University of California, Berkeley

TOXIC, CORROSIVE, AND PYROPHORIC (TCP) GAS PROGRAM

Prepared by:
Office of Environment, Health & Safety

Berkeley EH&S
UNIVERSITY OF CALIFORNIA

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Overview

UC Berkeley is known for diverse, cutting edge research. Modern laboratory research involves the use of hazardous materials, including toxic, corrosive and pyrophoric gases. Health hazards associated with accidental release of toxic and corrosive gases require additional safety review and oversight. In addition, pyrophoric gases, which ignite spontaneously in air, require additional safety and engineering controls.

The purpose of this program is to reduce the likelihood of an uncontrolled release of any gases that pose severe acute health hazards or immediate physical hazards. To ensure these gases are used safely, the Office of Environment, Health, & Safety (EH&S) and the Campus Fire Marshal review all new and existing uses of potentially toxic, corrosive, and pyrophoric gases to ensure compliance with state and federal codes and standards. Enforcing safety standards for purchasing, handling, use, storage, and disposal of these gases allows campus researchers and staff at UC Berkeley to work with these materials safely.

Gases that meet the California Fire Code (CFC) definitions for Highly Toxic, Toxic, Corrosive, and Pyrophoric gases have additional requirements that are enforced within individual control areas or laboratory suites in campus buildings. These requirements include not exceeding Maximum Allowable Quantities (MAQs) and use of gas cabinets or exhausted enclosures.

Definitions

Acutely toxic gas (per Globally Harmonized System, GHS) – A gaseous substance or mixture with serious health effects (i.e., lethality) that occur 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 LC_{50} (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

Chapter 3.1 (Acute Toxicity), Globally Harmonized System of Classification and Labelling of Chemicals (8th edition), United Nations, 2019.

California Fire Code (CFC) – California Code of Regulations, Title 24, Part 9, California Fire Code, 2019

Cal/OSHA – *California Division of Occupational Safety and Health*. 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 (see definition below).

Ceiling - The breathing zone chemical concentration in air that shall not be exceeded at any time.

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

1. Is a gas at [NTP] 68°F (20°C) or less at 14.7 psia (101 kPa, 1 atm) of pressure; and
2. Has a boiling point of 68°F (20°C) or less at 14.7 psia (101 kPa, 1 atm) which is either liquefied, nonliquefied 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).

The states of a compressed gas are categorized as follows:

1. Nonliquefied compressed gases are gases, other than those in solution, which are in a packaging under the charged pressure and are entirely gaseous at a temperature of 68°F (20°C).
2. Liquefied compressed gases are gases that, in a packaging under the charged pressure, are partially liquid at a temperature of 68°F (20°C).
3. Compressed gases in solution are nonliquefied gases that are dissolved in a solvent.
4. Compressed gas mixtures consist of a mixture of two or more compressed gases contained in a packaging, the hazard properties of which are represented by the properties of the mixture as a whole.

Corrosive (per CFC) - A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. A chemical shall be considered corrosive if, when tested on the intact skin of albino rabbits by the method described in DOTn 49 CFR 173.137, such chemical destroys or changes irreversibly the structure of the tissue at the point of contact following an exposure period of 4 hours. This term does not refer to action on inanimate surfaces.

Corrosive (per GHS) – See Skin Corrosion and Serious Eye Damage.

D.O.T. – United States *Department of Transportation*. Federal agency responsible for regulating the transport of hazardous materials.

EH&S – UC Berkeley's Office of *Environment, Health & Safety*. EH&S is responsible for providing technical guidance and services to the campus community that promote health, safety, and environmental stewardship. EH&S oversees the TCP Gas Program.

Exempt – *Exempt from the TCP Gas Program.* After an analysis by EH&S, use of a Toxic, Corrosive, or Pyrophoric gas is exempt from the TCP Gas Program due to concentration, quantity, or gas properties not falling under the scope of this program.

Exhausted Enclosure – 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.

GHS – *Globally Harmonized System* of Classification and Labelling of Chemicals (8^{th} edition), United Nations, 2019. GHS is adopted by reference per California Code of Regulations, Title 8, Section 5194.

Highly Toxic Gas (per CFC) – A gas that has a median lethal concentration (LC_{50}) 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.

IDLH – *Immediately Dangerous to Life or Health.* An atmospheric concentration (in ppm) 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).

LC_{50} – *Lethal concentration (50).* The median exposure level, expressed in parts per million (ppm), at which 50% of the testing population died following inhalation exposure.

Lower Explosive Limit (LEL) – The minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. The LEL is sometimes referred to as LFL or Lower Flammable Limit.

Maximum Allowable Quantity (MAQ) – The maximum amount of a 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 (CFC).

Moderately Toxic gas (per TGO) – A material that has a median lethal concentration (LC_{50}) in air of more than 2,000 parts per million (ppm) but not more than 5,000 ppm by volume of gas or vapor, or more than 20 milligrams per liter but not more than 50 mg/l of mist, fume or dust, when administered by continuous inhalation for an hour, or less if death occurs within one hour, to albino rats weighing between 200 and 300 grams each.

NTP – *Normal Temperature and Pressure.* NTP corresponds to 20°C (68°F, 293 K) and 1 atmosphere (atm) pressure (14.7 psi, 101.3 kPa).

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). When Cal/OSHA values are not available, OSHA values are used.

Pyrophoric (per CFC) – A chemical with an autoignition temperature in air, at or below a temperature of 130°F (54°C).

Pyrophoric Gas (per GHS) – A pyrophoric gas is a flammable gas that is liable to ignite spontaneously in air at a temperature of 54°C or below.

H220, Category 1A, Pyrophoric gas

RMPP – *Risk Management and Prevention Program.* A Risk Management Prevention Program is required by EPA, Cal/OSHA and California Office of Emergency Services 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 – *Restrictive Flow Orifice.* An in-cylinder device that reduces the maximum gas release rate.

SDS – *Safety Data Sheet.* 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.

Serious Eye Damage – *Serious eye damage* refers to the production of tissue damage to the eye, or serious physical decay of vision, which is not fully reversible, occurring after exposure of the eye to a substance or mixture.

> **H318, Category 1** criteria includes substances that have the potential to seriously damage the eyes.

Skin Corrosion (per GHS) – *Skin corrosion* refers to the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis occurring after exposure to a substance or mixture.

> **H314, Category 1** criteria includes destruction of skin tissue, namely, visible necrosis through the epidermis and into the dermis in at least one tested animal after exposure ≤ 4 hours.

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

STP – *Standard Temperature and Pressure.* STP corresponds to 0°C (32°F, 273 K) and 1 bar pressure (14.5 psi, 100 kPa).

TCP Gas Program – *Toxic, Corrosive, and Pyrophoric Gas Program.* UC Berkeley's program overseeing the storage, use, on-campus transportation, and handling of toxic, corrosive, and pyrophoric gases on UC Berkeley property. EH&S oversees the TCP Gas Program.

Terms and Conditions – A document containing the safety conditions that must be met by the Principal Investigator (PI) and users of all Toxic, Corrosive, and Pyrophoric gases. This applies to all gases, unless otherwise exempt from the TCP Gas Program.

TLV – *Threshold Limit Value.* The maximum average airborne concentration of a hazardous material to which healthy adult workers can be exposed during an 8-hour workday and 40-hour workweek without experiencing significant adverse health effects. TLVs are workplace exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

TGO – *Toxic Gas Ordinance.* A regulating code, adopted by several governmental agencies in the San Francisco Bay Area, for the use, distribution, handling and dispensing of Toxic Gases.

Toxic Gas (per CFC) – A gas that has a median lethal concentration (LC_{50}) 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.

Upper Explosive Limit (UEL) – The maximum concentration of vapor in air above which propagation of flame will not occur in the presence of an ignition source. The UEL is sometimes referred to as UFL or Upper Flammable Limit.

Valve Manifold Box (VMB) – A fully enclosed, ventilated enclosure used to house valves, fittings, pressure regulating, monitoring and flow control devices for gas distribution systems.

Applicability

The Toxic, Corrosive, and Pyrophoric (TCP) Gas Program applies to the purchase, on-campus transportation, use, storage, and disposal of all acutely toxic, corrosive, or pyrophoric gases by faculty, postdocs, visiting scholars, staff, and students of UC Berkeley. Table 1 outlines the scope of all gases included in the program. UC Berkeley is subject to California Fire Code and Cal/OSHA regulations pertaining to these gases, therefore the CFC and Cal/OSHA definitions encompass the program's scope. The Toxic Gas Ordinance (TGO) definitions are provided for reference only. The TGO is commonly used to regulate toxic gas storage and use within neighboring jurisdictions in the greater San Francisco Bay Area.

Gases that meet the California Fire Code (CFC) definitions for Highly Toxic, Toxic, Corrosive, and Pyrophoric gases have additional requirements that are enforced within individual control areas or laboratory suites in campus buildings. These requirements include not exceeding Maximum Allowable Quantities (MAQs) and use of gas cabinets or exhausted enclosures.

Table 1: Toxic Gas definitions

LC_{50} (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	H330, Category 2	H331, Category 3		H332, Category 4	H333, Category 5
TGO[c]	Class I	Class II		Class III	NR	

LC_{50} - *Lethal concentration (50).* The median exposure level, expressed in ppm, at which 50% of the testing population died following inhalation exposure after 1 hour.

NR – Not Regulated

[a]California Fire Code
[b]Globally Harmonized System
[c]Toxic Gas Ordinance
[d]Note – GHS Criteria included gases of relatively low toxicity hazard that may present a danger to vulnerable populations based upon test data or expert judgement.

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 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 TCP Gas Program. The worst-case calculation does not include the beneficial effect of ventilation or restrictive flow orifices.

Roles/Responsibility

Laboratory Operations and Safety Committee

- Provides oversight for implementation of the TCP Gas Program in laboratories
- Arbitrates appeals of purchase requests disapproved by EH&S

Principal Investigator or Gas Use Supervisor

- Maintains primary responsibility for compliance with the TCP Gas Program Terms and Conditions
- Includes written safety procedures in the laboratory Chemical Hygiene Plan
- Provides and maintains gas equipment and devices in good working order
- Conducts and documents laboratory safety self-assessment inspections at regular intervals
- Provides documented training to all users of compressed gases
- Arranges the return or disposal of gas cylinders when gas use is completed
- Maintains current chemical inventory online in *Chemicals*
- Responsible for Risk Management and Prevention Program (RMPP), if required
- Assures that proper SDSs are available and reviewed
- Verifies that Toxic, Corrosive, and Pyrophoric gases are stored in approved, functional exhausted enclosures when required

Office of Environment, Health & Safety (EH&S)

- Assists principal investigator (PI) and/or primary user in establishing appropriate safety procedures and equipment for the proposed use of TCP gases
- Reviews and approves new TCP gas purchases based upon potential hazards and available hazard controls
- Reviews and approves replacement TCP gas purchases based upon streamlined review process
- Outlines minimum requirements for safe use of TCP gas (Terms and Conditions)

- Provides gas release modeling data as necessary, determines if low concentrations or small quantities are exempt from TCP Gas Program requirements (Exempt)
- Conducts periodic follow-up evaluations of toxic gas installations to ensure requirements of the TCP Gas Program are still being met
- Maintains and updates the TCP Gas Program
- Notifies the department and PI if gas type and amount requested may necessitate a Risk Management and Prevention Program (RMPP)
- Enforces California Fire Code requirements for all gases under the scope of the TCP Gas Program

Supply Chain Management (BearBuy)

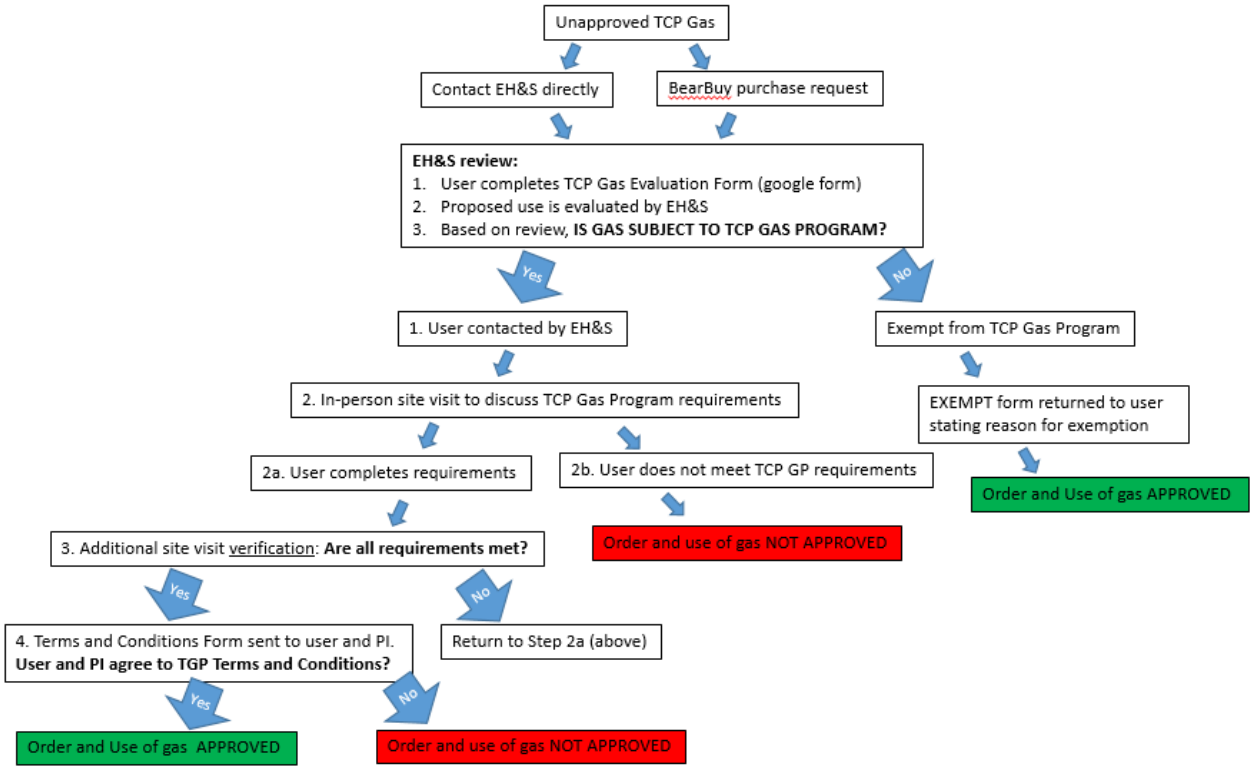
- Flags all TCP gas orders and routes to EH&S approver for review

Program Requirements/Procedures

PURCHASE APPROVAL PROCESS

The TCP gas purchase approval process applies to new and replacement TCP gas use. Changes in quantity, process, location, gas concentration, or other significant factors require additional review. The purchasing process is diagrammed in Figure 1. Renewal purchase requests for TCP gases may be expedited.

Figure 1: Toxic, Corrosive and Pyrophoric (TCP) Gas review process



Proposed new use of TCP gas is ideally routed directly to EH&S during experimental planning phases. If users do not contact EH&S initially, TCP gases are flagged through centralized purchasing based on gas name and CAS number. These are directed to EH&S for review prior to purchase.

New potential users of TCP gases initially complete an online (Google form) TCP Gas Evaluation Form (Attachment A) which is reviewed by EH&S staff. Initial review determines whether or not the material is subject to the Toxic, Corrosive, and Pyrophoric (TCP) Gas Program. This review is based upon the specific gas, quantity, concentration, and proposed location. If handling or use of the gas would not create an unsafe environment (no known adverse health effects) for occupants of the room, the gas may be exempt from the TCP Gas Program. If so, the user would be sent an EXEMPT form (Attachment B) stating the reason(s) for the exemption and orders would be approved.

For proposed gases that are subject to TCP Gas Program requirements, additional steps are warranted. Initially, the user and EH&S staff meet to discuss the requirements of the TCP Gas Program. This involves the following:

- Use of suitable, compatible equipment
- Use of appropriate engineering controls
- Development of Standard Operating Procedures (SOPs) for gas usage
- Review of CFC Maximum Allowable Quantities (MAQs) for proposed control area
- Leak-testing piping prior to initial experiment
- Updating campus chemical inventory with new materials
- Review of emergency procedures
- Regular maintenance of required equipment
- Planning for completion of experiment and disposal of toxic gas cylinder

After the initial site visit, the user is responsible for completing the requirements. The criterion for TCP gas purchase approval is the ability to provide a safe working environment and for proper gas handling and disposal. Once the user has completed the necessary requests, an additional site visit by EH&S experts is done to verify that all TCP Gas Program requirements are met.

If required changes are made, a Terms and Conditions Form (Attachment C) is sent to the primary user and the PI for review. Once approved by both the user and PI (responsible person), the order is approved.

If required conditions are not met, the order will not be approved by EH&S. EH&S will work closely with users to come up with safe alternatives in cases where meeting all requirements would be logistically difficult. Unapproved purchase requests that cannot be resolved may be appealed to the Laboratory Operations & Safety Committee (LO&SC) Chair for an acceptable resolution. If the TCP gas is not in the laboratory's current chemical inventory, the user shall amend the chemical inventory within fifteen (15) days of receiving the gas.

TRANSPORTING TOXIC, CORROSIVE and PYROPHORIC GASES

Transport from an Off-Campus supplier

All commercial delivery vendors shall comply with D.O.T. regulations regarding the transport of TCP gases. On campus, employees, staff, faculty, and graduate students shall follow current California Fire Code requirements for transporting TCP gases. Questions regarding the transportation of TCP gases should be directed to the Office of Environment, Health & Safety (EH&S) at 510-642-3073.

On-Campus Transport

On campus, employees, staff, faculty, and graduate students shall follow current California Fire Code requirements for transporting gases. All transport of TCP gases between on-campus locations must be conducted as follows:

- Gas cylinders exceeding 25 pounds must be transported on an approved cart or hand truck
- Gas cylinders shall be individually secured to the cart or truck to prevent dislodgement
- Cylinders must be continuously attended during transport in corridors and laboratories
- Cylinders must be clearly labeled with content and hazard information
- Cylinder protective caps must be in place
- Cylinder valve outlets shall be plugged
- Cylinders shall be leak checked before transporting
- For cylinder transportation in elevators:
    - No other passengers other than the individual handling the cart shall be allowed
    - Means shall be provided to prevent the elevator from being summoned to other floors
    - For Toxic and Highly Toxic gases exceeding 1 pound, elevators shall not have any passengers

These requirements apply to all gas containers subject to the TCP Gas Program, including empty and partially full cylinders.

STORAGE, HANDLING, AND USE REQUIREMENTS

Receiving

Upon receipt of TCP gases, cylinders shall be stored in a well-ventilated area that is attended or locked at all times. If storage is in a temporary location, appropriate signage shall indicate name and hazard of gas. Cylinders must be seismically secured.

Storage

Indoor storage of all TCP gas cylinders shall be in a mechanically ventilated, secure area. Rooms containing TCP gases shall be locked when not occupied by authorized persons.

Missing TCP gas cylinders shall be reported to campus police and EH&S immediately. All cylinders, gas cabinets, and entrances to the room containing the toxic gas must be clearly labeled with the full gas name and hazard information. Cylinder caps shall be in place at all times when the gas is not in use. Cylinders shall be secured at all times with non-combustible restraints (two contact points for full sized cylinders) attached to a fixed object. Smaller cylinders shall also be seismically secured. Outdoor storage shall be permitted if approved by the Campus Fire Marshal.

Gas Regulators and Piping

All regulators, valves, and piping must be compatible with the gases being used. Pressurized gas systems must be leak tested immediately after assembly and before each use with TCP gases. Piping and tubing used for Toxic, Highly Toxic, Corrosive, and Pyrophoric gases shall have welded, threaded or flanged connections throughout, except with piping is located exclusively within exhausted enclosures. TCP gases using pressurized piping greater than 15 psig may require additional controls, including leak detection and emergency shut-off or excess flow control.

Gas supply lines should be designed with a minimum number of fittings. All piping, regulators, and equipment shall be rated for the planned experimental pressure. Certain gases may require use of restrictive flow orifices (RFOs).

Cylinder and Reaction Vessel/Chamber Enclosure

Ideally, all TCP gas cylinders shall be kept in ventilated enclosures during use and storage. Highly Toxic gases (per CFC) are required to be in gas cabinets or exhausted enclosures with a minimum air flow velocity of 200 feet per minute (fpm). Gases that fall outside the scope of Highly Toxic may be permitted to be stored and used within gas cabinets or fume hoods with reduced air flow (no less than 100 fpm, on average). Ideally, equipment associated with the gas experiment should be located within exhausted enclosures. If this is not possible, additional engineering controls may be necessary, which can include the use of valve manifold boxes, restrictive flow orifices, gas detection (with alarms), automatic shut-offs, and administrative controls.

TCP gases shall only be used in rooms where exhaust ventilation is not recirculated. Ventilation rates in the room shall exhaust at a minimum of 1 cubic foot per minute/square foot or 6 air changes per hour, per California Mechanical Code.

Purge Vents and Exhaust Lines

All lines or ducts carrying purged or exhausted emissions of TCP gases must be connected to an exhaust system installed in compliance with the California Mechanical Code. Exhaust duct materials shall be chemically compatible with the gas in use.

In some circumstances, corrosive or toxic gases will require a treatment system capable of diluting, absorbing, neutralizing, burning or otherwise processing the maximum release of gas to one-half IDLH concentration at the point of discharge. When toxic or corrosive gases are emitted from exhaust systems at concentrations

which could pose health risks to rooftop workers, locked gates, doors, appropriate signage or other means shall be used to prevent worker access to stack discharge areas.

Ventilation Monitoring

A ventilation monitor is required on each fume hood or gas cabinet where TCP gases are used and stored. Acceptable monitors include audible and visual alarms, magnehelic gauges, or other devices which indicate that the enclosure is actively ventilated. Airflow meters should be clearly marked to indicate satisfactory ventilation rates. TCP gases cannot be used if the ventilation rate is not satisfactory. Ventilation monitoring interlocked with automatic gas shutdown may also be required for Highly Toxic and Pyrophoric gases, or for batch processes of more than 6 hours. EH&S reviews all fume hoods for proper ventilation annually. Users are responsible for checking that ventilation in fume hoods or gas cabinets is satisfactory prior to initiating use of TCP gases.

Empty Cylinder Disposal

All empty TCP gas cylinders shall be labeled as empty and shall remain within the exhausted enclosure until disposal. After the experiment is complete or the cylinder is empty, the TCP gas cylinder must be returned to the vendor or disposed of as hazardous waste through campus EH&S.

TOXIC or PYROPHORIC GAS MONITORS

Electronic gas monitors with alarms should be installed and continuously operated wherever a TCP gas is used which has a high concentration, large quantity, and/or poor physiological warning properties. The requirement for a monitoring system is determined based upon the particular gas, the quantity, the concentration, the proposed use, and the specific location. Gas monitoring equipment must be able to detect concentrations at or below the PEL for toxic and corrosive gases. For pyrophoric gases, gas monitors should shut off the gas at the source when the detected concentration is greater than 25% LEL (Lower Explosive Limit). Gas monitors shall be maintained and regularly calibrated according to the manufacturer's recommendations. The Office of Environment, Health & Safety (EH&S) may require periodic verification that the monitor is working properly.

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 required emergency procedures
- The Toxic or Corrosive gas alarm level set-point should be at the PEL or Threshold Limit Value
- Pyrophoric Gas alarms should be at 25% of the LEL (Lower Explosive Limit)

Power and Control

Gas monitors and alarms should, ideally, 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.

REVIEW OF EXISTING TCP GAS USE

TCP Gas Use that has been approved is subject to review and inspection by EH&S on a regular basis. Users are expected to follow the conditions of approval throughout the lifetime of the project and to notify EH&S (toxicgas@berkeley.edu) when any significant changes are being considered.

Referenced Codes and Standards

California Code of Regulations, Title 8, Section 5155, Airborne Contaminants

California Code of Regulations, Title 8, Section 5194, Hazard Communication, Register 2018, No 39

California Code of Regulations, Title 24, Part 2, California Building Code (CBC), 2019

California Code of Regulations, Title 24, Part 4, California Mechanical Code (CMC), 2019

California Code of Regulations, Title 24, Part 9, California Fire Code (CFC), 2019

Department of Transportation (DOTn), Code of Federal Regulations, Title 49, Part 173.179, 2009.

Globally Harmonized System of Classification and Labelling of Chemicals (8th edition), Chapter 3.1 (Acute Toxicity), United Nations, 2019

IDLH values published by National Institute for Occupational Safety and Health (NIOSH), 2017

Recommendations on the Transport of Dangerous Goods: Manual of Tests and Criteria (6th edition), United Nations, 2015

TLV from American Conference of Governmental Industrial Hygienists, 7th edition, 2019

Toxic Gas Ordinance (TGO), South Bay Piping Industry, 2017

United States Department of Labor, Occupational Safety and Health Administration (OSHA), Code of Federal Regulations, Title 29, Section 1910.1000, Air Contaminants

Attachment A

TOXIC, CORROSIVE, and PYROPHORIC GAS EVALUATION FORM

PART A-Users and Location

1. List of all Researchers (Names & Titles) who will be using flammable gases:

2. Contact information for primary user: Cell phone & Email
3. Principal Investigator:
4. Contact information for PI: Cell phone and Email
5. Lab room + Building name where flammable gases will be stored/used:
6. Room dimensions (ft) where gas will be located: length x width x height

PART B-Gas details

1. Name of gas to be used:
2. Concentration of gas:
3. If gas is a mixture, what is the carrier gas?
4. Amount of gas in cylinder (ft^3 or lbs):
5. Planned number of cylinders to be used or stored in the lab at one time:
6. Cylinder pressure:
7. Physical state (**G**aseous or **L**iquefied Gas):
8. Gas vendor:
9. Is the gas cylinder returnable to the vendor? ☐ **Y** ☐ **N**
10. Will this gas be entered into the campus chemical inventory system upon arrival to the lab? ☐ **Y** ☐ **N**

PART C-Training

1. Does the lab have a Standard Operating Procedure (SOP) for working with and changing out this gas? ☐ **Y** ☐ **N**
2. Have relevant lab members read and signed the above SOP? ☐ **Y** ☐ **N**
3. Has the researcher worked with this type of gas (toxic, corrosive, or pyrophoric) before? ☐ **Y** ☐ **N**
4. Have all lab members reviewed emergency procedures? ☐ **Y** ☐ **N**

PART D-Gas process and setup

1. Describe how the gas will be used:

2. Does the experiment use a continuous flow or a batch process (<30 min)?

   ☐ Continuous flow ☐ Batch process

3. How often will the gas be used? **Check all that apply.**

   ☐ Daily

   ☐ Weekly

   ☐ Monthly

   ☐ Other (please describe):

4. How long do you anticipate the experiment involving this gas will last?

5. Where do you plan to store this gas? **Check all that apply.**

   ☐ Lab bench

   ☐ Glove box

   ☐ Fume hood

   ☐ Gas cabinet

   ☐ Floor, open lab

   ☐ Other (please describe):

6. Where is the planned point of use for the gas? **Check all that apply.**

   ☐ Lab bench

   ☐ Glove box

   ☐ Fume hood

   ☐ Gas cabinet

   ☐ Other (please describe):

7. If this gas will be stored in a fume hood or gas cabinet, what is the working ventilation rate (feet per minute, fpm)?

8. Will all equipment, piping, and operations be designed, installed and maintained to ensure they reliably operate as intended? ☐ **Y** ☐ **N**

9. What type of piping and regulators are planned for use with this gas?

10. Will all piping be labeled with name of gas and direction of flow? ☐ **Y** ☐ **N**

    Comments:

11. Are valve manifold boxes planned to be used to house valves, fittings, regulators, pressure regulating and gas monitoring devices outside a gas cabinet? ☐ **Y** ☐ **N**
12. For pyrophoric and flammable gases, will flashback arrestors be on any of the piping or regulators? ☐ **Y** ☐ **N**
13. For pyrophoric and flammable gases, will all conductive and non-conductive components of the operation electrically interconnected and attached to a building ground? ☐ **Y** ☐ **N**
14. Will there be a method for gas leak detection? ☐ **Y** ☐ **N**

    Please describe:

15. Will there be automatic gas monitoring of the gas? ☐ **Y** ☐ **N**

    Please describe the concentration the detectors are set to alarm:

16. What type of gas shut-off and/or flow-reducing valves will be present? **Check all that apply.**

    ☐ Manual

    ☐ Automatic

    ☐ Emergency

    ☐ Excess flow control

    ☐ Restrictive Flow Orifice (RFO) valve

    ☐ Other (please describe):

17. Where will the gas shut-off valves be located? **Check all that apply.**

    ☐ At the source cylinder

    ☐ Remote location

    ☐ At the point of use

    ☐ On Valve Manifold Box

    ☐ Other (please describe):

PART E-General Fire and Life Safety

1. Will the work area be maintained free of flammable and combustible materials? (e.g., cardboard, wood, paper, plastics, cloth, kimwipes, flammable liquids/solids)
   ☐ **Y** ☐ **N**

   If NO, please describe flammable/combustible items in work area and why they are required:

2. Is the work area free of ignition sources, heat, and other hazards? (e.g., heating devices, hot plates, burners, extension cords, electrical sparks, motors, ovens, static electricity, others).

   ☐ **Y** ☐ **N**

   If NO, please describe potential ignition sources in work area and why they are required:

3. Are all exits and corridors free of storage and available for immediate evacuation in the case of an emergency? ☐ **Y** ☐ **N**

4. Are there fire sprinklers or another form of fire suppression in your lab? (To review with fire marshal). **Check all that apply.**

   ☐ Building has automatic fire sprinklers throughout

   ☐ Room (where gas operations will occur) has fire sprinklers

   ☐ Fume hood is internally sprinklered

   ☐ Gas cabinet is internally sprinklered

   ☐ No automatic fire sprinkler protection exists in room

   ☐ Other (please describe):

5. How will occupants of the room and building be notified in the event of a toxic, corrosive or pyrophoric gas release or other emergency? (To review with fire marshal). **Check all that apply.**

   ☐ Automatic smoke detectors

   ☐ Automatic heat detectors

   ☐ Gas detection device with alarm

   ☐ Horns

   ☐ Strobes

   ☐ Automatic fire alarm with manual pull station

   ☐ Other (please describe):

Attachment B

EXEMPTION from TCP GAS PROGRAM

Date:

PI:

User:

The proposed use of xx ft^3 of xx gas in room xx xx Hall is exempt from the Toxic, Corrosive, and Pyrophoric (TCP) Gas Program due to:

- ☐ low quantity of gas
- ☐ low concentration of gas
- ☐ gas is non-hazardous
- ☐ other:

Use of this gas, as proposed, given the current ventilation rates in the laboratory, is below any known health exposure limits.

xx (xx) is a xx gas. Please follow the manufacturer's recommendations per safety data sheets (SDSs) for safe handling and use of these gases.

Any changes made due to additional gases, experimental scale-up, different concentrations, different quantities, new equipment, different location, or any other substantial changes will require a new TCP gas evaluation. Contact EH&S if you have any questions.

Toxic, Corrosive, and Pyrophoric Gas Program

Office of Environment, Health & Safety

University of California, Berkeley

Email: toxicgas@berkeley.edu

Call: 510-642-3073

https://ehs.berkeley.edu/

Attachment C

Berkeley EH&S
UNIVERSITY OF CALIFORNIA

TOXIC, CORROSIVE, AND PYROPHORIC GAS PROGRAM – TERMS AND CONDITIONS

Date:

Name of lab:

Location of lab (room, building):

Quantity and name of gas: [List of hazards]

TOXIC GAS PROGRAM REQUIREMENTS:

Training:

1. Lab shall have a Standard Operating Procedure (SOP) for this operation or for working with toxic (and/or other hazard) gases. A separate SOP can be created that addresses changing and transporting cylinders.
2. All researchers who plan to work with this material shall read and sign the SOP(s).
3. All lab researchers who may be present in room xxx Hall shall understand emergency procedures. This shall be documented in the "Lab Site Safety Orientation" section of the Chemical Hygiene Plan.

Storage:

1. Portable gas cylinders shall be marked with the name of gas and the hazards. For [name of gas], the full name shall be marked on the cylinder and on the outside of the fume hood. The hazards for this gas include "xx."
2. Gas cylinders shall be secured to prevent falling by contact, vibration, or seismic activity.
3. Gas cylinders shall be stored in an upright position.
4. Gas cylinders shall have protective caps in place except when the cylinder is in use.
5. Gas cylinders shall be separated from incompatible materials. For example, oxidizing gases shall not be stored in the same gas cabinet as flammable gases.
6. [Name of gas] shall be stored within a continuously ventilated [gas cabinet or fume hood, depending on gas]. The average ventilation velocity in the fume hood shall not be less than 100 feet per minute (or 200 fpm for certain gases). Users must check that ventilation is functioning properly before initiating experiments.
7. No more than xxx ft3/lbs of [name of hazard class or classes] gases (aggregate total per hazard category) shall be permitted per control area on the xx floor of xx Hall.

8. Leaking, damaged, or corroded gas cylinders shall be removed from service.

Use and Handling:

1. All equipment, piping, tubes, valves, and fittings shall be designed, installed and maintained by trained personnel.
2. Emergency shutoff valves (manual or automatic) shall be provided at the point of use and at the gas source.
3. Work area shall be free of flammable and combustible materials (e.g., cardboard, paper, plastic, kimwipes, flammable liquids).
4. Work area shall be free of ignition sources, heat, and other hazards (e.g., hot plates, burners, motors, extension cords, electric sparks, motors, ovens, static electricity).
5. Gas monitors [should/shall, depending on gas] be installed at the point of use and in the room. Detection of the gas shall occur at xx ppm (Cal/OSHA or OSHA PEL). For pyrophoric gases, gas monitors will shut off the gas source when the concentration is greater than 25% LEL (Lower Explosive Limit). If alarm sounds, user can shut off gas cylinder if it is safe to do so. If alarm continues or user cannot safely shut off gas supply, all occupants of the room shall evacuate and contact emergency responders.

Additional requirements:

1. Prior to initial use, the equipment and final set-up shall be inspected.
2. All hazardous materials, including gases, shall be entered into the campus chemical inventory system upon arrival to campus buildings.
3. Any significant changes, including, but not limited to: the materials used, the procedure, the scale of the operation, the concentration of hazardous materials, or the equipment used shall be submitted for review to the TCP Gas Program.
4. When research using this material is phased out, the toxic, corrosive, or pyrophoric gas shall be disposed of as hazardous waste or returned to the vendor and removed from the chemical inventory system.
5. When research using this material is completed, EH&S will be notified.
6. All gas monitors and leak detection devices shall be maintained in good working condition and tested regularly, following the manufacturer's recommendations.
7. A working ABC fire extinguisher (or approved alternate extinguisher) shall be within 30 feet of the operation involving flammable gases.
8. All aisles, corridors and exits shall be maintained free of storage at all times and are available for clear evacuation in the case of an emergency.
9. Use of this gas is subject to regular inspection and review by EH&S.

Please contact EH&S with any questions or if there are any changes to this operation. Please note that re-ordering gas for the same operation will be subject to review and compliance with these requirements.

Toxic, Corrosive, and Pyrophoric Gas Program

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