grease or oil to be used on regulator or cylinder valves because these substances may cause an adverse, dangerous reaction within the cylinder gas.

7. Check for leaks.

9.6 Opening and Closing Cylinder Valves

Observing a few simple rules when opening and closing valves can prevent damage to valves and equipment and add years of useful service life to the valves. Following, are the key steps for properly opening any cylinder valve:

1. Close the regulator by turning the pressure adjusting screw counterclockwise.

2. When opening the main cylinder valve stand to the side and away from the regulator. Do not stand in front of or behind the pressure gauges when applying pressure to the regulator as old, or defective regulators, have been known to violently fragment and cause personal injury.

3. Crack the cylinder valve open slightly at first (by turning the handle or stem counterclockwise**)** to verify that the regulator's diaphragm is working. The regulator cylinder pressure gauge should register the cylinder pressure. Continue to open the valve slowly to allow equipment to gradually adjust to full pressure. Never apply excessive force when trying to open valves. Do not attempt to open a corroded valve as it may be impossible to reseal.

4. Stop turning as soon as there is any resistance. Turning the valve handle or stem too far in the open position can jam the stem causing damage and leaks, and potentially preventing later closure. Likewise, over tightening when closing a valve can damage or permanently distort the seat and result in leakage. Never leave a valve part way open, either open it all the way or close it all the way.

5. Slowly adjust the regulator control to the desired pressure on the regulatory delivery gauge.

Cylinders that require a wrench to open the main valve shall have the wrench left in place on the cylinder valve while it is open. Use an adequate sized wrench.

Close valves on gas cylinders when a system is not in use. Even when empty, air and moisture may diffuse through an open valve, causing contamination and corrosion within the cylinder.

10 Gas Cylinder System Maintenance

10.1 Introduction

Regular inspection and maintenance of regulators is important to ensuring their proper operation and to the safety of individuals working with compressed gases. The following sections provide general procedures for:

- Function testing of regulators;
- Testing for leaks; and
- Checking for pressure creep.

Release pressure from systems before connections are tightened or loosened and before any repairs.

10.2 Function Testing of Regulators

It is recommended that regulators be function tested every six months. Following, is a general procedure for function testing regulators.

1. Close the regulator by turning the pressure adjusting screw counterclockwise until fully released.

2. Close the cylinder valve. Ensure that lines leading from the regulator to equipment or apparatus are purged of pressure by opening the appropriate flow control valves.

3. The regulator delivery pressure gauge should drop to a pressure reading of zero. Record the delivery pressure gauge reading. The cylinder pressure gauge will read full pressure. Record the initial high pressure.

4. If the delivery pressure gauge does not read zero when all the pressure is removed, it may be damaged. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.

5. Check the cylinder pressure gauge reading after at least 30 minutes. Record cylinder pressure gauge reading. Any pressure drop will indicate leakage. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.

6. Release the pressure in the regulator by turning the pressure adjusting screw clockwise. After venting, close the regulator by turning the pressure adjusting screw counterclockwise.

10.3 Testing for Leaks

A leaking cylinder can pose a serious hazard to individuals working with the gas, and to the facility. Leak detection procedures should be implemented prior to the initial use of any system using compressed gas. Following, is a general procedure for performing a leak test on a compressed gas system.

For systems where toxic or corrosive gases will be used, first test the system with an inert gas before introduction of the hazardous material.

1. Prepare a soapy water solution or a 50% glycerin-water solution. Ensure the solution to be used is not incompatible with the gas in the system.

2. Pressurize the system.

3. Apply the solution to all connections (e.g. cylinder valve, regulator connections, other connections) observing for the formation of bubbles. If bubbles are formed, a leak is present.

4. Inspect and secure connections that are observed to be leaking, and retest.

5. If no bubbles are formed, the system is not leaking, and may be used.

6. If a leak cannot be corrected, the system should not be used. Notify your supervisor.

In instances where a cylinder valve is found to be leaking, the following should be adhered to. Never attempt to repair a cylinder valve.

1. Contact the supplier and ask for response instructions. Contact Safety Resources at 306-966-4675.

2. If the cylinder contains a flammable, inert, oxidizing or corrosive gas, remove it to an isolated, well ventilated area, away from incompatible materials, only if safe to do so.

Allow it to remain isolated until the gas has discharged, making certain that appropriate warning signs have been posted.

3. If the material is toxic, remove the cylinder to an isolated, well-ventilated area, but only if this is possible while maintaining personal safety. It may be necessary to evacuate the building by pulling a fire alarm.

10.4 Check for Regulator Pressure Creep

When working properly, regulators should maintain gas delivery pressures as set with the regulatory adjustment controls. The following general procedure may be followed to test if gas cylinder regulator pressure is slowly changing. Regulators should be checked for pressure creep every six months.

1. Attach the regulator to the cylinder.

2. Ensure the regulator is closed by turning the pressure adjusting screw counterclockwise.

3. Slowly open the cylinder valve until it is fully open. Ensure the cylinder has a pressure of at least 1500 psi.

4. Set the delivery pressure gauge to approximately 20 psi and then close off all downstream valves to maintain the pressure in the system. Record the set pressure. Check the pressure after 30 minutes and record the pressure.

5. If the pressure setting has increased, remove the regulator, there may be a problem with the regulator. Return the regulator to the manufacturer for service. A malfunctioning regulatory should never be used.

11 Compressed Gas Cylinder Disposal

Hazardous waste is to be disposed of in accordance with the *Hazardous Waste Disposal Standard.* Following, are the general rules that should be followed for the disposal of compressed gas cylinders.

- If possible, purchase compressed gas only from manufacturers that agree to take back the empty cylinders;
- Never completely empty the cylinder. Always leave a residual gas pressure of 30 psi. Maintaining a residual pressure in an "empty" compressed gas cylinder helps to prevent back flow or suck back. This is the drawing-back into the cylinder of contaminants or moist air from a higher pressure system or the atmosphere which can lead to serious contamination and corrosion problems within the cylinder;
- Always keep the cylinder valve closed on empty tanks. This practice will help maintain the positive pressure required to prevent back flow. As well, an increase in temperature

or a drop in atmospheric pressure can force the contents out of a cylinder, with an open valve, into a work space which could result in hazardous conditions depending on the gas and how much is forced out;

- If the research experiment is over and the cylinder still contains hazardous material, the cylinder should be sent back to the supplier for disposal or arrangements made for its transfer to a colleague that will use the cylinder;
- When a one-time use bottle (lecture bottle) is empty contact the Waste Management Facility at 966-8497 for assistance with proper disposal;
- Do not keep gas cylinders in the laboratory beyond the time they are needed. Cylinders have a finite life expectancy. This is especially true for cylinders containing corrosive materials. If you are not using it dispose of it properly;
- If the cylinder is empty, replace the cap and remove it to the storage area for empty cylinders. If a tag is present remove the bottom portion of the tag (the 'full' tag) leaving the 'empty' tag attached to the cylinder; and
- Leaking, defective, damaged or corroded cylinders shall not be shipped without the approval of the supplier.

For further information on the proper disposal of gas cylinders, or for assistance with disposal, contact Safety Resources at 306-966-4675.

12 Precautions and Warnings for Commonly Used Gases

Acetylene
A mixture of acetylene and oxygen or air will explode in a confined area in the presence of a spark. Use the appropriate regulator when drawing acetylene from a cylinder (Table 2). Never adjust the regulator for this gas to obtain delivery pressure greater than 15 psig. If the gas is used in high pressure areas, be sure that the pressure gauge plus the ambient pressure does not exceed 30 psi. Under certain conditions, acetylene forms explosive compounds with copper, silver and mercury. Do not use copper fittings or tubing on acetylene tanks. Contact between this gas and these metals, and their salts, must be avoided. It also reacts violently with fluorine and other halogens. Acetylene is thermodynamically unstable and sensitive to shock and pressure. It can polymerize exothermically leading to deflagration. Do not lay acetylene cylinders on their sides. If an acetylene tank has accidentally been left on its side, set it upright for at least one hour before it is used. Use flashback arrestors for hot work activities. In the event a fire propagates through the hose the arrestor will stop the fire from reaching the tank.

Ammonia

Ammonia is an extremely strong irritant and lachrymator. Exposures of 2500 ppm are life threatening.

Skin contact with the gas or liquid may result in severe frostbite. Do not touch frosted pipes and valves.

Ammonia reacts with diverse compounds to form explosive products. Especially avoid contact with silver, gold and mercury.

Always use the appropriate regulator with the gas in use (see Table 2).

Carbon Monoxide

Carbon monoxide is a colorless, odorless, tasteless gas and is highly toxic to humans and animals. Carbon monoxide combines with hemoglobin to produce carboxyhemoglobin, which is ineffective for delivering oxygen to bodily tissues. This condition is known as anoxemia.

Commons symptoms for carbon monoxide poisoning are headaches, nausea, vomiting, dizziness, lethargy and the feeling of weakness.

The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

An approved Emergency Response Plan must be in place prior to using this gas. Contact Safety Resources at 306-966-4675 for assistance in developing an appropriate Emergency Response Plan.

Chlorine

Chlorine gas is a severe irritant. Inhalation may result in death with exposures of 500 ppm for 30 minutes.

Prolonged exposure to chlorine gas can cause olfactory fatigue. Therefore, the installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Chlorine gas is a strong oxidizer and will support combustion of most flammable materials.

Chlorine gas is extremely reactive and reacts violently with hydrogen, hydrocarbons in the presence of light, ammonia, reactive metals and metal hydrides, including silane, phosphine and diborane.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

An approved Emergency Response Plan must be in place prior to using this gas. Contact Safety Resources at 306-966-4675 for assistance in developing an appropriate Emergency Response Plan.

Hydrogen

Hydrogen is a flammable gas. A mixture of hydrogen and oxygen or air will explode in a confined area in the presence of a spark. A hydrogen flame is virtually invisible in a well-lighted area. Hydrogen may cause severe frostbite as a liquid or gas. Do not touch frosted pipes or valves.

Take every precaution against hydrogen leaks. Escaping hydrogen cannot be detected by sight, sound, smell or taste. The installation of detectors or carrying personal sensing devices for leak detection is strongly recommended. Because of its low molecular weight, hydrogen tends to collect in high areas, such as at ceiling levels.

A flashback arrestor must be used when working with flammable gases. In the event a fire propagates through the hose the arrestor will stop the fire from reaching the tank.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

Hydrogen Cyanide

Hydrogen cyanide is a highly toxic gas. Inhalation can cause fatal respiratory damage. Exposure of 270 ppm is immediately fatal. Exposure of 180 ppm is fatal at 10 minutes. Exposure of 135 ppm is fatal after 30 minutes. The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Hydrogen Cyanide gas is flammable and must be protected from ignition sources.

All supervisors and employees using HCN or cyanide forming gases must maintain on hand the anecdote for cyanide poisoning, amyl nitrite pearls, and be proficient in emergency response.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

An approved Emergency Response Plan must be in place prior to using this gas. Contact Safety Resources at 306-966-4675 for assistance in developing an appropriate Emergency Response Plan.

Hydrogen Sulfide

Hydrogen sulfide is very toxic and flammable.

Exposure to hydrogen sulfide concentrations of 150-250 ppm can cause olfactory fatigue. An exposure of 50-100 ppm can lead to eye damage. An exposure of 800 ppm is the lethal concentration for 50% of humans after five minutes of exposure. At concentrations over 1000 ppm immediate collapse with loss of breathing after a single breath can occur.

The installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

An approved Emergency Response Plan must be in place prior to using this gas. Contact Safety Resources at 306-966-4675 for assistance in developing an appropriate Emergency Response Plan.

Nitrogen, Argon, Helium and Carbon Dioxide

These gases can all cause rapid asphyxiation and death if released in a confined area. These gases, either as a liquid or gas may cause severe frostbite to eyes or skin. Do not touch frosted pipes or valves.

Always use the appropriate regulator with the gas in use (see Table 2).

Oxygen

Oxygen supports and can greatly accelerate combustion of flammable materials. Oxygen, as a liquid or gas, may cause severe frostbite to the skin or eyes. Do not touch frosted pipes or valves.

Never use oil or grease on or around oxygen cylinders, valves, fittings or regulator as it may cause fire or explosion.

Always use the appropriate regulator with the gas in use (see Table 2).

Phosgene

Phosgene is a highly toxic, corrosive gas. Inhalation can cause respiratory damage that can be fatal. Brief exposure at 50 ppm can result in death within a few hours.

The lowest concentration that phosgene can be detected with the human sense of smell (odour threshold) is approximately 0.5 ppm. This is 5 times greater than the allowable exposure limit of 0.1 ppm. Therefore, the installation of permanent gas detectors or carrying personal sensing devices for leak detection is required.

Phosgene liquid is highly corrosive and can cause severe burns to exposed skin.

Gas detectors and monitors must be calibrated and maintained as per the manufacturer's operating instructions. Records of this maintenance must be maintained.

Always use the appropriate regulator with the gas in use (see Table 2).

An approved Emergency Response Plan must be in place prior to using this gas. Contact Safety Resources at 306-966-4675 for assistance in developing an appropriate Emergency Response Plan.

13 References

- Praxair Cylinder Size Chart.
- *Compressed and Liquefied Gases*, Texas A & M University.
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