UNIVERSITY OF TORONTO

ENVIRONMENTAL HEALTH & SAFETY

Compressed Gas Safety

Introduction

Compressed gasses present a unique set of hazards versus other toxic materials because of the types of containers they are stored in and the pressures they are stored at. Special precautions must be taken with compressed gasses used at the University. This standard is based on best practices for the handling of compressed gasses that would meet or exceed the Occupational Health and Safety Act stipulation of taking "every precaution reasonable in the circumstances for the protection of a worker" (R.S.O. 1990, c. O.1, s. 25 (2)(h)). Other applicable legislation includes The Technical Standards and Safety Act, 200, S.O. 2000, c.16, Ontario Regulation 223/01 Codes and Standards Adopted by Reference, Part 4 of the Ontario Fire Code, and Ontario Regulation 211/01 Propane Storage and Handling. The Ontario Regulations also refer to the CSA B149 group of standards.

Scope

This standard covers all activities involving compressed gasses and liquefied petroleum gasses (LPG). Cryogenic liquids are covered in two other standards the Control Program for Liquid Cryogenic Facilities and the Standard for Inert Cryogenic Liquid Usage in the Laboratory.
According to the Ontario Fire Code-O.Reg.213/07, **compressed gas** means any contained mixture or material with either an absolute pressure exceeding 275.8 kPa at 21°C (~2.7 atmospheres) or an absolute pressure exceeding 717 kPa at 54°C, or both, or any liquid having an absolute vapour pressure exceeding 275.8 kPa at 37.8°C.
There are three major types of compressed gasses: liquefied (e.g., ammonia, carbon dioxide, propane), non-liquefied (e.g., oxygen, nitrogen, hydrogen sulphide), and dissolved gasses such as acetylene[1].

Responsibilities

Compressed Gas Cylinder Safety

Supervisors must:

- provide training and appropriate personal protective equipment to all compressed gas cylinder users;
- ensure that all gas cylinders are used, stored and transported according to applicable legislation and guidelines and;
- inspect labs using or storing compressed gas cylinders as part of the standard walkthrough.

Prior to use, users must:

- be aware of hazards associated with compressed gasses and the equipment connected to them;
- read the safety data sheet (SDS) for toxic gasses to obtain hazard and emergency response information;
- receive appropriate training prior to contact with compressed gasses;
- follow procedures and wear the appropriate personal protective equipment provided.

Compressed Gas Safety

Hazards

Figure 1 - compressed gas symbol (WHMIS 1988)

Figure 2 - compressed gas symbol (WHMIS 2015)

WHMIS 1988 (*figure 1*) and WHMIS 2105 (*figure 2*) hazard symbols for compressed gas. Cylinders are also labeled with their contents and handling instructions including first aid instructions. Refer to SDS for first aid / what to do in case of emergency.

Fire and Explosion Hazards

Flammable Gasses such as acetylene, ethylene, hydrogen, methylamine and vinyl chloride, can burn or explode when gas concentration is within the flammable or explosive range in the presence of an ignition source or when the auto-ignition temperature is reached. [1] Note that ***butane*** is a flammable liquid per the Ontario Fire Code definition, and thus is not considered a compressed gas or LPG.[4i] It should however still be used with caution.

Oxidizing Gasses Oxidizing gasses include any gasses containing oxygen at higher than atmospheric concentrations (above 23-25 percent), nitrogen oxides, and halogen gasses such as chlorine and fluorine. These gasses can react rapidly and violently with combustible materials and result in fire and explosion. [1] In particular, compressed oxygen can cause explosions if grease is used on the fittings.

Dangerously Reactive Gasses Some pure compressed gasses are chemically unstable. If exposed to slight temperature or pressure increases, or mechanical shock, they can readily undergo certain types of chemical reactions such as polymerization or decomposition. These reactions may become violent, resulting in fire or explosion. Some dangerously reactive gasses have other chemicals, called inhibitors, added to prevent these hazardous reactions. [1] Common dangerously reactive gasses are acetylene, 1,3-butadiene, methyl acetylene, vinyl chloride, tetrafluoroethylene and vinyl fluoride. [1]

Health hazards
Toxic gasses can cause various health problems (including death) upon inhalation, eye or skin contact. Examples used at the University are hydrogen sulphide, sulphur dioxide, arsine, phosgene, and silane.

Liquefied Gasses Skin or eye contact with liquefied gasses can freeze body tissue and cause burns.[1] For instance liquefied propane or other LPG (Liquefied Petroleum Gas). For cryogenic materials see the appropriate standards listed in the Scope.

Inert gasses, such as argon and nitrogen, displace air thus reducing oxygen levels and can cause loss of consciousness or even death.[1]

Corrosive gasses, such as hydrogen chloride and ammonia, attack and corrode metals and in turn can destroy and burn body tissues on contact.[1]

Flammable Gasses, such as acetylene, must be stored away from flammable liquids, oxidizers, combustible materials, sparks and other sources of heat or ignition. All equipment and lines in use with these gasses must be grounded and bonded
Acetylene gas must be stored upright. During use, an appropriate regulator must be used to keep the pressure under 15psi.
Oxidizing Gasses must be stored away from combustible materials or flammable gas containers. Oxidizers must be kept away from greases, oils, and from equipment that is not oxygen-compatible. One must never use grease or oil on compressed gas tank fixtures.

Dangerously Reactive Gasses must be stored away from incompatible materials and conditions. Storage rooms shall have exterior signs with minimum 50 mm high letters indicating the nature of the compressed gasses.

General Storage and Usage Guidelines

Cylinders must be stored in dry, ventilated areas.
Gas cylinders must be stored upright and capped when not in use to protect the valve from damage.
Keep valves closed and cylinders capped when not in use.
Use an appropriate pressure regulator. Use the cylinder valve to shut off the gas flow, not the regulator.
Gas cylinders must be labelled.
Cylinders must be kept away from fire; sparks and electricity, including intense sources of heat e.g. radiators, welding, and Bunsen flames. Ambient temperature should not exceed 52 degrees Celsius.
Compressed gas cylinders must be held securely in racks either together or nested as a group. As much as possible, gas cylinders in use should be individually held in place.
A cylinder should usually be strapped securely to an immovable object at 2/3 height, although in special situations another form of purpose built support may be used.
Store empty and full cylinders separately.
For temporary usage in an area, cylinders may be supported on a carrier as long as there is no risk of the cylinder falling or rolling away.
Inspect the cylinder and regulator prior to use. Never use cylinders or regulators that are damaged or corroded.

Follow the gas supplier's recommendation for temperature storage to prevent excessive pressure buildup.
Refer to the SDS.
When cylinders are empty they need to be returned to the supplier. Close valves and replace protective caps. Tear the attached tag to read 'Empty' instead of 'In-use' or 'Full'. If a tag is not available, chalk 'MT' or 'EMPTY' on the cylinder.

General Transportation Guidelines

Make sure the valve protective cap of the gas cylinder is in place. Never move a cylinder with the regulator attached.
Use a dolly designed for compressed gas cylinder transport and make sure the cylinder is tightly secured with straps or chains.
Move cylinders individually to avoid striking each other and do not drop, roll or drag them. Note: when moving a cylinder the short distance from a dolly to the place of installation it is acceptable to rotate the cylinder on its base while near vertical.
Lecture size or small compressed gas cylinders are typically 12–18 inches (300–460 mm) long and 1–3 inches (25–76 mm) in diameter). While dollies are preferred, cylinders weighing 11 Kg (25 lbs) or less may be hand-carried.

Use an elevator to transport cylinders between floors.

Propane and Other LPG

Propane cylinders may not be stored or used indoors in a lab with the exception of a very small quantity such as that found in a single 5lb disposable cylinder per fire compartment (10, sec. 6.7.3).
Storage overnight of even two of these cylinders would violate TSSA rules. *Only under special circumstances should a standard 20lb (~24L) "BBQ tank" or larger tank be used or stored indoors.*
Storage would require a dedicated purpose built storage room per section 6.5.10 of CSA B149.2 or usage/ storage outside. Note that usage outside can mean that the tank is outside but the fuel is piped inside according to the requirements of the TSSA and B149.2. Please have any such piping work done by a certified tradesperson.
The 2017 TSSA Propane Code Adoption Document allows up to 20x5lb disposable cylinders to be used in a lab or classroom for small appliances (e.g. Bunsen burners), but does not allow for storage in the room (see annex Q). Storage would need to be per TSSA or B149 – outside or in a specially built room.
Offences under the Technical Standards and Safety Act are up to $100,000 *per day* for a corporation or up to $25,000 *per day* for an employee, officer, agent, or director of a company.

Flammable Compressed Gas

Heavier Than Air Gasses

Special considerations (e.g. ventilation, storage, and transportation) apply to the following:
More than 100 kg of flammable heavier than air compressed gas or more than 3 flammable gas cylinders. Therefore, a lab may have up to 3 heavier than air cylinders with up to 100Kg of gas total as long as it is a mechanically ventilated room. However, these cylinders cannot be kept or used in a sub-grade basement lab(4).

Lighter than Air Flammable Gasses

Flammable lighter than air gasses such as hydrogen or methane can be stored Per NFPA 55 in a lab as long as the amount does not exceed 28m^3 (11). The maximum for hydrogen would be roughly five (5) full size "K" cylinders.

Determining Volumes or Masses of Gas

In order to determine the mass of gas in your cylinders you can ask your gas supplier to determine the volume of the cylinder or find the volume in an online guide (8). You can then use the density from a gas encyclopedia (such as (9)) to determine the mass.
To determine the expanded volume of gas in a cylinder, consult your supplier, or use an online gas encyclopedia (9) to convert the liquid volume into an expanded gas volume.

Non-Flammable, Low Toxicity Gasses

There is no set limit for non-flammable gasses in University occupancies[8]. See the Fire Code section 5.6.2.4. (2) and (3). (7)

Poisonous (e.g. chlorine, fluorine), corrosive or dangerously reactive compressed gas

The Principal investigator or manager of a lab that has the above compressed gasses must contact EHS to conduct a further assessment to ensure all procedures outlined in Section 5.6 Compressed Gas Cylinders of the Ontario Fire Code 213/07 and industry best practices are followed.
Compressed gasses that may react with one another either need to be stored in separate fire compartments or they need to be separated by specific distances.
For more information, please refer to Section 5.6 Compressed Gas Cylinders of the Ontario Fire Code O.Reg. 213/07 or contact EHS.

Disposal

Disposal of gas cylinder should be arranged with the gas supplier for empty or otherwise unneeded cylinders. In the event that this is not possible, follow the UofT Hazardous Waste Disposal Procedures found at http://www.ehs.utoronto.ca .

Regulator Care

Regulators should be connection leak tested on a regular basis, and creep (internal leak) tested at least annually. The frequency of testing depends on factors such as the toxicity of the gas, the corrosivity of the gas, and the use of the gas. More toxic, more corrosive and use of the gas in a critical system increase the frequency of tests. For low hazard situations, it is recommended by manufacturers that external leak testing be conducted monthly, and creep testing annually. Environmental conditions can dramatically affect the life of a regulator; of particular note is use outside or in salt spray (ocean) conditions.

Manufacturers suggest sending a regulator for service once every 5 years if no failures have been encountered. Replacement is typically recommended after 10 years, although in practice some regulators have lasted decades in low stress environments and applications.
For information on creep testing protocols and detailed information on regulators for specific applications, please visit manufacturer or gas supplier websites such as www.scottgas.com, www.parker.com, and http://www.harrisproductsgroup.com.

References

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[2.] Harvard University. *Compressed gas and compressed air*. University Operations Services: Environmental Health & Safety. March 8, 2011, from <http://www.uos.harvard.edu/ehs/safety/compressed_gas.pdf>.

[3.] Laboratory Safety CSCT Workshop, Canadian Society for Chemical Technology, September 17-18, 2012.

[4.] Commentary on Part 4 of the Ontario Fire Code O.REG. 388/97 (Revised by O.REG. 475/00), Jan 2001, Ministry of the Solicitor General of Ontario

[5.] Scott Specialty Gas – Pressure Regulators Maintenance. Accessed online Aug. 2014, URL: http://www.scottecatalog.com/dsguide.nsf/74923c9ec562a6fb85256825006eb87d/dab60763c15a8267852568f2005ca6a0?OpenDocument

[6.] 1999, Compressed Gas Association, Handbook of Compressed Gases, Fourth Edition, Kluwer Academic Publishers

[7.] Illustrated Commentary: Ontario Fire Code – Section 5.6 Compressed Gas Cylinders, accessed online Sept. 2014, http://www.mcscs.jus.gov.on.ca/english/FireMarshal/Legislation/FireCode/ArchivedDocuments/Commentaries/Cylinders.html

[8.] Air Liquide Speciality Gases, Packaging – Cylinders for Every Application, http://www.specialtygases.ca/file/otherelement/pj/0a/07/58/ec/air_liquide_gas_cylinder_specifications369253603474886740.pdf accessed June 2016.

[9.] Air Liquide Gas Encyclopedia, http://encyclopedia.airliquide.com/encyclopedia.asp?LanguageID=11&GasID=36, accessed online June 2016

[10.] Propane Code Adoption Document Amendment FS-224-17, TSSA, April 10, 2017

11. NFPA 55: Compressed Gases and Cryogenic Fluids Code, 2016 Edition. In NFPA National Fire Codes Online. Retrieved from http://codesonline.nfpa.org

Note 1
The use of propane is covered by the Fire Code (4), the Technical Standards and Safety Act, 2000, S.O. 2000, c. 16, O.R. 211/01 (Propane Storage and Handling), O.Reg. 223/01 (Codes and Standards Adopted by Reference), CSA B149 standards (via the Code Adoption Document) and the Technical Standards and Safety Authority (TSSA) of Ontario. The TSSA Act has promulgated under it O.Reg. 211 (Propane Storage and Handling), which references O.Reg. 223 and the Code Adoption document. The Code Adoption Document refers to and modifies B149. As a result, B149 as modified by the Code Adoption Document has effectively been added to O. Reg. 211.

Appendix A – Gas Cylinder Checklist

Checklist of Items to be reviewed by Compressed Gas Cylinder User

*Should any of these items **fail** the inspection **do not use**, tag, take out of service, and **report** to a person in charge*

Review the following:

- ✓ Is the tank in good condition?
- ✓ Cap is on while transporting/not in use?
- ✓ Moved only with proper cart, chained on?
- ✓ Secured to wall or bench for use?
- ✓ Proper regulator and flow meter for gas type used?
- ✓ Tag on tank and safety data sheet (SDS) read? Dangers of specific gas should be known.
- ✓ Valve opened slowly to use, closed when done?
- ✓ Proper PPE for cylinder handling used?

Spill: Call ***'8-7000' /*** '***6-3473***' or Campus Police ***'8-2222'*** (after-hours)