



Toxic/Corrosive/Flammable/Pyrophoric Gas Program

I. Policy

A broad spectrum of toxic, corrosive and pyrophoric compressed gases is used at the California State University Fullerton (CSUF) campus. Increased recognition of the hazards associated with the transportation, operation, and storage of these gases has prompted a higher level of governmental regulation regarding these activities in all work settings. Because of the extreme health hazard presented by an accidental release of a highly toxic gas on the CSUF campus, the Environmental Health & Safety Department has developed a Toxic Gas Program designed to minimize the hazards associated with toxic and corrosive gases.

The purpose of this program is to minimize the likelihood of an uncontrolled toxic gas release by establishing minimum standards and uniform procedures for purchasing, handling, use, storage, and disposal of these gases at UC Berkeley facilities.

II. Authority

California Code of Regulations (CCR), Title 8, Section 4650

California Code of Regulations (CCR) Title 8 §5191 et al

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

III. Scope

This program applies to the purchase, transportation, use, storage, and disposal of toxic gases (as defined in this document) by faculty, staff, and students of UC Berkeley. Definitions are provided in Appendix A. This Program applies to all CSUF instructional and research including leased properties. The Program 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. This Program does not address USE of the gases, but addresses industry/institutional accepted standard safe work practices.

Certain dilute toxic gases are exempt from this program if worst case release modeling of an accidental acute release indicates that the gas concentration will not result in exposures to laboratory personnel exceeding any of the following:

- The Cal/OSHA Short Term Exposure Limit (STEL)
- The Threshold Limit Value-ceiling (TLV-C)

- One half of the concentration established as Immediately Dangerous to Life or Health (IDLH) as defined in the California Code of Regulations, Title 8, Section 5192

IV. Definitions

Ceiling:

The chemical concentration about the breathing zone that must not be exceeded at any time for a working exposure.

DOT:

The United States Department of Transportation. DOT is responsible for promulgating regulations controlling the transport of toxic gases.

IDLH:

Immediately Dangerous to Life or Health. "An atmospheric concentration of any toxic, corrosive, or asphyxiant 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" (California Code of Regulations, Title 8, Section 5192).

Manometer:

An instrument for measuring pressure. A U-tube partially filled with a liquid that indicates the pressure exerted on the instrument by displacement of the liquid.

Leak Test:

Testing pressurized apparatus by a reliable method. This may include coating all non-welded joints with a soap solution which is capable of forming bubbles at leak points, a pneumatic leak-down test using accurate gauges, or other effective measures.

Magnehelic:

A diaphragm-type pressure differential sensor with a direct reading gauge.

NFPA:

National Fire Protection Association.

PEL:

Permissible Exposure Limit: The maximum concentration of an airborne contaminant to which a worker may be exposed for an 8-hour shift. PELs are established and enforced by Cal/OSHA (California Occupational Safety and Health Administration).

RMPP:

Risk Management and Prevention Program. A Risk Management Prevention Program is required to anticipate and prevent circumstances that could result in accidental releases of acutely hazardous materials (AHMs) if used in amounts greater than the threshold planning quantity (TPQ). The RMPP includes a hazard and operability study, offsite consequence analysis, and seismic analysis.

RFO:

Restricted Flow Orifice. An in-cylinder device that reduces the maximum gas release rate.

STEL:

Short Term Exposure Limit. A maximum time weighted exposure that should not be exceeded for any 15-minute period during a workday.

TLV-TWA:

The threshold limit value time weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Toxic Gas:

Toxic gases, for the purpose of this program, are gases that may cause significant acute health effects at low concentrations. Health effects may include severe skin or eye irritation, pulmonary edema, neurotoxicity, or other potentially fatal conditions. The criteria used to establish the list for this policy (see Appendix A) are: (1) A National Fire Protection Association (NFPA) health rating of 3 or 4; (2) An NFPA health rating of 2 with poor physiological warning properties; (3) Pyrophoric (self igniting) characteristics or; (4) Extremely low occupational exposure limits in the absence of an NFPA health

V. Accountability

Establish and implement a program to identify toxic/corrosive/flammable/pyrophoric gases utilized in research at CSUF and provide a mechanism to safely transport, store, and use of toxic/corrosive/flammable/pyrophoric gases.

Environmental Health and Safety Department

The Environmental Health and Safety Department (EH&S) provides the Principle Investigator, Academic Laboratory Leader assistance in establishing appropriate safety procedures and safety equipment for the safe use of toxic/corrosive/flammable/pyrophoric gases. EHI&S will provide training upon request as well as provide consultation on regulatory compliance. EHI&S will provide reviews of equipment setup and gas handling procedures. EHI&S will notify the PI if the gas type and amount may necessitate a Risk Management and Prevention Plan. EHI&S will assist the PI in developing a RMPP and act as a liaison with applicable regulatory agencies. EH&S maintain an active Toxic/Corrosive/Flammable/Pyrophoric Gas Program and will perform semiannual inspections of all laboratory spaces to verify compliance with this manual, and provide the results to the appropriate college Dean(s).

Chemical Hygiene Officer

The Chemical Hygiene Officer (CHO) shall keep an inventory gases (Toxic / corrosive / flammable / pyrophoric /cryogenic) utilized in research at CSUF. The CHO will inspect each laboratory semiannually and perform random 'Spot-Inspections' in all laboratories. The CHO will inspect the cylinder storage, gas regulators and to a limited aspect the connection(s) to

the experiment in order to provide recommendations to the safe storage and management of the gases.

Dean, College of Natural Science and Mathematics College Deans

The College Dean is responsible for providing the space, equipment, and funding necessary for safe laboratory operation.

Department Chairs

Department Chairs are responsible for supporting the established Campus policies, procedures, guidelines and standard operating procedures in order to provide an effective laboratory safety in their Departments.

Principal Investigator / Academic Laboratory Leader

The Principal Investigator (PI) or Academic Laboratory Leader (ALL, the Faculty or Graduate Student/Teaching Assistant member in charge of an academic laboratory section) is responsible for ensuring all laboratory activities under their control meet or exceed applicable industry/institutional standards and all applicable State and Federal regulations and local ordinances, and present a minimal level of risk to laboratory participants. The PI or ALL/TA is responsible for identification of hazards and the assessment of all risks associated with laboratory operations. The PI or ALL/TA is responsible for toxic/corrosive/flammable/pyrophoric gas safety in the laboratory. The PI or ALL/TA shall provide and document safety instruction to ensure that staff and/or students are aware of hazards involved with their laboratory tasks, and the equipment and practices required to safely perform their assigned tasks. The PI or ALL/TA shall ensure necessary safety equipment is available in the laboratory, used when required, and adequately maintained. The PI or ALL/TA shall establish and annually review emergency procedures. The PI or ALL shall arrange for immediate medical attention for injured personnel and report incidents of injury or property damage as required.

Laboratory Staff/Student

It is the responsibility of each person working in a laboratory to be aware of the risks associated with their assigned duties, and to comply with the procedures provided. Report any unsafe conditions or practices to the PI, ALL, or to EH&S by calling 657.278.7233 (x. 7233). Report all incidents resulting in injury, property damage, or exposure to a hazardous agent to the EH&S by calling 657.278.7233 (x. 7233) and your PI or ALL.

Environmental Health and Safety Department

The Environmental Health and Safety Department (EH&S) provides consulting, training, and compliance verification support for laboratory matters relating to regulatory and policy compliance, safety, risk, and health in the laboratory. EH&S will perform semiannual and 'Spot' inspections of all laboratory spaces to verify compliance with this and other policies, procedures, guidelines, and standard operating procedures and provide the results to the appropriate Department Chair(s) and college Dean(s).

VI. Program

Upon receipt of toxic/corrosive/flammable/pyrophoric gases cylinders, the cylinders shall be temporarily stored in a well-ventilated area that is locked at all times. All cylinders shall be immediately leak tested with a leak indicating solution and must be clearly labeled with content and hazard information. Temporary storage locations shall have appropriate signage in place. Cylinders must be seismically secured at all locations with chains at two contact points on the cylinder body, using unistruts or an equivalent. Seismic securing should prevent cylinders from rolling, shifting, or falling.

Storage & Security

Laboratory storage of all toxic gas cylinders shall be in a mechanically ventilated, lockable area. Examples of mechanical ventilation include vented gas cabinets and fume hoods (lecture bottle size (F) to D size bottles only). Rooms containing toxic gases shall be locked when not occupied by authorized persons. All cylinders and gas cabinets must be clearly labeled with content and hazard information. Cylinders shall be seismically secured at all locations with chains (2 contact points), using unistruts or an equivalent for cylinders larger than lecture bottles. Lecture bottles must be secured to a stable surface. Outdoor storage is only allowed on a short term basis in a secure, lockable area at least 75 feet from an exterior door, window, or air intake location.

Transport from Off-campus Supplier

All commercial vendors and university employees shall comply with DOT regulations, where applicable, regarding the transport of toxic gases. Questions regarding the transportation of toxic gases should be directed to EH&S 657.278.7233 (x. 7233).

On-campus Transport

Transport of ALL toxic gases between on-campus locations must be conducted as follows:

- Gas cylinders must be secured to the transport vehicle (cart, motor vehicle, hand truck, etc.)
- Cylinders must be continuously attended during transport
- Cylinders must be clearly labeled with content and hazard information
- Cylinder caps must be in place

These requirements apply to all listed toxic gas containers, including empty and partially full cylinders. [Common Toxic Gases as Defined by the Toxic Gas Ordinance and California Fire Code](#)

Gas Regulators and Lines

All regulators, valves, and lines must be chemically compatible with the gases being used. Compatibility can be determined by contacting the gas vendor or by calling EH&S 657.278.7233 (x. 7233). Regulator/line systems must be leak tested immediately after assembly and before each use. Regulators shall be compatible with the size and type of gas cylinder being used, and rated for full cylinder pressure.

Cylinder and Reaction Vessel/Chamber Enclosure

All toxic gas cylinders and reaction vessels/chambers shall be kept in ventilated enclosures during use and storage. Air-flow velocities at all openings in the vented enclosures must be 0.5 m/s (100 fpm) or greater while in the open position. Where regular access is needed, small access doors must be used to minimize exhaust flow reduction.

Purge Vents and Exhaust Lines

All lines or ducts carrying purged or exhausted emissions of toxic/ corrosive/flammable/ pyrophoric gases must be connected to a mechanical exhaust system that discharges to a safe location (i.e., presents no potential for re-entrainment into any building supply air intake or occupied area). Exhaust duct walls shall be chemically resistant to degradation by the toxic gas in use.

Significant emissions of corrosive or toxic gases require an emission control device (e.g., scrubber, flare device, adsorbent) before the purged gas can be vented into the exhaust duct system. Significant emissions are defined as duct concentrations that result in duct corrosion or acute health risk to persons exposed near exhaust fan stacks as determined by release modeling. When toxic gases are emitted from exhaust systems at concentrations which could pose health risks to rooftop workers, locked gates, doors, or other means shall be used to prevent worker access to stack discharge areas. Warning signs must be conspicuously placed.

Ventilation Monitoring

A ventilation monitor is required on each lab hood or gas cabinet in which toxic/corrosive/ flammable/pyrophoric gases are used and stored. Acceptable monitors include audible and visual alarms, in conjunction with magnehelic gauge, inclined manometer, or other devices which indicate that the enclosure is actively ventilated. Manometers and gauges should be clearly marked to indicate safe pressure limits.

Empty Cylinder Disposal

All empty toxic/ corrosive/flammable/pyrophoric gases gas cylinders shall be labeled as empty. Depleted toxic gas cylinders should be returnable to the vendor according to their guidelines. The purchase of any gases that will not be completely used in the course of research must be approved by the vendor for return, or by EH&S for disposal as hazardous waste. Disposal of toxic gas cylinders by EH&S, even when empty, may entail extraordinary costs. Therefore, toxic gases should be purchased only from vendors who will accept returns.

Toxic Gas Monitors

Electronic toxic/ corrosive/flammable/pyrophoric gas monitors with alarms should be installed and continuously operated wherever a toxic gas is used which has a high concentration, large quantity, and/or poor physiological warning properties (odor or irritation). The requirement for a monitoring system will be decided on a case by case basis and will be required more commonly for continuous operations and long term research situations. A toxic gas has poor warning properties when such properties are only noticeable at or above harmful concentrations (e.g., the PEL). Some toxic gases with poor warning properties are identified in [the list of common toxic gases](#). Gas monitoring equipment must be able to detect concentrations at or below the PEL.

Alarm Locations

All gas monitoring systems should have:

- Audible and visible alarms in the following locations: gas supply location, gas use or operator room, and outside the gas use room (e.g., corridor)

- An alarm status and gas concentration readout panel located outside the gas use room
- Local audible and visual alarms specific and distinct from fire alarm bells and signs to indicate the alarm's meaning and required personnel action
- The toxic gas alarm level setpoint set at the PEL or Threshold Limit Value

Power and Control

Toxic gas monitors and alarms should be connected to an emergency power source. In the event of a power failure, the detection system should continue to operate without interruption, or gas systems should automatically shut down at the source. Power connections, control switches, and adjustments that affect the detection system operation should be protected from direct access by locks on the enclosures.

Updated 9/14/11 tw

COMMON TOXIC GASES AS DEFINED BY THE TOXIC GAS ORDINANCE AND CFC

For Use By All Jurisdictions, Cities and County, Within the Limits of Santa Clara County.

Authority Cited: California Fire Code (CFC); California Building Code (CBC); Toxic Gas Ordinance (TGO)

GAS & FORMULA	CAS No./ UN No.	CBC/CFC CLASS ¹	TGO CLASS ²	IDLH ³	LC ₅₀ ⁴	LOC	MAX TQ	PEL ⁵
Ammonia - NH ₃	7664-41-7 UN1005	Corrosive ^{6,7} Flammable	III	300 ppm	4,000 ppm	30 ppm	8,000 lbs.	50 ppm
Arsine - AsH ₃	7784-42-1 UN2188	Highly Toxic Flammable	I	3 ppm	20 ppm	0.3 ppm	N/A	0.05 ppm
Boron Tribromide - BBr ₃	10294-33-4 UN2692	Toxic WR-2	II	50 ppm	380 ppm	5 ppm	760 lbs.	1 ppm ©
Boron Trichloride - BCl ₃	10294-34-5 UN1741	Corrosive ⁶ WR-1	II	25 ppm ⁸	2,541 ppm	2.5 ppm	5,082 lbs.	5 ppm
Boron Trifluoride - BF ₃	7637-07-2 UN1008	Toxic WR-1	II	25 ppm	806 ppm	2.5 ppm	1,612 lbs.	1 ppm ©
Bromine - Br ₂	7726-95-6 UN1744	Highly Toxic Corrosive Oxidizer	I	3 ppm	113 ppm	0.3 ppm	N/A	0.1 ppm
Carbon Monoxide - CO	630-08-0 UN1016	Flammable ⁶	III	1,200 ppm	3,760 ppm	120 ppm	7,520 lbs.	50 ppm
Chlorine - Cl ₂	7782-50-5 UN1017	Toxic Corrosive Oxidizer	II	10 ppm	293 ppm	1 ppm	586 lbs.	1 ppm ©
Chlorine Dioxide - ClO ₂	10049-04-4 NA9191	Toxic UR-3 Oxidizer WR-1	II	5 ppm	250 ppm	0.5 ppm	500 lbs.	0.1 ppm
Chlorine Trifluoride - ClF ₃	7790-91-2 UN1749	Toxic Oxidizer WR-3	II	20 ppm	299 ppm	2 ppm	598 lbs.	0.1 ppm ©
Diborane - B ₂ H ₆	19278-45-7 UN1911	Highly Toxic Flammable WR-2	I	15 ppm	80 ppm	1.5 ppm	N/A	0.1 ppm

Common Toxic Gases as Defined by the Toxic Gas Ordinance and CFC – Page 2 of 4

GAS & FORMULA	CAS No./ UN No.	CBC/CFC CLASS ¹	TGO CLASS ²	IDLH ³	LC ₅₀ ⁴	LOC	MAX TQ	PEL ⁵
Dichlorosilane - SiH ₂ Cl ₂ (HCl)	4109-96-0 UN2189	Toxic Corrosive Flammable	II	50 ppm	314 ppm	5 ppm	628 lbs.	5 ppm ©
Ethylene Oxide - C ₂ H ₄ O	75-21-8 UN1040	Flammable ⁶ UR-3	III	800 ppm	4,350 ppm	80 ppm	8,700 lbs.	1 ppm
Fluorine - F ₂	7782-41-4 UN1045	Highly Toxic Oxidizer	I	25 ppm	185 ppm	2.5 ppm	N/A	0.1 ppm
Germane - GeH ₄	7782-65-2 UN2192	UR-3 Toxic Flammable	II	6 ppm ⁸	622 ppm	0.6 ppm	1,244 lbs.	0.2 ppm ⁹
Hydrogen Bromide - HBr	10035-10-6 UN1048	Corrosive ⁶	II	30 ppm	2,860 ppm	3 ppm	5,720 lbs.	3 ppm
Hydrogen Chloride - HCl	7647-01-0 UN1050	Corrosive ⁶	II	50 ppm	2,810 ppm	5 ppm	5,620 lbs.	5 ppm ©
Hydrogen Cyanide - HCN	74-90-8 UN1051	Highly Toxic Flammable	I	50 ppm	40 ppm	5 ppm	N/A	10 ppm
Hydrogen Fluoride - HF	7664-39-3 UN1052	Toxic	II	30 ppm	1,300 ppm	3 ppm	2,600 lbs.	3 ppm
Hydrogen Selenide - H ₂ Se	7783-07-5 UN2202	Highly Toxic Flammable	I	1 ppm	2 ppm	0.1 ppm	N/A	0.05 ppm
Hydrogen Sulfide - H ₂ S	7783-06-4 UN1053	Toxic Flammable	II	100 ppm	712 ppm	10 ppm	1,424 lbs.	20 ppm
Methyl Bromide - CH ₃ Br	74-83-9 UN1062	Toxic Flammable	II	250 ppm	1,007 ppm	25 ppm	2,014 lbs.	20 ppm ©
Methylisocyanate - CH ₃ NCO	624-83-9 UN2480	Highly Toxic Flammable WR-2	I	3 ppm	22 ppm	0.3 ppm	N/A	0.02 ppm

Common Toxic Gases as Defined by the Toxic Gas Ordinance and CFC – Page 3 of 4

GAS & FORMULA	CAS No./ UN No.	CBC/CFC CLASS ¹	TGO CLASS ²	IDLH ³	LC ₅₀ ⁴	LOC	MAX TQ	PEL ⁵
Methyl Mercaptan - CH ₃ SH	74-93-1 UN1064	Toxic Flammable	II	150 ppm	1,350 ppm	15 ppm	2,700 lbs.	10 ppm ©
Nickel Carbonyl - Ni(CO) ₄	13463-39-3 UN1259	Highly Toxic UR-3 Flammable WR-1	I	2 ppm	18 ppm	0.2 ppm	N/A	0.001 ppm
Nitric Oxide - NO	10102-43-9 UN1660	Highly Toxic Oxidizer	I	100 ppm	115 ppm	10 ppm	N/A	25 ppm
Nitrogen Dioxide - NO ₂	10102-44-0 UN1067	Highly Toxic Oxidizer WR-1	I	20 ppm	115 ppm	2 ppm	N/A	5 ppm ©
Phosgene - COCl ₂	75-44-5 UN1076	Highly Toxic WR-1	I	2 ppm	5 ppm	0.2 ppm	N/A	0.1 ppm
Phosphine - PH ₃	7803-51-2 UN2199	Highly Toxic Pyrophoric	I	50 ppm	20 ppm	5 ppm	N/A	0.3 ppm
Phosphorus Oxychloride - POCl ₃	10025-87-3 UN1810	Highly Toxic WR-2	I	0.96 ppm ⁸	96 ppm	0.096 ppm	N/A	0.1 ppm ^{8,9}
Phosphorus Pentafluoride - PF ₅	7647-19-0 UN2198	Toxic Oxidizer WR-1	II	2.6 ppm ⁸	260 ppm	0.26 ppm	520 lbs.	3 ppm
Phosphorus Trichloride - PCl ₃	7719-12-2 UN1809	Toxic UR-2 WR-2 Oxidizer	II	25 ppm	208 ppm	2.5 ppm	416 lbs.	0.5 ppm
Selenium Hexafluoride - SeF ₆	7783-79-1 UN2194	Highly Toxic	I	2 ppm	50 ppm	0.2 ppm	N/A	0.05 ppm (as Se)
Silicon Tetrachloride - SiCl ₄ (HCl)	10026-04-7 UN1818	Toxic Corrosive	II	50 ppm	750 ppm	5 ppm	1,500 lbs.	5 ppm ©
Silicon Tetrafluoride - SiF ₄ (HF)	7783-61-1 UN1859	Toxic WR-2	II	30 ppm	450 ppm	3 ppm	900 lbs.	0.1 ppm

Common Toxic Gases as Defined by the Toxic Gas Ordinance and CFC – Page 4 of 4

GAS & FORMULA	CAS No./ UN No.	CBC/CFC CLASS ¹	TGO CLASS ²	IDLH ³	LC ₅₀ ⁴	LOC	MAX TQ	PEL ⁵
Stibine - SbH ₃	7803-52-3 UN2676	Highly Toxic Flammable	I	5 ppm	20 ppm	0.5 ppm	N/A	0.1 ppm
Sulfur Dioxide - SO ₂	7446-09-5 UN1079	Corrosive ⁶	II	100 ppm	2,520 ppm	10 ppm	5,040 lbs.	5 ppm
Sulfuryl Fluoride - SO ₂ F ₂	2699-79-8 UN2191	Corrosive ⁶	III	200 ppm	3,020 ppm	20 ppm	6,040 lbs.	5 ppm
Tellurium Hexafluoride - TeF ₆	7783-80-4 UN2195	Highly Toxic	I	1 ppm	25 ppm	0.1 ppm	N/A	0.02 ppm (as Te)
Titanium Tetrachloride - TiCl ₄	7550-45-0 UN1838	Highly Toxic Corrosive WR-2	I	1.3 ppm	119 ppm	0.13 ppm	N/A	
Tungsten Hexafluoride - WF ₆ (HF)	7783-82-6 UN2196	Toxic Corrosive WR-2	II	30 ppm	217 ppm	3 ppm	434 lbs.	0.1 ppm

Notes:

- ¹ Class as defined in CFC: 1.) Health Hazards per Chapter 27: Highly Toxic = < 200 LC₅₀, Toxic = 200 - 2,000 LC₅₀. 2.) Physical Hazards per CFC Chapter 27 and NFPA 704.
- ² TGO Class Defined As: Class I = < 200 LC₅₀, Class II = 200 – 3,000 LC₅₀, Class III = 3,001 – 5,000 LC₅₀
- ³ IDLH values published in 1994 by the National Institute for Occupational Safety and Health (NIOSH).
- ⁴ LC₅₀ data: Lowest reported value, 1 hour adjusted, taken from DOT, CGA, RTECS.
- ⁵ PEL values published by OSHA (29 CFR, part 1910.1000, Table Z-1) dated 7/1/95. OSHA values used if available, otherwise Threshold Limit Value (TLV) from American Conference of Governmental Industrial Hygienists (ACGIH) (1994-1995) or Cal OSHA values used. © = Ceiling Limit.
- ⁶ Moderately toxic as adopted by the cities of San Jose, Santa Clara, and Milpitas: LC50 = 2,000 – 5,000.
- ⁷ When used as a refrigerant, CBC Class does not apply. See TGO consensus guidelines for additional information regarding ammonia refrigeration systems.
- ⁸ IDLH determined by 0.01 of LC₅₀.
- ⁹ Cal OSHA PEL, Title 8, Section 5155, 9/1/95.