

Section 1.3: PRESSURE VESSEL COMPONENTS AND SYSTEMS AND COMPRESSED GAS CYLINDERS**TABLE OF CONTENTS**

	<u>Page</u>
A. Regulations, Standards and References	1.3-2
B. Scope	1.3-2
C. Design Features for the Storage of Compressed Gas Cylinders - General	1.3-3
D. Design Features for the Storage of Compressed Gas Cylinders - Toxic and Highly Toxic Gases	1.3-4
E. Design Features for the Storage of Compressed Gas Cylinders - Medical Gases	1.3-7
F. Design of Systems and Apparatus for Cryogenic Fluids	1.3-8
G. Design of Pressure Vessels and Systems	1.3-9

A. Regulations, Standards and References

California Code of Regulations (CCR), Title 8, Section 4650
California Code of Regulations, Title 19, Section 3.18
California Code of Regulations, Title 24, Part 9, Chapter 74, Section 7404, 8003
NFPA 45, Chapter 8
NFPA 99, Chapter 4
NFPA 704, Chapter 2
Santa Clara County Central Fire Protection District, Standard Details & Specification #SI-3
STANFORD UNIVERSITY Administrative Policy Guide, Policy 550-11, 550-12

B. Scope

The Guide applies to all Stanford University facilities, including leased properties. It covers all unfired pressure vessels (i.e., storage tanks; compressed gas cylinders) that have been designed to operate at pressures above 15 psig., including the storage and use of compressed gas cylinders and cryogenic fluids.

Note that there are numerous regulations governing the proper **use** of compressed gas cylinders; **use** is not addressed by the Guide, as it is a work practices issue, rather than design feature.

C. Storage of Compressed Gas Cylinders – General**➤ Location/Design**

1. **Laboratory design shall include a storage area for cylinders of compressed gases where:**
 - **they are protected from external heat sources such as flame impingement, intense radiant heat, electric arc, or high temperature steam lines.**
 - **they are in a well protected, well ventilated, dry location, at least 20 feet from highly combustible materials**

CCR, Title 8, Section 4650(a)
NFPA 99, 4-3.1.1.2
CCR, Title 8, Section 4650(b)

2. **Adequate space shall be made available for the segregation of gases by hazard class. Flammable gases shall not be stored with oxidizing agents. Separate storage for full or empty cylinders is preferred. Such enclosures shall serve no other purpose.**

NFPA 99, Section 4-3.1.2(a)2

3. **Design features which are prohibited:**
 - **Unventilated enclosures such as lockers, coldrooms and cupboards.**

CCR, Title 8, Section 4650(c)

Work practice issues: Oxygen cylinders shall not be stored near highly combustible materials, especially oil or grease, or near any other substance likely to cause or accelerate fire (per 8 CCR 4650(d)).

- 4. Liquefied fuel-gas cylinders shall be stored in an upright position so that the safety relief device is in direct contact with the vapor space in the cylinder at all times.**

8 CCR 4650(e).

- 5. The heating of flammable gas storage areas shall be indirectly heated, such as by air, steam, hot water, etc.**

Good practice.

➤ **Cylinder Restraint Systems**

- 6. Laboratory design shall include restraints for the storage of cylinders greater than 26 inches tall; the restraint system shall include at least 2 restraints (made of non-combustible materials), which are located at one-third and two-thirds the height of the cylinder.**

Santa Clara County Central Fire Protection District, Standard Details & Specification #SI-3
CCR, Title 8, Section 4650 (e)
CCR, Title 19, Section 3.18
CCR, Title 24, Part 9, Section 7401.6.4
NFPA 45, 8-1.5
NFPA 99, 4-3.1.1.2.3

A restraint system of chains, metal straps, or storage racks provides a reliable method of securing gas cylinders. Chains or metal straps at the bottom and top one third of each cylinder provides protection against tipping and falling. [Work Practice Note: When compressed gas cylinders in service, they shall be adequately secured by chains, metal straps, or other approved materials, to prevent cylinders from falling or being knocked over.]

- 7. The purchase and installation of compressed gas cylinder securing systems must be subject to review of EH&S.**

Good Practice per Stanford EH&S

EH&S can assist in identifying good quality securing systems.

- 8. Gas cylinder securing systems should be anchored to a permanent building member or fixture.**

Good practice

Connection to a permanent building member or fixture is needed to prevent movement during a seismic event.

D. Storage of Compressed Gas Cylinders - Toxic and Highly Toxic Gases

Note: The following requirements apply to H-7 occupancies only.

1. **Laboratory design shall incorporate storage capabilities of compressed gas cylinders of toxic and highly toxic gases per the following table. The number of lecture bottle cylinders [approximately 5 cm x 33 cm (2 in. x 13 in.)] shall be limited to 25.**

Table 6-1

	Flammable or Oxidizing Gases		Liquefied Flammable Gases		Gases with Health Hazard Rating of 3 or 4
	Sprinklered Space	Nonsprinklered Space	Sprinklered Space	Nonsprinklered Space	Nonsprinklered or Sprinklered Space
Max. no. of cylinders per 46.5m ² (500 ft ²) or less	6	3	3	2	3

NFPA 45, Table 8-1

➤ **Storage Systems**

2. **Laboratory design shall include one of the following storage systems for toxic and highly toxic compressed gas cylinders:**

- **ventilated gas cabinets/exhausted enclosures/ laboratory fume hoods; or**
- **separate ventilated gas storage rooms without other occupancy or use, which have explosion control.**

CCR, Title 24, Part 9, Section 8003.3

CCR, Title 24, Part 9, Section 8003.1.12

3. **When gas cabinets or exhausted enclosures are provided they shall:**

- a. **be located in a room or area which has independent exhaust ventilation;**
- b. **operate at negative pressure in relation to the surrounding area;**
- c. **have self-closing limited access parts or noncombustible windows to provide access to equipment controls, with an average face velocity of at least 200 fpm and with a minimum of 150 fpm at any part of the access port or window; and with design criterion of 200 fpm at the cylinder neck when the average face velocity is >200 fpm.**
- d. **be connected to an exhaust system;**
- e. **have self-closing doors and be constructed of at least 0.097 inch (12 gauge) steel;**
- f. **be internally sprinklered;**
- g. **be seismically anchored;**
- h. **contain not more than 3 cylinders per gas cabinet, except where cylinder contents are 1 pound net or less, in which case gas cabinets may contain up to 100 cylinders;**
- i. **be fitted with sensors connected to alarms to notify in the event of a leak, or exhaust system failure.**

CCR, Title 24, Part 9, Section 8003.3.1.3.1, 8003.3.1.3.2, 8003.3.3.1.8

4. When separate gas storage rooms are provided they shall:

- a. **Operate at a negative pressure in relation to the surrounding area;**
- b. **Direct the exhaust ventilation to an exhaust system.**

CCR, Title 24, Part 9, Section 8003.3.1.3.4

➤ **Treatment**

5. Treatment systems for the exhaust of toxic and highly toxic gases must be reviewed and approved by EH&S.

SCCo Toxic Gas Ordinance No. NS-517.44

EH&S reviews treatment systems to ensure they are compliant with TGO requirements and are consistent.

➤ **Emergency Power**

6. **Emergency power shall be provided for exhaust ventilation, gas-detection systems, emergency alarm systems, and temperature control systems.**

CCR, Title 24, Part 9, Section 8003.3.1.4

➤ **Detection System**

7. **A continuous gas detection system shall be provided for Class I and II toxic gases regulated by Santa Clara County's Toxic Gas Ordinance to detect the presence of gas at or below the permissible exposure limit in occupiable areas and at or below ½ the IDLH (or 0.05 LC50 if no established IDLH) in unoccupiable areas. The detection system shall initiate a local alarm and transmit a signal to a constantly attended location. Activation of the monitoring system shall automatically close the shut-off valve on toxic and highly toxic gas supply lines to the system being monitored.**

CCR, Title 24, Part 9, Section 8003.3.1.6, 8003.3.1.7
SCCo Toxic Gas Ordinance No. NS-517.44

Guidance about the gases to be monitored, alarm set points, and where and how the alarms annunciate must be provided by the campus EH&S.

8. **An approved supervised smoke detection system shall be provided in rooms or areas where highly toxic compressed gases are stored indoors.**

CCR, Title 24, Part 9, Section 8003.3.1.7

➤ **Security**

9. **Storage areas shall be secured against unauthorized entry.**

CCR, Title 24, Part 9, Section 7401.6.1

E. Storage of Compressed Gas Cylinders - Medical Gases

1. **Enclosures such as 1-hour interior and exterior rooms (detailed below) must be provided for supply systems cylinder storage or manifold locations for oxidizing agents such as oxygen and nitrous oxide. Such enclosures must be constructed of an assembly of building materials with a fire-resistive rating of at least 1 hour and must not communicate directly with anesthetizing locations.**

CCR, Title, 8, Section 4650(d)
NFPA 99, Sections 4-3.1.1.2(a).2

Other nonflammable (inert) medical gases may be stored in the enclosure. Flammable gases shall not be stored with oxidizing agents. Storage of full or empty cylinders is permitted. Such enclosures shall serve no other purpose.

2. **A 1-hour exterior room shall be a room or enclosure separated from the rest of the**

building by not less than 1-hour-rated fire-resistive construction. Openings between the room or enclosure and interior spaces shall be smoke-and draft-control assemblies having no less than a 1-hour fire-protection rating. Rooms shall have at least one exterior wall provided with at least two vents. Each vent shall not be less than 36 square inches in area. One vent shall be within 6 inches of the floor and one shall be within 6 inches of the ceiling. Containers of medical gases shall be provided with at least one fire sprinkler to provide container cooling in case of fire.

CCR, Title 24, Part 9, Section 7404.2.1.2

3. **When an exterior wall cannot be provided for the room, automatic sprinklers shall be installed within the room. The room shall be exhausted through a duct to the exterior. Makeup air to the room shall be taken from the exterior. Both separate air streams shall be enclosed in a 1-hour-rated shaft enclosure from the room to the exterior. Approved mechanical ventilation shall be in accordance with the California Mechanical Code and provided at a minimum rate of 1 cubic foot per minute per square foot of the room area.**

CCR, Title 24, Part 9, Section 7404.2.1.3 CCR, Title 24, Part 9, Section 7404.2.1.3

4. **Medical gas system cabinets shall be in accordance with the following:**
 - a. **Operated at a negative pressure in relation to surrounding area,**
 - b. **Provided with self-closing, limited-access ports or noncombustible windows to give access to equipment controls. The average velocity of ventilation at the face of access ports or windows shall not be less than 200 feet per minute, with a minimum of 150 feet per minute at any point of the access port or window,**
 - c. **Connected to an exhaust system,**
 - d. **Provided with a self-closing door,**
 - e. **Constructed of not less than 0.097-inch (12 gage) steel, and**
 - f. **Internally sprinklered.**

CCR, Title 24, Part 9, Section 7404.2.1.4

F. Design of Systems and Apparatus for Cryogenic Fluids

1. **The position of valves and switches for emergency shutdowns shall be accessible and clearly labeled.**

Good practice.

- 2. Uninsulated pipes or vessels should be positioned and/or identified to prevent inadvertent contact with an unprotected part of the body.**

Good practice.

- 3. Critical vent areas should be covered, or pointed down (i.e., Dewar necks and pressure reliefs).**
- 4. Portable cryogenic containers are required to be individually secured with a minimum of 1 (one) restraint. Restraint material can be combustible or non-combustible but must be strong enough to prevent the dewar from shifting during a seismic event.**

Reference - 2001 Calif. Fire Code Sec. 7501.8.3

G. Design of Pressure Vessels and Systems

- 1. Normal and emergency relief venting and vent piping for pressure vessels should be adequate and in accordance with the design of the vessel.**

ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

8 CCR Chapter 4, Subchapter 1