UC Irvine
Environmental Health & Safety

Toxic Gas Program

Responsible Administrator: Senior Research Safety Specialist
Issued: December 2025

Summary: This program establishes the framework for safe storage, handling, and use of toxic gases at University of California, Irvine (UCI). Toxic gases subject to the UCI Toxic Gas Program are classified as highly toxic, toxic, and moderately toxic in accordance with the applicable regulations and the definitions provided in this document. It provides high-level requirements to ensure compliance with federal, state, and local laws, especially the California Fire Code (CFC), California Building Code (CBC), National Fire Protection Association (NFPA), California Occupational Safety and Health Administration (Cal/OSHA), Department of Transportation (DOT), and Globally Harmonized System (GHS) regulations, while equipping researchers and lab staff with roles, engineering and administrative controls, and reporting obligations.

Program Description

The Toxic Gas Program aims to minimize the risk of exposure, leaks, or releases of toxic gases that can affect health or safety. Environmental Health & Safety (EHS) is responsible for oversight, including approvals, hazard assessments, and ensuring compliance with applicable regulations. Toxic gas users must comply with the requirements of this program.

Scope

The Toxic Gas Program applies to the storage and use of toxic gases by faculty, staff, and students. Toxic gases subject to the UCI Toxic Gas Program are classified as highly toxic, toxic, and moderately toxic in accordance with the applicable regulations and the definitions provided in this document. Table 1 outlines the scope of all gases included in the program. UC Irvine is subject to California Fire Code (CFC), California Building Code (CBC), National Fire Protection Association (NFPA), California Occupational Safety and Health Administration (Cal/OSHA), Department of Transportation (DOT), and Globally Harmonized System (GHS) regulations pertaining to these gases, therefore the CFC, CBC, NFPA, Cal/OSHA, and DOT definitions encompass the program's scope.

Table 1: Toxic Gas Definitions

	LC_{50} 1hr (ppm)					
	≤200	**>200 to ≤1,000**	**>1,000 to ≤2,000**	**>2,000 to ≤5,000**	**>5,000 to ≤40,000**	**Note[d]**
CFC[a]	Highly Toxic	Toxic		NR		
GHS[b]	H330, Category 1 (Fatal)	H330, Category 2 (Fatal)	H331, Category 3 (Toxic)		H332, Category 4 (Harmful)	H333, Category 5 (May be harmful)
DOT[c]	A	B	C (>1,000 to ≤3,000)	D (>3000 to ≤5,000)	NR	NR
Gases Subject to the UC Irvine Toxic Gas Program	Highly Toxic	Toxic			Moderately Toxic	NR

LC_{50} 1hr (Lethal Concentration 50): *The median exposure level, expressed in parts per million (ppm), at which 50% of the test population is expected to die following a one-hour inhalation exposure.*

NR (Not Regulated): *Indicates that gas is not specifically regulated under the referenced system or code.*

[a] ***California Fire Code (CFC):*** *Defines gases with LC_{50} ≤ 200 ppm as Highly Toxic and gases with LC_{50} > 200 ppm and ≤ 2,000 ppm as Toxic.*

[b] ***Globally Harmonized System (GHS):*** *Classifies gases by toxicity categories (1–5) based on LC_{50} values, ranging from Category 1 (most toxic) to Category 5 (least toxic).*

[c] *US Department of Transportation (DOT): Classifies toxic gases into four hazard Zones (Zone A, B, C, and D) based on their lethal concentration (LC50) values for acute inhalation toxicity.*

[d] ***Note:*** *GHS criteria also include gases of relatively low toxicity that may still present a hazard to sensitive or vulnerable populations based on test data or expert judgment.*

Dilute toxic gases may be exempt from this program if worst-case release modeling of an accidental acute release indicates that the gas concentration will not result in an average concentration exceeding any of the following:

- The Cal/OSHA Ceiling Limit, or twice the Short-Term Exposure Limit (STEL)
- The OSHA or Cal/OSHA Permissible Exposure Limit (PEL), whichever is lower
- One half of the concentration established as Immediately Dangerous to Life or Health (IDLH)

Worst-case release modeling will be conducted by EHS and is based upon one cylinder or container discharging its entire contents into a room; the average concentration cannot exceed the values described above to be exempt from the Toxic Gas Program. The worst-case calculation does not include the beneficial effect of ventilation.

Definitions

Acutely Toxic Gas (per Globally Harmonized System [GHS]): A gaseous substance or mixture with serious health effects (i.e., lethality) that occurs after a single or short-term inhalation exposure. Classification criteria for substances further differentiates acutely toxic gases by severity of exposure ranging from Category 1-5, with Category 1 being the most toxic and Category 5 being the least toxic. Acute toxicity values are expressed as LC50 (inhalation) values or as acute toxicity estimates (ATE). The following Hazard (H)-codes identify acutely toxic gases:

- H280: Contains gas under pressure; may explode if heated

And one of the following:

- H330, Category 1: Fatal if inhaled
- H330, Category 2: Fatal if inhaled
- H331, Category 3: Toxic if inhaled
- H332, Category 4: Harmful if inhaled
- H333, Category 5, May be harmful if inhaled

California Building Code (CBC): California Building Code (CBC): California Code of Regulations, Title 24, Part 2, California Building Code, 2025.

California Fire Code (CFC): California Code of Regulations, Title 24, Part 9, California Fire Code, 2025.

California Occupational Safety and Health (Cal/OSHA): State of California agency responsible for setting and enforcing standards for protection of health and safety for workers in California. Cal/OSHA and Federal OSHA require labeling of hazardous chemicals according to GHS.

Compressed Gas: A material, or mixture of materials that:

- Is a gas at normal temperature and pressure (NTP) 68°F (20°C) or less at 14.7 psia (101 kPa, 1 atm) of pressure; and
- Compressed gas is either liquefied, non-liquefied or in solution, except those gases which have no other health- or physical hazard properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia (282 kPa, 2.78 atm) at 68°F (20°C).

Department of Transportation (DOT) part 173: Part 173 of Title 49 of the Code of Federal Regulations (CFR) outlines the requirements for the safe transportation of hazardous materials in the United States.

Environmental Health & Safety (EHS): UC Irvine office responsible for administering this program.

Exhausted Enclosures: An appliance or piece of equipment that consists of a top, a back, and not less than two sides providing a means of local exhaust for capturing gases, fumes, vapors and mists. Such enclosures include laboratory fume hoods and similar appliances and equipment used to retain and exhaust locally the gases, fumes, vapors and mists that could be released.

Gas Cabinet: A fully enclosed, ventilated noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are allowed to be included.

Highly Toxic Gas (per CFC): A gas that has a median lethal concentration (LC50) in air of 200 parts per million (ppm) or less by volume of gas or vapor, or 2 milligrams per liter (mg/l) or less of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

Immediately Dangerous to Life or Health (IDLH): An atmospheric concentration of any toxic substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere.

Leak Test: Any reliable method used to test a pressurized gas cylinder connection. It may include coating all non-welded joints or connections with a soap solution that is capable of forming bubbles at any gas leak points, a pneumatic pressure leak-down test using accurate pressure gauges, or other effective measures.

Lethal Concentration 50% (LC50): The airborne concentration of a toxic gas that kills 50% of the test animals during a 1-hour exposure period. It is a measure of acute toxicity by the inhalation route of exposure.

Maximum Allowable Quantity (MAQ) (per CFC): The maximum amount of hazardous material allowed to be stored or used within a control area inside a building or an outdoor control area. The maximum allowable quantity per control area is based on the material state (solid, liquid or gas) and the material storage or use conditions.

National Fire Protection Association (NFPA) 55: Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids.

Permissible Exposure Limit (PEL): Maximum legal airborne concentration over an 8-hour shift.

Safety Data Sheet (SDS): A standardized document provided by a manufacturer about a specific hazardous material. The SDS contains information on physical properties, hazards, safe use, handling, transport, and other regulatory information for the chemical.

Toxic Gas (per CFC): A gas that has a median lethal concentration (LC50) in air of more than 200 ppm but not more than 2,000 ppm by volume of gas or vapor, or more than 2 mg/l but not more than 20 mg/l of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

Responsibilities

Principal Investigators / Managers

- Maintain primary responsibility for compliance with the Toxic Gas Program.
- Include written safety procedures in the Laboratory Safety Binder.
- Provide and maintain gas equipment and devices in good working order.
- Provide training for all users of compressed gases and related equipment.
- Maintain current chemical inventory.
- Responsible for Risk Management and Prevention (RMP) program, if required.
- Assure that proper SDSs are available and reviewed.
- Verify that gases are stored in approved, functional exhausted enclosures when required.

Researchers / Staff

- Complete the required safety training.
- Follow SOPs and wear required personnel protective equipment (PPE).
- Label all cylinders, piping, and designated areas.
- Follow signage and evacuation procedures.

Environmental Health & Safety (EHS)

- Assists principal investigator (PI) and/or primary user in establishing appropriate safety procedures and equipment for the proposed use of toxic gases.
- Outlines minimum requirements for safe use of toxic gases.
- Conducts periodic inspection of toxic gas users to ensure requirements of the Toxic Gas Program are being met.
- Maintains and updates the Toxic Gas Program.
- Verify the California Fire Code requirements for all gases under the scope of the Toxic Gas Program are being met.

Program Components

1. **Engineering Controls**

- **Room Ventilation:** Rooms must provide negative pressure relative to hallways and non-recirculated exhaust.
- **When above the MAQ Limit:** The lab should reduce the quantity to below the MAQ. Indoor storage areas and storage buildings shall be fully equipped with an approved automatic sprinkler system.
- **Exhausted Enclosure:**
    - **Construction**. Exhausted enclosures shall be of noncombustible construction.
    - **Ventilation**. Exhausted enclosures shall be provided with an exhaust ventilation system. The ventilation system for exhausted enclosures shall be designed to operate at a negative pressure in relation to the surrounding area. Ventilation system shall be installed in accordance with the California Mechanical Code. Ventilation systems used for highly toxic and toxic gases shall also comply with the following:
        - The average ventilation velocity at the face of the enclosure shall be not less than 200 feet per minute (1.02 m/s) with not less than 150 feet per minute (0.76 m/s).
        - Exhausted enclosures shall be connected to an exhaust system.
        - Exhausted enclosures shall not be used as the sole means of exhaust for any room or area.
    - **Fire-extinguishing system**. Exhausted enclosures where flammable materials are used shall be protected by an approved fire-extinguishing system.

- **Gas Cabinet:**
    - **Construction**. Gas cabinets shall be constructed with the following:
        - Not less than 0.097-inch (2.5 mm) (No. 12 gage) steel.

    - Self-closing limited access ports or noncombustible windows to give access to equipment controls.
    - Self-closing doors.
    - Interiors treated, coated or constructed of materials that are compatible with the hazardous materials stored. Such treatment, coating or construction shall include the entire interior of the cabinet.
  - **Ventilation.** Gas cabinets shall be provided with an exhaust ventilation system. The ventilation system for gas cabinets shall be designed to operate at a negative pressure in relation to the surrounding area. Ventilation system shall be installed in accordance with the California Mechanical Code. Ventilation systems used for highly toxic and toxic gases shall also comply with the following:
    - The average ventilation velocity at the face of gas cabinet access ports or windows shall be not less than 200 feet per minute (1.02 m/s) with not less than 150 feet per minute (0.76 m/s) at any point of the access port of window.
    - Gas cabinets shall be connected to an exhaust system.
    - Gas cabinets shall not be used as the sole means of exhaust for any room or area.
  - **Maximum number of cylinders per gas cabinet.** The number of cylinders contained in a single gas cabinet shall not exceed three. (Note: for toxic and highly toxic gases, there is an exception for cabinets containing cylinders not exceeding one pound (0.454 kg) where net contents are allowed to contain up to 100 cylinders).

- **When above the MAQ limit**, the following requirements shall apply:
    - Gas cabinets and exhausted enclosures shall be equipped internally with automatic sprinkler systems
    - Treatment system
    - Emergency power
    - Automatic fire detection system
    - Gas detection system
- **Seismic Restraint:** All gas cabinets, machinery, equipment, piping and tubing utilizing highly toxic and toxic gases must be braced and anchored in accordance with the seismic design requirements. Also, toxic gas cylinders must be secured to a fixed object by a noncombustible, two-point restraint system (i.e., chains).
- **Piping, Tubing, Valves, Fittings, and Related Components:** All components must be designed and fabricated from materials that are compatible with the material to be contained and must be of adequate strength and durability to withstand the pressure.
- **Manual Valves or Automatic Shutoff Valves:** manual and remotely activated fail-safe emergency shutoff valves must be installed on piping and tubing.
- **Backflow Prevention or Check Valves:** These valves must be provided where the backflow of hazardous materials could create a hazardous condition.
- **Pressure Relief Devices:** Pressure relief devices shall be used within the gas cabinet or vented to a treatment system.
- **Filling or Dispensing Connections:** Filling or dispensing connections must be provided with a means of local exhaust.
- **Piping and Tubing Connections:** Piping and tubing utilized for the transmission of highly toxic, toxic, and corrosive gases must have welded, threaded or flanged connections and must not be located in corridors and within any portion of a means of egress.

- **Valve Protection:** Compressed gas cylinder valves must be protected from physical damage by means of protective caps when they are not used.
- **Incompatible Gases:** Compressed gases must be separated from each other based on the hazard class of their contents. Do not store two incompatible gas cylinders in the same gas cabinet.
- **Storage and Use Requirements:** The classification of gases for storage and use is based on LC_{50} (1-hour, ppm) toxicity ranges, which determines whether a gas is considered highly toxic, toxic, and moderately toxic under the UC Irvine Toxic Gas Program and defines the minimum face velocity required for exhausted enclosures.

	LC_{50} 1hr (ppm)				
	≤200	**>200 to ≤1,000**	**>1,000 to ≤2,000**	**>2,000 to ≤5,000**	**>5,000 to ≤40,000**
Gases Subject to the UC Irvine Toxic Gas Program	Highly Toxic	Toxic			Moderately Toxic
Exhausted enclosure face velocity requirement	200 fpm (per CFC)	200 fpm (per CFC)	200 fpm (per CFC)	100 fpm (per Cal/OSHA)	100 fpm (per Cal/OSHA)

2. Administrative Controls

- **Work Practices:** As a best practice, work involving toxic gases should not be conducted alone. Having another trained individual nearby can improve safety and emergency readiness.
- **SOP:** SOP must address the safe handling, emergency shutdown, storage, transport, and disposal of toxic gases. SOPs must be reviewed and updated whenever processes, equipment, or materials change to maintain accuracy and compliance with current safety standards.
- **Training:** All users complete Lab Safety Fundamentals, Compressed Gas Training, and any specific laboratory or vendor training.
- **Chemical Inventory:** Maintain up-to-date chemical inventories.
- **Signage:** Rooms that store or use toxic gases must display compliant hazard signage in accordance with the UCI Laboratory Door Placards Reference Guide at all entrances. The signage should clearly indicate the presence of toxic gases and identify the associated hazards to ensure personnel and emergency responders are aware of potential risks.
- **Piping System Signs:** Piping systems must be clearly marked with the name of their contents and include arrows indicating the direction of flow.
- **Gas Cabinet Signage:** Gas cabinets must be clearly labeled with the name of the toxic gas, its concentration, and the associated hazards.
- **Maintenance:** Equipment, machinery, detection and alarm systems, and automatic emergency shut-off valves associated with highly toxic and toxic gases must be tested and maintained in proper working conditions. All maintenance activities should follow the manufacturer's requirements to ensure reliability and compliance.
- **Storage:** Secure gas cylinders to prevent falling due to accidental contact, vibration, or earthquakes. Cylinders are secured in one of the following ways:

    - By a noncombustible, two-point restraint system (i.e., chains) that secures the cylinder at the top and bottom one-third portions.
    - By a noncombustible rack, framework, cabinet, approved strapping device, secured cylinder cart, or other assembly that prevents the cylinder from falling.
- **Leak Test Procedures**: Laboratories must have leak test procedures in place to ensure the safe operation of gas systems and equipment. These procedures should outline the steps for conducting regular leak checks, acceptable detection methods, and proper documentation of results. Leak tests should be conducted regularly and before the start of each experiment.
- **Incident Investigation:** Incidents, injuries, and near-misses that result in, or could have resulted in, catastrophic releases must be investigated by EHS within 48 hours including the Fire Safety division. Reports must include descriptions, contributing factors, and corrective actions, and be shared with affected personnel.
- **Compliance Audits:** Audits must be conducted by the EHS. Findings must be documented, corrective actions tracked, and the two most recent audit reports retained.

3. Personal Protective Equipment (PPE)

- Eye protection (safety glasses or goggles) is always required. Use of face shields will depend on the task being performed.
- Lab coats (flame-resistant if fire hazard exists), long pants, closed-toe shoes required.
- Gloves: Appropriate gloves must be worn when handling compressed gas cylinders to protect against sharp edges, cold temperatures, and potential contact with hazardous materials. The type of glove should be selected based on the specific gas and task being performed.
- Respiratory protection is required when all other exposure control methods (engineering, administrative) are inadequate. Use of respiratory protection is subject to the campus respiratory protection program.
- Steel-toed shoes recommended for moving cylinders; barriers/shields required for certain high-hazard operations. Consult with EHS.

Reporting Requirements

- Unauthorized Removal or Missing Cylinder: Immediately notify the PI, EHS, and Campus Police.
    - If you witness an active theft or an attempt to remove a cylinder without authorization, call 911 immediately.
- Accidental Release: Evacuate, pull fire alarm, close enclosure if safe; notify PI, lab staff, and EHS.
- Alarm Activation / Equipment Failure: Report promptly to PI and EHS.

References

- California Code of Regulations, Title 24, Part 2, California Building Code (CBC), 2025.
- California Code of Regulations, Title 24, Part 9, California Fire Code (CFC), 2025.
- California Code of Regulations, Title 8. Cal/OSHA Sections 5154, 5155, & 5194.
- Occupational Safety and Health Administration (OSHA) 29 CFR 1910.1000 – Air contaminants.
- National Fire Protection Association (NFPA) 55, 2023. Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids (latest edition).
- United Nations (UN), Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 9th Revised Edition, 2021.
- U.S. Department of Transportation (DOT), Title 49, Code of Federal Regulations, Part 173: Shippers—General Requirements for Shipments and Packaging.
- National Institute for Occupational Safety and Health (NIOSH), Immediately Dangerous to Life or Health (IDLH) Values, NIOSH Pocket Guide to Chemical Hazards, 2023.
- University of California, Irvine. Compressed Gases Safety Program. Environmental Health & Safety (EHS).