Compressed Gas Safety, Transportation, and Handling

1. **Definition:**
   a. 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.
   b. 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 acetylene1.

2. **Responsibility:**
   a. Managers, or Supervisors or Principal Investigators shall:
      - Ensure that only workers who are informed about hazards, controls, safe work and emergency procedures can use compressed gas.
      - 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.
      - Inspect labs using or storing compressed gas cylinders as part of the standard walkthrough.

   b. 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.

3. **Precautions:**
   a. 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.

b. Cylinders are labeled with WHMIS 2015 hazard symbols for compressed gas, and also labeled with their contents and handling instructions including first aid instructions.
c. **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. Note that butane is a flammable liquid per the Ontario Fire Code definition, and thus is not considered a compressed gas. It should however still be used with caution.
d. **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. In particular, compressed oxygen can cause explosions if grease is used on the fittings.
e. **Dangerously Reactive 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. Common dangerously reactive gasses are acetylene, 1,3-butadiene, methyl acetylene, vinyl chloride, tetrafluoroethylene and vinyl fluoride.

4. Training:

a. Managers, Supervisors, and Principal Investigators must:
   i. provide training and appropriate personal protective equipment to all compressed gas cylinder users;
   ii. ensure users are using approved laboratory equipment for their transportation and use of gas cylinders (cylinder carts, cylinder clamps, and regulators);
   iii. ensure that all gas cylinders are used, stored and transported according to applicable legislation and guidelines;
   iv. inspect labs using or storing compressed gas cylinders as part of the standard walkthrough.
b. 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 gases;
   - follow procedures and wear the appropriate personal protective equipment provided.

5. **General Storage and Usage:**
    a. Cylinders must be stored in dry, ventilated areas; must be stored upright and capped when not in use to protect the valve from damage; and valves must be kept closed and cylinders capped when not in use.
    b. Use an appropriate pressure regulator. Use the cylinder valve to shut off the gas flow, not the regulator.
    c. Cylinders must be kept away from fire, sparks and electricity, including intense sources of heat (e.g., radiators, welding, Bunsen flames). Ambient temperature should not exceed 52 degrees Celsius.
    NOTE: Follow the gas supplier's recommendation for temperature storage to prevent excessive pressure buildup.
    d. 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. Check that cylinder clamp straps and buckles are in good condition before using, and report faulty clamps, straps and buckles to admin.tbep@utoronto.ca
    NOTE: Store empty and full cylinders separately.
    e. The number of cylinders stored in the laboratory must be kept to a minimum. Empty gas cylinders should be removed promptly and placed in the empty tank area.
    f. 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.
    g. 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 'EMPTY' on the cylinder.

6. **General Transportation Guidelines:**
    a. Never move a cylinder with the regulator attached. Make sure the valve protective cap of the gas cylinder is in place
    b. Use a dolly designed for compressed gas cylinder transport and make sure the cylinder is tightly secured with straps or chains.
    c. 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.

7. **Transportation Guidelines in a Tissue Culture Room:**
    Transportation of gas cylinders in the tissue culture rooms poses some unique challenges, specifically because of the configuration of the room, and the occasional necessity of replacing an empty tank that is situated behind a partially full tank. In this situation, changing a tank requires two people following one of two protocols:

a. Changing tanks with removal of the regulator (in situations when it is possible to temporarily interrupt CO_2 supply to the incubator):
   i. Remove the regulator and replace the valve protector cap of the empty tank. Also, remove the regulator and replace the valve protector cap of the partially full tank in front of it.
   ii. The first person will place the partially full tank in a dolly and move it out of the way.
   iii. The second person will place the empty tank in a dolly and move it to the empty tank area. They will then retrieve a full CO_2 tank.
   iv. The second person will then place the full tank in the tissue culture rack, remove the valve protector cap, and attach a regulator.
   v. The first person will replace the partially full tank, remove the valve protector cap, reattach the regulator, and secure the rack.

b. Changing tanks without the removal of the regulator (in situations when it is not possible to temporarily interrupt CO_2 supply to the incubator):
   i. Remove the regulator and replace the valve protector cap of the empty tank. Also, ensure there is enough lead line from the partially full tank in front of it.
   ii. The first person will place the partially full tank, with regulator attached, in a dolly, and ensuring the CO_2 line does not become tangled or detached, move it out of the way.
   iii. The second person will place the empty tank in a dolly and move it to the empty tank area. They will then retrieve a full CO_2 tank.
   iv. The second person will then place the full tank in the tissue culture rack, remove the valve protector cap, and attach a regulator.
   v. The first person will replace the partially full tank and secure it in the rack.

8. Regulator Care:

a. Regulators should be connection leak tested on a regular basis (monthly as recommended by manufacturers), 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.
   i. The regulator should be securely installed on the cylinder valve using the proper wrench and without forcing the connection. Do not use pipe dope, pipe thread or Teflon tape on valve connections, and never use valve connections that leak.
   ii. Check the system for leaks by closing the downstream equipment valve, setting regulator pressure, closing the cylinder valve and turning the regulator adjusting knob one turn counter-clockwise. A decrease in the high-pressure gauge will indicate a leak in the cylinder valve inlet fitting or high-pressure gauge. A decrease in the low-pressure gauge indicates a leak in the outlet fitting, low-pressure gauge or a downstream equipment connection. Check for

the exact location by using appropriate leak detection instrumentation or methods. A decrease in the high-pressure gauge occurring concurrently with an increase in the low-pressure gauge indicates a leak in the regulator seat.

b. Manufacturers suggest sending a regulator for service once every 5 years if no failures have been encountered. Replacement is typically recommended after 10 years.

9. References

a. https://ehs.utoronto.ca/wp-content/uploads/2018/12/Compressed-gas-safety-standard-November-2021.pdf
b. https://www.scottmedicalproducts.com/technical-data/pressure-regulators/
c. https://www.ccohs.ca/oshanswers/prevention/comp_gas.html