Center for Molecular and Genomic Imaging (CMGI) ● University of California, Davis

CMGI LABORATORY SAFETY PLAN

Site-Specific Responsibility for Laboratory Safety

Department:	Biomedical Engineering: Center for Molecular and Genomic Imaging (CMGI)
Building:	GBSF
Rooms covered by this plan:	0202, 0302, 0303, 0309, 0310, 0311, and 0662 GBSF
Department Chairperson or Director:	Alyssa Panitch, Chairperson, Biomedical Engineering
Phone:	(530) 754-3222
E-mail:	apanitch@ucdavis.edu
Principal Investigator, Faculty Member, or Supervisor:	Abhijit J. Chaudhari, Associate Professor, Radiology, UCDHS School of Medicine; Director, CMGI
Office:	0307 GBSF
Phone:	(916) 734-0833
E-Mail:	ajchaudhari@ucdavis.edu
Principal Investigator, Faculty Member, or Supervisor:	Julie L. Sutcliffe, Associate Professor, Dept. of Internal Medicine; Director, CMGI
Office:	IRC Building, Sacramento
Phone:	(916) 734-5536
E-Mail:	jlsutcliffe@ucdavis.edu
Laboratory Manager (Imaging):	Jennifer Fung
Office:	0300 GBSF
Phone:	(530) 754-6633
E-Mail:	jyfung@ucdavis.edu
Laboratory Manager (Radiochemistry):	Dave Kukis
Office:	0307 GBSF
Phone:	(530) 752-6029
E-Mail:	dlkukis@ucdavis.edu
Implementation Date:	04/15/14
Current Revision:	08/15/17
Annual Review Date:	August
UC Davis Laboratory Safety Manual:	safetyservices.ucdavis.edu/article/laboratory-safety-manual
UC Davis Chemical Hygiene Plan:	Contained within the UC Davis Laboratory Safety Manual
Biomedical Engineering Injury and Illness Prevention Plan (IIPP) and Emergency Action Plan (EAP) :	https://bme.ucdavis.edu/safety/

CMGI LABORATORY SAFETY PLAN

Revision History

Revision	Date	Revised Content
Original	04/15/14	
Rev. 1	12/18/14	Added SOP 1: Receipt, Use, Storage, and Disposal of Hazardous Chemicals Added SOP 2: Proper Use, Storage, and Disposal of Acids Added SOP 3: Proper Use, Storage, and Disposal of Bases Added SOP 4: Proper Use, Storage, and Disposal of Flammable Liquids Added SOP 5: Proper Use, Storage, and Disposal of Chloroform
Rev. 2	09/11/15	Renamed Chemical Safety Plan (Previously Chemical Hygiene Plan) Added SOP 6: Carcinogens Added SOP 7: Acutely toxic solids, liquids, and gases Added SOP 8: Cryogens Added SOP 9: Pyrophorics Added SOP 10: Reproductive toxins Added SOP 12: Working alone
Rev. 3	10/06/16	Updated responsible personnel, page 1 Added SOP 11: Isoflurane Formalin and formaldehyde were added to SOP 6.
Rev. 4	01/10/17	Revised SOP 7: Acutely toxic solids and liquids (previously Acutely toxic solids, liquids, and gases), eliminating references to acutely toxic gases. Added SOP 13: Acutely toxic gases: 5% fluorine in argon
Rev. 5	06/01/17	Added SOP 14: Nanomaterials
Rev. 6	08/15/17	Changed document title from "Chemical Safety Plan" to "CMGI Laboratory Safety Plan." Revised SOP 6: Carcinogens; SOP 7: Acutely toxic solids and liquids; and SOP 10: Reproductive toxins, to update lists of chemicals in use at CMGI.

Site-Specific Information on Chemical Receiving, Storing, or Dispensing

Give the location of your laboratory's chemical receiving, storage, or dispensing areas. Describe any ordering policies or procedures for hazardous chemicals. List any chemicals that require prior Principal Investigator approval for purchase.

Receiving:	Chemicals are received at the GBSF Receiving facility, and distributed to 2303 GBSF for pickup and documentation of receipt. Chemicals are stored in 0202, 0302, 0303, 0309, 0310, 0311, and 0662 GBSF. On receipt, laboratory personnel are to: • Write the date received and the name of receiving personnel on the label. • Identify the Stanford Storage Group on the bottle. • Store the chemical with compatible chemicals. • Use secondary containment for corrosives.
Ordering:	All orders require approval by supervisory personnel.
Restricted chemicals:	All orders of restricted chemicals are processed and documented by the University according to applicable regulations.
Storage/dispensing:	Vented storage cabinets for flammable chemicals and corrosives/acids are located in 0302 GBSF. Drugs subject to restricted access and inventory logs are stored in a locked cabinet in 0310 GBSF. Radioactive materials are stored behind shielding, dispensed only by trained, authorized personnel, and logged as specified by EH&S Health Physics.
Chemical Inventory:	A chemical inventory is maintained and updated at University-required intervals using the University inventory system.

For more details, please refer to CMGI Chemical Safety Plan SOP 1: Receipt, Use, Storage, and Disposal of Hazardous Chemicals

MSDS and Other Reference Materials Available in the Laboratory

Describe how and where MSDSs and other reference materials are available in this laboratory. (See the Bibliography for a list of recommended references.)

The general-use computer in the CMGI lobby (opposite the cubicle office area) has a link to Safety Data Sheets (formerly MSDSs), displayed on the computer desktop.

In addition, any internet-linked computer in the Facility or personal smart phones may be used to access SDSs via the EH&S-recommended references, chemical manufacturer website, or internet search.

For UC Davis Safety Services SDS links and information, go to:

http://safetyservices.ucdavis.edu/ps/cls/msds

Emergency Response Instructions

GENERAL PROCEDURES:

The following are some general instructions for actions to take in case of an emergency:

Medical Emergency

1. Remain calm.
2. Initiate lifesaving measures if required.
3. Call for Emergency Response --- **CALL 911**
4. Do not move injured person unless it is necessary to prevent further harm.
5. Keep injured person warm.

Major Incident

1. Attend to injured or contaminated person and remove him or her from exposure.
2. Alert people to evacuate the area.
3. Call for Emergency Response --- **CALL 911**
   - Fire.....**911**
   - Chemical, radiation, biological spill.....**911**
   - (Evenings and weekends) **911**
4. Close doors to affected areas.
5. Have person knowledgeable of incident assist emergency workers.

LABORATORY-SPECIFIC PROCEDURES:

The following are specific instructions for actions to take during an emergency situation in your laboratory.

In the event of an emergency, suspend all laboratory activities.

Refer to laboratory-specific animal protocols regarding steps to be taken when working with animals in the laboratory.

Refer to RUA 1517 SOPs to respond to high radiation fields. If you know or suspect a sustained field >10 mR/h, evacuate the affected area and do not return until field has returned to a safe level. Alert EH&S Health Physics for advice and assistance if needed.

Radioactive splashes, spills, and decontamination: refer to UCD Safety Net #37. Alert EH&S Health Physics for advice and assistance if needed.

EMERGENCY EQUIPMENT LOCATIONS

Emergency Showers:	(1) East corridor near exit; (2) Room 0302
Emergency Eyewashes:	(1) Room 0302; (2) Room 0311
Fire Extinguisher:	North corridor
Spill kits:	(1) Room 0302; (2) Room 0311

Site-Specific Hazardous Material Control Systems (Engineering Controls)

List hazardous material control systems (*e.g.*, fume hoods) available in the laboratory. Include information on restrictions, special precautions or procedures, preventive maintenance schedules, and any other information relevant to safe operation in the laboratory.

Chemical fume hood, room 0302 GBSF

- Training is required for proper use and applications of the fume hood.
- The chemical fume hood will be used, if required, when working with hazardous chemicals in the laboratory. Examples include volatile, flammable, and highly acidic chemicals.
- Avoid overcrowding the fume hood during active use.
- The fume hood is certified annually by TSS under contract with the University.

Biological Safety Cabinet, room 0662 GBSF

- Training is required for proper use and applications of the biosafety cabinet.
- The biosafety cabinet will be used, if required, when working with biohazardous materials in the laboratory.
- The biosafety cabinet is certified annually by TSS under contract with the University.

Radiochemistry hot cells and manipulators, room 0311 GBSF

- CMGI radiation safety training is required for proper use and applications of the hot cells and manipulators.
- The hot cells and manipulators will be used, when applicable, when performing radioactive chemical synthesis and high-activity experiments in the radiochemistry laboratory.
- Hot cells are continuously monitored for exhaust. Preventive maintenance and repairs of hot cells and manipulators are performed by qualified CMGI staff or contractors.

Secondary containment

- Secondary containment of hazardous chemicals and hazardous chemical waste will be used when there is a possibility of leakage or overflow.

Personal Protective Equipment Available in the Laboratory

List the personal protective equipment available in the laboratory and when it should be used. See Chapter V for additional information.

Eye Protection	Eye protection is provided to staff and guests of CMGI, based on a risk assessment, when there is hazardous activity taking place in the laboratory.
Gloves	Appropriate laboratory gloves are available, based on a risk assessment of the hazardous activity taking place in the laboratory.
Other Protective Clothing	Laboratory coats (*e.g.*, white cotton, barrier, flame resistant, and aprons) are provided to staff and guests of CMGI, based on a risk assessment of the hazardous activity taking place in the laboratory.
Respiratory Protection	Respirators can be provided to staff and guests of CMGI, based on a risk assessment of the activity taking place in the laboratory. Laboratory workers will be required to complete the respiratory protection medical evaluation, fit testing, and training through Employee Health Services before wearing a respirator in the laboratory.
Other	Hearing protection can be provided to staff and guests of CMGI, based on a risk assessment of the activity taking place in the laboratory.

Clients working in the CMGI facility will be trained in task-appropriate PPE, and CMGI will make reasonable efforts to monitor and advise clients on the appropriate use of PPE. However, PPE supply, maintenance, and compliance are the responsibility of client PIs.

Prior Approvals Required

List prior approvals required for particular laboratory functions. The Principal Investigator or Laboratory Supervisor will determine which laboratory operations, if any, will require prior approval.

CMGI Client Users:

CMGI checklist training signed by the trainee is used to assure proper performance of laboratory functions.

- CMGI Safety Training is required for all client users before they may access or work in the facility. General safety procedures are reviewed, and in the checklist, the trainee attests to completing applicable task-appropriate University requirements (e.g., Radiation Safety training, enrollment in the Occupational Health Program, Biosafety Cabinet training, etc.).
- CMGI Radiation Safety Training is additional training required for users of the radiochemistry laboratory (Room 0311). Topics include chemical receipt, RUA compliance specifications, radiation monitoring and emergency response, and other site-specific and task-specific procedures.
- On both training documents, the trainee attests to the following by signature: "I understand that it is my responsibility to talk with a supervisor should I be unsure about the safety of any procedure or should I need further information or advice regarding potential hazards."

Equipment-specific training is sometimes provided by the manufacturer to groups, but is usually provided on as-needed individual basis. CMGI staff will reserve equipment for use only by fully trained client users.

CMGI Staff:

CMGI staff meet the same requirements to perform specific lab functions as described above for client users, plus a complete skills checklist supported by training documentation is maintained for staff. Some laboratory functions are reserved exclusively for staff. For example, the requirements for certification as a Cyclotron Operator include 80 hours of training and annual recertification review, as specified in the University Broadscope License and CMGI's RUA.

Chemical Safety SOPs

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Chemistry Standard Operating Procedure 1: Receipt, Use, Storage, and Disposal of Hazardous Chemicals

I. RECEIVING CHEMICALS

A. Write the date received and your name on the label.
B. Identify the Stanford Storage Group on the bottle.
C. Store the chemical with compatible chemicals.
D. Corrosives: use secondary containment.

II. OPENING CHEMICALS:

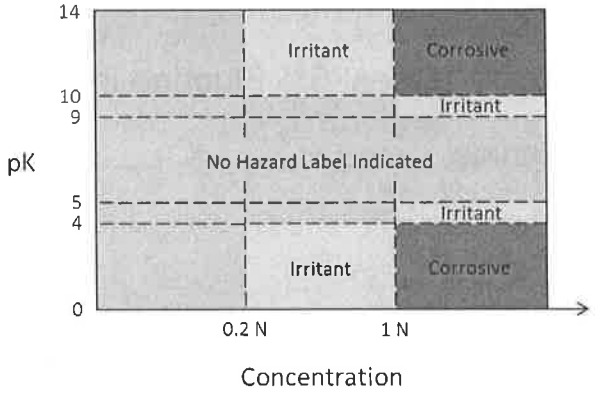
A. Write the date opened and your name on the label.
B. Prominently indicate the Stanford University Compatible Storage Group Classification on the container.

III. DILUTIONS OR REAGENTS PREPARED IN THE LABORATORY

A. Label the container with:
   1. Chemical name
   2. Hazard warning(s)
   3. Your name
   4. Date prepared
   5. Stanford Storage Group
B. Store the chemical with compatible chemicals.
C. Corrosives: use secondary containment.

IV. IRRITANTS AND CORROSIVES: HOW TO ASSIGN LABORATORY-PREPARED DILUTIONS AND SOLUTIONS TO "IRRITANT" OR "CORROSIVE" HAZARD CLASS

A. Rigorous guideline: assign per the chart below (*source: UC Davis Safety Services*).



B. **Practical guideline: if it is a dilution of an acid or a base, label it as corrosive.** This broad guideline will overstate the hazard in some cases, but as long as we don't allow too much accumulation, it is practical and manageable.

Chemistry Standard Operating Procedure 1: Receipt, Use, Storage, and Disposal of Hazardous Chemicals

V. SECONDARY CONTAINMENT

A. Is ***required*** for corrosive liquids

B. Is ***required*** for hazardous chemical waste, including HPLC waste

C. Is ***preferred***, but not required, for flammable liquids.

Secondary containment for flammable liquids is preferred in CMGI Radiochemistry to promote safety, awareness, and good housekeeping

D. Check the SDS for secondary containment recommendations for other chemicals, such as toxins and solid corrosives.

VI. CHEMICAL STORAGE: SEGREGATE INCOMPATIBLE CHEMICALS FROM ONE ANOTHER

Chemicals will be stored according to the Stanford University Compatible Storage System. Below are specifics that address most situations at CMGI. Please consult resources or the CMGI laboratory manager for questions not addressed below.

A. Store **flammable liquids** in the Flammables cabinet in room 0302.

Up to 10 gallons may be stored in each room 0202, 0302, and 0311 outside the Flammables cabinet.

B. Store **strong bases** in the Bases cabinet in room 0302.

C. Store **strong acids** in the Acids cabinet in room 0302.

D. Use secondary containment to separate these incompatible acids from one another in the Acids cabinet:

1. Inorganic oxidizing acids (e.g. nitric acid)
2. Inorganic nonoxidizing acids (e.g. phosphoric acid, sulfuric acid, hydrochloric acid)
3. Organic acids (e.g. acetic acid, formic acid, trifluoroacetic acid)

VII. APPLICABLE SAFETY NETS

Safety Net #4: Partial list of Incompatible chemicals

Chemistry Standard Operating Procedure 2: Proper Use, Storage, and Disposal of Acids

I. PROCESS

Some laboratory procedures that use acids: Making buffers, adjusting pH of solutions, making an acid stock solution

II. CLASS OF HAZARDOUS CHEMICALS: ACIDS

A. Acids are corrosive and react violently with bases.

B. There are two main groups of acids: organic acids (contains carbon) and inorganic (mineral) acids.

Some inorganic acids are oxidizers that will react with organics and contribute an oxygen source to a combustion reaction, increasing the burning rate of combustibles Therefore, inorganic acids should be stored separately from organic acids.

C. Examples of Organic Acids (formula): Formic acid (HCOOH), Acetic acid (CH3COOH), Trifluoracetic acid (CF3COOH).

D. Examples of Inorganic (mineral) acids (formula): hydrochloric acid (HCl), hydrofluoric acid (HF), phosphoric acid (H3PO4)

E. Examples of Inorganic Oxidizing acids (formula): Nitric acid (HNO3), Sulfuric acid (H2SO4), Perchloric acid (HClO4)

III. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Wear gloves, eye protection and a lab coat when working with acids.

A. Surgical latex gloves do not effectively protect against many concentrated acids. Use gloves made of a synthetic material; for example neoprene, nitrile or Viton.

B. Even with correct gloves, protection may not be complete; therefore, gloves should be changed frequently, and always after a chemical splash.

C. See Safety Net #50 and the campus Chemical Laboratory Safety Manual. See MSDS for specific information.

IV. ENGINEERING/VENTILATION CONTROLS

A. Use concentrated solutions in a fume hood.

B. Keep containers tightly closed except when in use.

C. Do not taste chemicals, do not mouth pipet, avoid smelling chemicals.

D. Follow MSDS for specific chemical recommendations to become familiar with the characteristics of the chemical.

Chemistry Standard Operating Procedure 2: Proper Use, Storage, and Disposal of Acids

V. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS:

A. Label containers, including transfer containers:
   1. Chemical name
   2. Name of Preparer
   3. Date Prepared
   4. Hazard warning and storage class, if applicable

B. Segregate acids from: bases; active metals (such as postassium and magnesium); chemicals that can liberate toxic gases upon contact (such as sodium cyanide); and solvents (such as toluene and xylene).

C. Store glacial acetic acid separately or with flammables rather than with inorganic acids.

D. Store oxidizing inorganic acids separately from organic acids.

E. Use secondary container for carrying and storage (large enough to contain 110% of the largest container).

F. Perchloric acid and picric acid require special handling; refer to the MSDS.

G. Always add acid to water, never water to acid.

H. References: Safety Nets #4 and 42.

VI. SPILL AND ACCIDENT PROCEDURES

Know the locations of fire extinguishers, alarm pull stations, eyewashes, and emergency showers. Know how to operate them BEFORE you need them.

A. Large spills (> 1 pint):

From Safety Net $13: When 1 pint or more of a hazardous material or any amount of an extremely toxic substance is spilled or when in doubt, call UC Davis Fire Department (911) or from a cell phone (530) 752-1230. Evacuate the room, close the door, and wait for emergency personnel.

B. Small spills (< 1 pint):
   1. Spill kits are in rooms 0311 (Radiochemistry), 0302 (QC), 0309 (PET imaging), and other locations in CMGI.
   2. Small spills may be covered with inert absorbent (dependent upon specific acid; refer to MSDS).
   3. The contaminated absorbent and associated materials must be labeled for EH&S waste pick-up.
   4. From Safety Net 13: DO NOT attempt to absorb hydrofluoric acid (HF). . Follow the procedure for large spills.

C. Personnel exposure: Remove contaminated clothing and flush affected area with water for 20 minutes at closest eye wash or shower. See Safety Net #52 for emergency care. Notify supervisor and the safety coordinator of the accident as soon as possible which may be AFTER receiving emergency care.

Chemistry Standard Operating Procedure 2: Proper Use, Storage, and Disposal of Acids

VII. WASTE COLLECTION AND DISPOSAL

A. Chemical waste containers must be compatible for the chemical(s) stored within, have a closable lid, have a properly completed UCD "Hazardous Waste" label, and be placed in a secondary container.

B. ALL chemical waste must be disposed through the EH&S hazardous waste program.

C. Chemical waste cannot be accumulated in laboratories for more than NINE (9) MONTHS. Call EH&S for pickup before 9 months have elapsed.

D. To prepare chemical waste solutions for pickup, adjust pH to greater than 4 and less than 10, if it can be done safely.

E. To complete an online pick up request: go to safetyservices.ucdavis.edu, click Quick Link "Hazardous Waste Disposal Request", select "Chemical and Sharps Request" and follow instructions.

F. For additional information for waste disposal and EH&S Pick-up, see Safety Nets #6, 8, 34, and 43.

VIII. APPLICABLE SAFETY NETS

Safety Net #4:	Partial list of Incompatible chemicals
Safety Net #6:	Can this go down the drain?
Safety Net #8:	Guidelines for disposal of chemical waste
Safety Net #13:	Guidelines for chemical spill control
Safety Net #34:	Managing chemical waste streams to reduce disposal costs
Safety Net #42:	General guidelines for management of laboratory chemicals
Safety Net #43:	Identification and segregation of chemical waste
Safety Net #50:	Guidelines for the selection of chemical resistant gloves
Safety Net #52:	Emergency medical care

Chemistry Standard Operating Procedure 3: Proper Use, Storage, and Disposal of Bases

I. PROCESS

Some laboratory procedures that use bases: Making buffers, adjusting pH of solutions, making an basic stock solution

II. CLASS OF HAZARDOUS CHEMICALS: BASES

A. Bases are corrosive and react violently with acids.

B. When bases come in contact with skin, eyes, or respiratory tract, they react with those tissues and cause local injury.

C. Examples of bases: ammonium hydroxide, sodium hydroxide, calcium hydroxide, and organic amines.

III. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Wear gloves, eye protection and a lab coat when working with bases.

A. Nitrile or neoprene gloves generally provide better protection from penetration than latex.

B. Even with correct gloves, protection may not be complete; therefore, gloves should be changed frequently, and always after a chemical splash.

C. See Safety Net #50 and the campus Chemical Laboratory Safety Manual. See MSDS for specific information.

IV. ENGINEERING/VENTILATION CONTROLS

A. Use concentrated solutions in a fume hood.

B. Keep containers tightly closed except when in use.

C. Do not taste chemicals, do not mouth pipet, avoid smelling chemicals.

D. Follow MSDS for specific chemical recommendations to become familiar with the characteristics of the chemical.

V. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS:

A. Label containers, including transfer containers:

1. Chemical name
2. Name of Preparer
3. Date Prepared
4. Hazard warning and storage class, if applicable

B. Segregate bases from acids.

C. Solid corrosives, such as sodium hydroxide, interact with the skin when dissolved by moisture on the skin surface. Damage then occurs both from the corrosive action and from the heat of solution. Because they are solid, these chemicals are relatively easy to remove; but because they may not react immediately and may not be painful at first, they could cause substantial damage before being detected.

D. Store inorganic hydroxide (e.g. sodium hydroxide) in polyethylene containers.

Chemistry Standard Operating Procedure 3: Proper Use, Storage, and Disposal of Bases

VI. SPILL AND ACCIDENT PROCEDURES

Know the locations of fire extinguishers, alarm pull stations, eyewashes, and emergency showers. Know how to operate them BEFORE you need them.

A. Large spills (> 1 pint):

From Safety Net $13: When 1 pint or more of a hazardous material or any amount of an extremely toxic substance is spilled or when in doubt, call UC Davis Fire Department (911) or from a cell phone (530) 752-1230. Evacuate the room, close the door, and wait for emergency personnel.

B. Small spills (< 1 pint):

1. Spill kits are in rooms 0311 (Radiochemistry), 0302 (QC), 0309 (PET imaging), and other locations in CMGI.
2. Small spills may be covered with inert absorbent (dependent upon specific acid; refer to MSDS).
3. The contaminated absorbent and associated materials must be labeled for EH&S waste pick-up.
4. From Safety Net 13: DO NOT attempt to absorb hydrofluoric acid (HF). . Follow the procedure for large spills.

C. Personnel exposure: Remove contaminated clothing and flush affected area with water for 20 minutes at closest eye wash or shower. See Safety Net #52 for emergency care. Notify supervisor and the safety coordinator of the accident as soon as possible which may be AFTER receiving emergency care.

VII. WASTE COLLECTION AND DISPOSAL

A. Chemical waste containers must be compatible for the chemical(s) stored within, have a closable lid, have a properly completed UCD "Hazardous Waste" label, and be placed in a secondary container.

B. ALL chemical waste must be disposed through the EH&S hazardous waste program.

C. Chemical waste cannot be accumulated in laboratories for more than NINE (9) MONTHS. Call EH&S for pickup before 9 months have elapsed.

D. To prepare chemical waste solutions for pickup, adjust pH to greater than 4 and less than 10, if it can be done safely.

E. To complete an online pick up request: go to safetyservices.ucdavis.edu, click Quick Link "Hazardous Waste Disposal Request", select "Chemical and Sharps Request" and follow instructions.

F. For additional information for waste disposal and EH&S Pick-up, see Safety Nets #6, 8, 34, and 43.

Chemistry Standard Operating Procedure 3: Proper Use, Storage, and Disposal of Bases

VIII. APPLICABLE SAFETY NETS

Safety Net #4:	Partial list of Incompatible chemicals
Safety Net #6:	Can this go down the drain?
Safety Net #8:	Guidelines for disposal of chemical waste
Safety Net #13:	Guidelines for chemical spill control
Safety Net #34:	Managing chemical waste streams to reduce disposal costs
Safety Net #42:	General guidelines for management of laboratory chemicals
Safety Net #43:	Identification and segregation of chemical waste
Safety Net #50:	Guidelines for the selection of chemical resistant gloves
Safety Net #52:	Emergency medical care

Chemistry Standard Operating Procedure 4: Proper Use, Storage, and Disposal of Flammable Liquids

I. PROCESS

Flammable liquids are primarily used as a solvent or reaction vehicle.

II. CLASS OF HAZARDOUS CHEMICALS: FLAMMABLE LIQUIDS

A. The greatest hazard, working with flammable (and combustible) liquids, is fire.

B. Flammable liquids are defined by their flash point, which is the temperature at which the liquid gives off enough vapor to ignite. The lower the flash point, the greater the risk of ignition and fire. Below is a table with flash points for common flammable liquids.

For purposes of this SOP, flammable and combustible liquids are treated the same, with similar risk of fire (dependent on flash point).

Common name	CAS Number	Flash point
Diethyl ether	60-29-7	−45 °C (−49 °F)
Dimethyl ether	115-10-6	−41 °C (−42 °F)
Gasoline	n/a mixture	<−40 °C (−40 °F)
Acetone	67-64-1	−17 °C (1 °F)
Methanol	67-56-1	11 °C (52 °F)
Ethanol	64-17-5	12.8 °C (55.0 °F)

C. Many flammable liquids are also toxic by inhalation and some are readily absorbed through the skin. Toluene is an example of this – toxic by inhalation, has reproductive effects and is absorbed through the skin. Proper use of engineering controls (fume hood), PPE and attention to hygiene is important when working with these materials.

D. Some flammable liquids are also peroxide-forming chemicals. Diethyl ether and tetrahydrofuran (THF) are common examples. Refer to Safety Net #23 for advice.

III. PERSONAL PROTECTIVE EQUIPMENT (PPE)

A. Eye Protection

1. ANSI-compliant safety glasses with side shields, or chemical splash goggles.
2. When pouring a quantity of flammable liquid out of a large container (4 liters or more), goggles must be worn.

B. Skin Protection

1. Lab coat, preferably made of anti-static material.
2. A flame retardant lab coat may be required, if quantities in use are large (> 4 liters) or if the activities include the use of flammable liquids in the presence of an open flame or ignition source.
3. Long pants, closed-toe and closed-heel shoes. (
4. Non-synthetic clothing should be worn.

5. Handle with appropriate chemical-resistant gloves. Nitrile gloves are the common default but may not be sufficiently protective.

   Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with flammable liquids.

   Refer to glove selection chart from the links below:

   http://www.allsafetyproducts.biz/page/74172

   http://www.showabestglove.com/site/default.aspx

   http://www.mapaglove.com/

C. Additional PPE may be required if procedures or processes present additional risk. Contact EH&S for consultation.

D. Hygiene measures: Avoid contact with skin, eyes, and clothing. Wash hands before breaks and after handling.

IV. ENGINEERING/VENTILATION CONTROLS

All activities involving the use of flammable liquids should be carried out in a certified chemical fume hood with the sash closed to the lowest practical position.

V. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS:

A. Store flammable liquids in a flammable liquid storage cabinet. Ten gallons may be stored outside the cabinet, but this is not recommended.

B. Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or fail catastrophically if exposed to heat.

C. Avoid contact with oxidizing agents and alkali metals such as sodium and potassium.

D. Do not store flammable liquids in proximity to pyrophoric or water reactive materials. Segregate these materials as much as possible.

E. Minimize your purchases to only what is needed in a reasonable amount of time. Use small quantities whenever possible.

F. Secondary containers must be labeled clearly. Also, follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

G. Monitor your inventory closely to assure that you have tight control over your material.

H. Wash hands and arms with soap and water after handling.

Chemistry Standard Operating Procedure 4: Proper Use, Storage, and Disposal of Flammable Liquids

VI. SPILL AND ACCIDENT PROCEDURES

Know the locations of fire extinguishers, alarm pull stations, eyewashes, and emergency showers. Know how to operate them BEFORE you need them.

A. Spill

1. Chemical Spill: Dial 911 and EH&S at (530) 752-1493 for assistance.
2. Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).
3. Small (<1 L): Proceed only if injury to yourself or others is unlikely and it is neither an emergency nor likely to become an emergency. If you have training, you may assist in the clean-up effort. Use appropriate personal protective equipment and clean-up material for chemical spilled. Double bag spill waste in clear plastic bags, label and take to the next chemical waste pick-up.
4. Large (>1 L) – Dial 911 and EH&S at 530-752-1493 for assistance.

B. First Aid

1. Chemical spill on body or clothes: Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at (530) 752-1493 immediately.
2. Chemical splash into eyes: Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at (530) 752-1493 immediately.

C. Medical Emergency

1. Life-threatening emergency, after hours, weekends, and holidays: Dial 911
2. Non-life threatening emergency: Go to Occupational Health Services, (530) 752-6051 in the Cowell Building. Hours: M - F, 8:00 a.m. to 5:00 p.m. At all other times, report to the Sutter Davis Emergency Room at (530) 757-5111.
3. Note: All serious injuries must be reported to EH&S at (530) 752-1493 within 8 hours.

Chemistry Standard Operating Procedure 4: Proper Use, Storage, and Disposal of Flammable Liquids

VII. WASTE COLLECTION AND DISPOSAL

A. Chemical waste containers must be compatible for the chemical(s) stored within, have a closable lid, have a properly completed UCD "Hazardous Waste" label, and be placed in a secondary container.

B. ALL chemical waste must be disposed through the EH&S hazardous waste program.

C. Chemical waste cannot be accumulated in laboratories for more than NINE (9) MONTHS. Call EH&S for pickup before 9 months have elapsed.

D. To prepare chemical waste solutions for pickup, adjust pH to greater than 4 and less than 10, if it can be done safely.

E. To complete an online pick up request: go to safetyservices.ucdavis.edu, click Quick Link "Hazardous Waste Disposal Request", select "Chemical and Sharps Request" and follow instructions.

F. For additional information for waste disposal and EH&S Pick-up, see Safety Nets #6, 8, 34, and 43.

VIII. DECONTAMINATION

Decontaminate work space with 70-75% ethanol. Wash hands and arms with soap and water after finished. Contaminated pipet tips, Eppendorf tubes, and gloves should be discarded as hazardous waste disposal procedures.

IX. PRIOR APPROVAL / REVIEW REQUIREMENTS

A. All work with flammable liquids requires the following prior to beginning work:

1. Must have documented Chemical and Laboratory Safety training and specific training on the techniques and processes to be used.
2. Must read the relevant Safety Data Sheet.
3. Must demonstrate competence to perform work.

B. When there are any changes to procedures, personnel, equipment, or when an incident or near-miss occurs, a review of this SOP and reapproval is required.

Chemistry Standard Operating Procedure 5: Proper Use, Storage, and Disposal of Chloroform

I. PROCESS

At CMGI, chloroform is primarily used to clean cyclotron components.

II. HAZARDOUS CHEMICAL: CHLOROFORM

A. ***Chloroform is a probable human carcinogen.***
Please refer to SOP 6: Carcinogens

B. ***Chloroform is a reproductive toxin.***
Please refer to SOP 10: Reproductive Toxins

C. Inhalation of vapors can cause headaches, drowsiness, dizziness, and nausea. At high concentrations, disorientation, anesthetic effects, and unconsciousness can occur, but acute toxicity is low.

D. Chloroform is an eye and skin irritant.

E. The OSHA Permissible Exposure Limit for chloroform is 50 ppm as a ceiling limit (exposure must never exceed this level). ACGIH has a threshold limit value (TLV) for chloroform of 10 ppm for an 8-hour workday. The odor threshold for chloroform ranges from 85-307 ppm (above OSHA's ceiling limit), so it does not have good warning properties.

F. Chloroform is not combustible but exposure to fire or high temperatures may lead to formation of phosgene, a highly toxic gas.

G. Consult the Safety Data Sheet for chloroform for additional information on hazards.

III. ENGINEERING AND VENTILATION CONTROLS

Work with chloroform in a certified chemical fume hood with sash at lowest possible position.

IV. WORK PRACTICE CONTROLS

A. Keep containers of chloroform closed as much as possible.

B. Be aware of skin absorption as a possible route of exposure. Plan work so that minimal glove contact is expected, and purchase appropriate gloves for cleaning up small spills (for glove recommendation, see Spill Procedure section).

C. Use in the smallest practical quantities for the experiment being performed.

D. To decontaminate surfaces, wipe the affected area three times with towels moistened with water (gloves must be worn).

V. PERSONAL PROTECTIVE EQUIPMENT (PPE)

A. **WARNING:** Chloroform readily penetrates standard nitrile laboratory gloves along with many other types of gloves. Wear two pairs of standard nitrile gloves, and remove outer layer immediately in event of splash or spill.

B. Gloves for spills: **Do NOT use double nitrile gloves for spills due to quick breakthrough time.** Use Best Viton gloves, North Silver Shield/4H laminate gloves (which will provide protection for over 8 hours), or other gloves protective for chloroform (note: not all laminate gloves provide good protection for chloroform.) To improve dexterity with laminate gloves,

don a nitrile glove over the laminate glove.

C. Eye Protection
   1. ANSI-compliant safety glasses with side shields, or chemical splash goggles.
   2. Wear goggles whenever there is a possibility of splashing.

D. Skin Protection
   1. Chemical-resistant lab coat preferably made of anti-static material, long pants, closed-toe and closed-heel shoes.
   2. Non-synthetic clothing should be worn.
   3. Handle with appropriate chemical-resistant gloves.

E. Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

F. Hygiene Measures: Avoid contact with skin, eyes, and clothing. Wash hands before breaks and after handling.

VI. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

A. Do not store chloroform with these incompatible chemicals: acetone, alkalis, chemically-active metals (aluminum, magnesium, sodium, or potassium), dinitrogen tetroxide, fluorine, triisopropylphophine, or solid potassium tert-butoxide.

B. Transport chloroform in secondary containment, preferably a polyethylene or other non-reactive acid/solvent bottle carrier.

C. Store in secondary container.

D. Avoid storing on the floor.

VII. SPILL AND INCIDENT PROCEDURES

Know the locations of fire extinguishers, alarm pull stations, eyewashes, and emergency showers. Know how to operate them BEFORE you need them.

A. Spill
   1. Chemical Spill: Dial 911 and EH&S at (530) 752-1493 for assistance.
   2. Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).
   3. Small (<1 L): Proceed only if injury to yourself or others is unlikely and it is neither an emergency nor likely to become an emergency. If you have training, you may assist in the clean-up effort. Use Silvershield, Viton, or other gloves protective for spills (not nitrile), splash goggles, lab coat (and impermeable apron, if available), and use absorbent pads to absorb spilled material. Double bag spill waste in clear plastic bags, label and take to the next chemical waste pick-up.
   4. Large (>1 L) – Dial 911 and EH&S at 530-752-1493 for assistance.

B. First Aid
   1. Chemical spill on body or clothes: Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at (530) 752-1493 immediately.
   2. Chemical splash into eyes: Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at (530) 752-1493 immediately.

C. Medical Emergency
   1. Life-threatening emergency, after hours, weekends, and holidays: Dial 911
   2. Non-life threatening emergency: Go to Occupational Health Services, (530) 752-6051 in the Cowell Building. Hours: M - F, 8:00 a.m. to 5:00 p.m. At all other times, report to the Sutter Davis Emergency Room at (530) 757-5111.
   3. Note: All serious injuries must be reported to EH&S at (530) 752-1493 within 8 hours.

VIII. WASTE COLLECTION AND DISPOSAL

A. Dispose of chloroform with chlorinated solvent waste only.

B. Chemical waste containers must be compatible for the chemical(s) stored within, have a closable lid, have a properly completed UCD "Hazardous Waste" label, and be placed in a secondary container.

C. ALL chemical waste must be disposed through the EH&S hazardous waste program.

D. Chemical waste cannot be accumulated in laboratories for more than NINE (9) MONTHS. Call EH&S for pickup before 9 months have elapsed.

E. To complete an online pick up request: go to safetyservices.ucdavis.edu, click Quick Link "Hazardous Waste Disposal Request", select "Chemical and Sharps Request" and follow instructions.

F. For additional information for waste disposal and EH&S Pick-up, see Safety Nets #6, 8, 34, and 43.

IX. DECONTAMINATION

Decontaminate work space with 70-75% ethanol. Wash hands and arms with soap and water. Discard contaminated pipet tips, Eppendorf tubes, and gloves as hazardous waste.

X. PRIOR APPROVAL / REVIEW REQUIREMENTS

A. All work with chloroform requires the following prior to beginning work:
   1. Must have documented Chemical and Laboratory Safety training and specific training on the techniques and processes to be used.
   2. Must read the relevant Safety Data Sheet.
   3. Must demonstrate competence to perform work.

B. When there are any changes to procedures, personnel, equipment, or when an incident or near-miss occurs, a review of this SOP and re-approval is required.

Chemistry Standard Operating Procedure 6: Carcinogens

I. HAZARD OVERVIEW

Carcinogens are chemicals that are known to cause cancer in humans and/or animals, or are suspected of causing cancer. Some of the chemicals used in academic laboratory research, industrial processes, and daily activities are carcinogenic. Recognition of the hazards associated with the transportation, use, storage, and disposal of these materials is essential. Precautions must be taken to minimize any potential chemical exposure to Carcinogens.

II. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

Carcinogens are chemicals that are capable of causing cancer or tumor development, typically after repeated or chronic exposure. Their effects may only become evident after a long latency period and may cause no immediate harmful effects.

A. Carcinogens regulated by the California Occupational Safety and Health Administration (Cal/OSHA) can be found in Title 8 of California Code of Regulations (8 CCR), Article 110, §5200-5220. Additionally, Cal/OSHA defines Carcinogens in 8 CCR §5191 as materials that meet any of the following:

1. Is a regulated Cal/OSHA carcinogen;
2. Is listed as "known to be carcinogens" in the National Toxicology Program (NTP) Annual Report on Carcinogens;
3. Is listed as Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC) Monographs; or
4. Is listed in either Group 2A ("probably carcinogenic to humans") or 2B ("possibly carcinogenic to humans") by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals under defined conditions (see 8 CCR §5191 for more details).

B. Carcinogens can be identified in the Globally Harmonized System by the Hazard Codes H350 (May cause cancer) and H351 (Suspected of causing cancer). Some common examples of UC Davis laboratory Carcinogens include:

1. Arsenic and Arsenic compounds (inorganic)
2. Benzene
3. Cadmium and Cadmium compounds
4. Chromium (VI) compounds
5. Cobalt and Cobalt compounds
6. Dichloromethane
7. Formaldehyde
8. Lead and Lead compounds (inorganic)
9. Nickel compounds

Chemistry Standard Operating Procedure 6: Carcinogens

10. Polycyclic Aromatic Hydrocarbons (PAHs)

    Note: many carcinogens have additional chemical hazards. Review a current Safety Data Sheet for each carcinogen prior to use.

Carcinogens Used at CMGI:

Chemical	Code / Hazard	Room	Use / restrictions
Ascarite II	H350: May cause cancer, Category 1A, 1B	0302	**CMGI staff only**, to repack C11 Tracerlab drying columns
Cobalt nitrate hexahydrate	H351: Suspected of causing cancer, Category 2	0302	**CMGI staff only**, to prepare carrier-added Co-57
Nickel powder	H351: Suspected of causing cancer, Category 2	0311	**CMGI staff only**, for ^{64}Cu production and assays
Chloroform	H351: Suspected of causing cancer, Category 2	0202	**CMGI staff only**, to clean cyclotron components
Methyl iodide solution	H351: Suspected of causing cancer, Category 2	0302	**CMGI staff only**, as an HPLC standard
Lead/lead shielding	H351: Suspected of causing cancer, Category 2	All labs	Wear gloves

- **Use of any other carcinogens by any other personnel is NOT authorized at CMGI.**
- **If you need to use a carcinogen for work at CMGI, please see the Radiochemistry Facility Manager to establish safety procedures.**

III. ENGINEERING/VENTILATION CONTROLS

Use available engineering/ventilation controls to keep exposure to Carcinogens as low as possible. The following is a general plan for Carcinogens:

A. Use containment devices (*e.g.,* chemical fume hoods, glove boxes, localized exhaust ("snorkel"), etc.) when:
   1. Using volatile and/or semi-volatile substances;
   2. Manipulating substances that may generate aerosols; and
   3. Performing laboratory procedures that may result in an uncontrolled release.

B. Use high-efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.

C. Ventilated containment should be used to weigh out solid chemicals (*e.g.,* ventilated

balance safety enclosure, etc.). Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a fume hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the fume hood. If a chemical needs to be added or removed, this manipulation is carried out in the fume hood. In this manner, all open chemical handling is conducted in the fume hood.

If you must use Carcinogens without/outside of engineering or ventilation controls, you must contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for an exposure assessment. Formaldehyde use in anatomy, histology and pathology laboratories must be evaluated by EH&S to ensure airborne concentrations of formaldehyde are below the Action Level of 0.5 parts per million by volume.

Appropriate carcinogen work areas at CMGI:
Fume hood in room 0302

IV. ADMINISTRATIVE CONTROLS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory.
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory.
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer.
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS).
5. Implement good laboratory practices, including good workspace hygiene.
6. Inspect all equipment and experimental setups prior to use.
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location.
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor.

9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving Carcinogens described in this SOP.
10. Abide by the laboratory-specific working alone SOP, if applicable.

B. For Carcinogens, the following are also required:
1. Adhere to the UC Davis Carcinogen Program described in the Chemical Carcinogen Safety Manual and SafetyNet #32.
2. Work surfaces should be protected (*e.g.*, disposable absorbent bench paper, aluminum foil, etc.) and must be decontaminated after each use.
3. All waste containing Carcinogen materials at greater than 0.001% wt., including preserved tissue samples, must be disposed as hazardous waste.
4. This SOP is **not** meant to address 8 CCR §5209 "Listed" Carcinogens. If you are using one of these materials you must develop a separate Listed Carcinogens SOP.

V. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE are required for work with Carcinogens:

A. Eye Protection: Eye protection is required for all work with Carcinogens.
1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
3. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
1. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.
3. Hand Protection: Hand protection is needed for the activities described in this SOP. Define the type of glove to be used based on: (1) the chemical(s) being

used, (2) the anticipated chemical contact (*e.g.*, incidental, immersion, etc.), (3) the manufacturers' permeation/compatibility data, and (4) whether a combination of different gloves is needed for any specific procedural step or task.

CMGI-specific PPE requirements:

- **Chloroform: Per SOP 5, Proper use, storage, and disposal for chloroform**
- **Ascarite II, cobalt nitrate hexahydrate, methyl iodide, and nickel powder: Standard PPE as described above**

VI. SPILL AND EMERGENCY PROCEDURES

A. Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual

B. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide.

C. For spills of solid materials, DO NOT dry sweep.

D. EH&S **must be notified immediately** for any uncontrolled release of Carcinogens; please call (530) 752-1493. Some examples of an uncontrolled release include, but are not limited to, equipment failure, rupture of containers, or failure of control equipment. EH&S must report this information to Cal/OSHA within 24 hours.

VII. WASTE MANAGEMENT AND DECONTAMINATION

A. Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

B. Decontamination procedures vary depending on the material being handled. Carefully inspect work areas to make sure no hazardous materials remain. Following dispensing or handling, all surfaces and equipment should be wiped with the appropriate cleaning agent to prevent accumulation of Carcinogen chemical residue. Dispose of cleaning materials properly. Be sure all ignition sources are secured before beginning clean up with flammable liquids. Decontaminate vacuum pumps or other contaminated equipment before removing them from the regulated area or before resuming normal laboratory work in the area.

C. Upon completion of work with Carcinogens and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated Carcinogen work area remove all PPE worn and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

CMGI-specific waste and decontamination requirements:

- **Chloroform: Per SOP 5, Proper use, storage, and disposal for chloroform**
- **Ascarite II, cobalt nitrate hexahydrate, methyl iodide, and nickel powder: Standard procedures as described above**

VIII. DESIGNATED AREA

Designated area(s) for the use and storage of Carcinogens shall be established where limited access, special procedures, knowledge, and work skills are required. Signage indicating the materials being used and/or stored and the applicable hazards should be easily visible for the designated work space and/or storage area, for example: DANGER! CARCINOGEN WORK AREA!

CMGI-specific posting requirements:

- **Assure that containers of carcinogens are labeled as such**
- **Post work area DANGER! CARCINOGEN WORK AREA! while working with carcinogens**

Chemistry Standard Operating Procedure 7: Acutely Toxic Solids and Liquids

I. HAZARD OVERVIEW

There is a broad spectrum of Acutely Toxic solid and liquid materials. For these materials, a single short-term exposure at low concentrations can cause serious illness or death. Recognition of the hazards associated with the transportation, operation, storage, and disposal of these materials is essential.

II. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

An Acutely Toxic Material is a chemical falling within any of the following categories:

A. A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to albino rats weighing between 200 and 300 gm each.

B. A chemical with a median lethal dose (LD50) of 200 mg or less per kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kg each.

C. A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2 mg per liter 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 gm each.

Acutely Toxic Materials can be identified using the Globally Harmonized System Hazard Codes H300 (Fatal if swallowed), H310 (Fatal in contact with skin) and H330 (Fatal if inhaled). A few examples of common Acutely Toxic Materials used at the UC Davis campus include, but are not limited to, the following:

A. Sodium Azide
B. Mercaptoethanol
C. Cyanide salts
D. Mercury compounds
E. Isocyanates

Chemistry Standard Operating Procedure 7: Acutely Toxic Solids and Liquids

Acutely Toxic Solids and Liquids Used at CMGI:

Chemical	Code / Hazard	Room	Use / restrictions
Tetramethyl ammonium hydroxide, 25%	H300: Acute toxicity, oral - fatal if swallowed, Category 1 and 2	0302	Preparation of aprotic bases and buffers
Phosphorous pentoxide	H330: Acute toxicity, inhalation - fatal if inhaled, Category 1 and 2	0302	**CMGI staff only**, to repack C11 Tracerlab drying columns
Methyl iodide solution	H330: Acute toxicity, inhalation - fatal if inhaled, Category 1 and 2	0302	**CMGI staff only**, as an HPLC standard

- **Use of any other acutely toxic solids and liquids is NOT authorized at CMGI.**
- **If you need to use an acutely toxic solid or liquid for work at CMGI, please see the Radiochemistry Facility Manager to establish safety procedures.**

III. ENGINEERING/VENTILATION CONTROLS

The following is a general plan for all Acutely Toxic Materials:

A. Use containment devices (*e.g.,* chemical fume hoods, glove boxes, etc.) when:

1. Using volatile and/or semi-volatile substances.
2. Manipulating substances that may generate aerosols.
3. Performing laboratory procedures that may result in an uncontrolled release.

B. Use high-efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.

C. Ventilated containment should be used to weigh out solid chemicals (*e.g.,* certified laboratory chemical fume hood). Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a fume hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the fume hood. If a chemical needs to be added or removed, this manipulation is carried out in the fume hood. In this manner, all open chemical handling is conducted in the fume hood.

If you must use Acutely Toxic Materials without engineering or ventilation controls, you must contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for an exposure assessment.

IV. ADMINISTRATIVE CONTROLS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory.
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory.
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer.
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS).
5. Implement good laboratory practices, including good workspace hygiene.
6. Inspect all equipment and experimental setups prior to use.
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location.
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor.
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving Acutely Toxic Materials described in this SOP.
10. Abide by the laboratory-specific working alone SOP, if applicable.

B. For Acutely Toxic Materials, the following are also required:
   1. Work surfaces should be protected (*e.g.,* disposable absorbent bench paper, aluminum foil, etc.) and must be decontaminated after each use.

V. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for work with Acutely Toxic Materials:

A. Eye Protection: Eye protection is required for all work with Acutely Toxic Materials.

1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
3. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   1. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
   2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.

C. Hand Protection: Hand protection is needed for the activities described in this SOP. Define the type of glove to be used based on: (1) the chemical(s) being used, (2) the anticipated chemical contact (*e.g.*, incidental, immersion, etc.), (3) the manufacturers' permeation/compatibility data, and (4) whether a combination of different gloves is needed for any specific procedural step or task.

VI. SPILL AND EMERGENCY PROCEDURES

A. Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual

B. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide.

C. For spills of solid materials, DO NOT dry sweep.

VII. WASTE MANAGEMENT AND DECONTAMINATION

A. Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

B. Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces and equipment should be wiped with the appropriate cleaning agent following dispensing or handling to prevent accumulation of Acutely Toxic chemical residue. Decontaminate vacuum pumps or other contaminated equipment before removing them from the designated area or before resuming normal laboratory work in the area.

C. Carefully inspect work areas to make sure no hazardous materials remain. Clean contaminated work areas with an appropriate cleaning agent, and dispose of cleaning materials properly. Be sure all ignition sources are secured before beginning clean up with flammable liquids.

D. Upon completion of work with Acutely Toxic Materials and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated Acutely Toxic Materials work area remove all PPE worn and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

VIII. DESIGNATED AREA

Designated area(s) are required for the use and storage of Acutely Toxic Materials. Such areas must be clearly marked with signs that identify the chemical hazard and include an appropriate warning; for example: DANGER! ACUTELY TOXIC MATERIAL WORK AREA!

CMGI-specific procedures:

- Assure that acutely toxic chemicals are labeled as such and are stored appropriately according to SOP 1.
- While working with acutely toxic materials, please post the work area: DANGER! ACUTELY TOXIC MATERIAL WORK AREA!

Chemistry Standard Operating Procedure 8: Cryogens

I. HAZARD OVERVIEW

Cryogens are liquefied or solid gases at low temperatures. These materials may be used for cooling, sample storage, or a ready source of pressurized gas. Cryogen exposure may result in tissue damage or asphyxiation due to displaced oxygen. Cryogenic materials stored in pressurized containers must contain safety pressure release valves in order to avoid rapid expansion and container failure.

II. HAZARDOUS CHEMICALS/CLASS OF HAZARDOUS CHEMICALS

Cryogenic liquids are defined as liquids with a normal boiling point below -150 °C (-240 °F). Some examples include: liquid N_2, O_2, He, etc, which have typical gas:liquid expansion volumes of 650-1500:1. Cryogenic solids are defined as solids with a sublimation range of -78.5 °C to -109.3 °C (-109.3 °F to -164.7 °F). An example of this would be solid CO_2 (dry ice). Finally, some mixtures of Cryogenic materials and a solvent (e.g., dry ice/acetone) may have flammability or other hazards in addition to Cryogenic hazards.

Cryogens used at CMGI:

- Liquid nitrogen (stocked in room 0311): generally used for cold traps in radiochemistry hot cells or "snap freezing" liquid samples in Eppendorf vials
- Solid CO_2 (dry ice; from shared chest on 4th floor): generally used to pack frozen samples for transport

III. ENGINEERING/VENTILATION CONTROLS

Cryogens should only be used in well-ventilated areas. Use within small rooms or unventilated areas (e.g., cold rooms) may cause a buildup of gas as the Cryogen evaporates or sublimes, displacing oxygen creating an asphyxiation hazard. If the use of Cryogens are required in a small or unventilated room contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for alternative respiratory and/or ventilation options.

"How Not to Do It"
http://pipeline.corante.com/archives/2006/03/08/how_not_to_do_it_liquid_nitrogen_tanks.php.

CMGI laboratories are adequately vented for use of liquid nitrogen and dry ice as described in Section II.

IV. ADMINISTRATIVE CONTROLS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory.
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including

any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory.

3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer.
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS).
5 Implement good laboratory practices, including good workspace hygiene.
6. Inspect all equipment and experimental setups prior to use.
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location.
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor.
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving Cryogens described in this SOP.
10. Abide by the laboratory-specific working alone SOP, if applicable.

B. For Cryogens, the following are also required:

1. Successful completion of the Cryogen Safety training course.
2. Have read SafetyNet #58 - Safety Precautions for Cryogenic Liquids.
3. Do not alter or disable the pressure-relief mechanisms/valves as installed by the manufacturer.
4. Do not alter/modify the Cryogen containers as received from the vendor.
5. Use tongs or similar tools to immerse and remove objects from liquid Cryogens.
6. Do not touch Cryogenic materials, or tools in contact with Cryogens, with bare skin or disposable gloves (see PPE requirements below).
7. Do not lubricate equipment for Cryogenic oxygen use.
8. Cryogenic dewars and/or delivery lines should be inspected for leaks and must be composed of compatible materials.

Chemistry Standard Operating Procedure 8:
Cryogens

IV. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE are required for work with Cryogens:

A. Eye Protection: Eye protection is required for all work with Cryogens.
   1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
   2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
   3. In addition to safety glasses/goggles, a face shield, in good condition, is **required** for transferring from any pressurized container, and should be considered for large volume transfers.
   4. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   1. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
   2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.
   3. Pants should not have cuffs, which could catch the liquid Cryogen causing dermal burns.
   4. Shoes should be made of non-porous materials or have impermeable uppers.

C. Hand Protection: When hand protection is needed for the activities described in this SOP define the type of glove to be used based on: (1) the chemical(s) being used, (2) the anticipated chemical contact (*e.g.*, incidental, immersion, etc.), (3) the manufacturers' permeation/compatibility data, and (4) whether a combination of different gloves is needed for any specific procedural step or task.
   1. Loose-fitting, thermal-insulated gloves (not intended for full immersion purposes) that are meant for incidental contact **must** be available to all personnel using Cryogens. No metal jewelry, watches, or rings should be worn while handing Cryogens.

Thermal-insulated gloves are available in room 0311.

Chemistry Standard Operating Procedure 8: Cryogens

VI. SPILL AND EMERGENCY PROCEDURES

Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (posted in the laboratory).

A. For a small spill of Cryogenic liquid:
   1. Evacuate the area.
   2. Allow ventilation to dissipate the gas.
   3. Contact EH&S at (530) 752-1493 for oxygen deficiency monitoring prior to reentry.

B. For large spills, delivery line failures, tank/dewar failures, or any other uncontrolled release immediately evacuate the room and pull the fire alarm to evacuate building.

C. If a leak is suspected from a Cryogen dewar or delivery line/system discontinue use. If it is safe and feasible to do so, move the leaking dewar to a safe location. Contact the vendor immediately.

D. Care should be taken to prevent the accidental accumulation of liquid Oxygen. Laboratory activities where liquid Nitrogen or Helium are used for cooling (e.g., vacuum traps) have increased potential for liquid oxygen enrichment or entrapment.

E. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

VII. WASTE MANAGEMENT

Specific waste concerns for Cryogens:

A. Do not put unneeded Cryogens into a sealed container. Ensure good ventilation while the unneeded Cryogen evaporates/sublimates;

B. If Cryogen has been mixed with a liquid (e.g., dry ice/acetone) that would normally be disposed as hazardous waste, follow waste disposal procedures for that liquid once the Cryogen has completely dissipated; and

C. Do not dispose of Cryogens into sinks, as thermal shock or gaseous expansion may damage the sink and/or plumbing.

VIII. DESIGNATED AREA.

Liquid nitrogen and dry ice may be used in all CMGI laboratories.

Chemistry Standard Operating Procedure 9: Pyrophorics

I. HAZARD OVERVIEW

Pyrophoric materials are substances that can ignite spontaneously upon exposure to air or oxygen. They can also be water-reactive, where heat and a flammable gas are produced. For Pyrophoric materials, oxidation of the compound by oxygen or moisture in air proceeds so rapidly that ignition occurs.

II. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

Typical Pyrophorics include, but are not limited to: metal hydrides, select finely divided metal powders, nonmetal hydride and alkyl compounds, white phosphorus, alloys of reactive materials, Grignard reagents, and some organometallic compounds (including alkyllithium, and alkylzinc reagents).

Materials that may spontaneously auto-ignite can be identified using the Globally Harmonized System using the Hazard Codes of H-250 (Catches fire spontaneously if exposed to air) and H-260 (In contact with water releases flammable gases which may ignite spontaneously).

Sodium hydride is the only pyrophoric compound in regular use at CMGI. Minute amounts (<5 mg) are spooned into dry reaction vials as a base, before addition of other reagents in dry organic solution. Sodium hydride used for this purpose is supplied in 60% dispersion in mineral oil, for safe brief exposure to air. Sodium hydride is stored with water-reactive chemicals in a dessicator under vacuum, in room 0302.

PLEASE CONSULT WITH THE RADIOCHEMISTRY LABORATORY MANAGER IF YOU PLAN TO WORK WITH PYROPHORIC MATERIALS, to assure that appropriate safety procedures are established.

III. ENGINEERING/VENTILATION CONTROLS

The following is a general plan for all Pyrophorics:

A. Work under an inert and dry atmosphere (argon, nitrogen) in an enclosed glove box.

B. If work in a glove box is impractical or otherwise not possible:

1. Work inside a properly functioning certified chemical fume hood using air-free (e.g., Schlenk) technique when handling Pyrophoric materials. Work with the sash as low as possible.
2. Work away from water sources or potential water splash.
3. Remove adjacent ignition sources and unneeded flammable/combustible materials.
4. Use fresh dry solvents.
5. If materials or side products are prone to rapid decomposition, use a portable blast shield.

Chemistry Standard Operating Procedure 9: Pyrophorics

IV. ADMINISTRATIVE CONTROLS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory.
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory.
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer.
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS).
5. Implement good laboratory practices, including good workspace hygiene.
6. Inspect all equipment and experimental setups prior to use.
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location.
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor.
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving Pyrophorics described in this SOP.

B. For Pyrophorics, the following are also required:

1. **Never work alone.** All work involving Pyrophorics must be performed in the presence of at least one safety buddy. The safety buddy must be a person who has been trained in the use of Pyrophorics and who is proficient with the Pyrophoric emergency protocols set forth in this SOP. Furthermore, the safety buddy must be within audible and visible range of the person that is handling Pyrophorics at all times, and must not be concurrently working with Pyrophorics or any other compound or process that cannot be easily and safely abandoned.

Chemistry Standard Operating Procedure 9: Pyrophorics

2. Any individual using Pyrophorics must be trained on all information contained within **SafetyNet #135**.
3. It is better to do multiple transfers of small volumes (less than 10 mL) than attempt to handle larger quantities. Never transfer more than one aliquot using same syringe. Never transfer more than half of the volume contained by a syringe (e.g., do not transfer more than 5mL of liquid in a 10 mL syringe). Liquids may be safely transferred without a glove box by employing certain syringe or cannula techniques. For large volume transfers the cannula technique should be considered. Before transferring, make sure that the material is at the appropriate temperature [see SDS]. See **SafetyNet #135** for further details.
4. Ensure all equipment is dry, damage-free, air-free, clean, and appropriate for the task.
5. Be sure to have a quenching scheme for residual materials prior to beginning work.
6. Clear the area of unrelated and incompatible hazards.
7. Know the location of eye wash/safety shower and first aid kit. Only use if the area is properly equipped with this safety equipment located within ten seconds of travel.
8. You **must** have an appropriate extinguishing agent (dry sand, Met-L-X, soda ash, or lime) for the Pyrophoric material you are using immediately available adjacent to your workspace. Extinguishing agents for Pyrophorics are not provided by campus Fire Prevention and must be obtained by the lab personnel working with Pyrophorics.
9. Pyrophorics shall have their own dedicated storage with secondary containment and segregated from incompatibilities. Pyrophoric gases shall be stored in compliance with California Fire Code requirements. Please contact the Chemical Hygiene Officer for storage recommendations and requirements.
10. Minimize your purchases of Pyrophoric materials to quantities that will be used within one year. The date of receipt and date of opening must be written onto the container. Contact the Chemical Hygiene Officer for the storage restrictions for your specific laboratory/building.

Small amounts of sodium hydride in 60% dispersion in mineral oil (<5 mg) may be spooned into a dry reaction vessel in air, in the fume hood in room 0302. The vessel may be removed from the fume hood for weighing. These exceptions to standard pyrophorics practice are allowed for this reagent only, because it is formulated for safe brief exposure to air. Other requirements (e.g., an immediately available extinguishing agent and a "safety buddy") are NOT waived.

C. Storage Considerations for Pyrophorics:

1. When appropriate store under inert (e.g., N2, Ar) gas;
2. Store all pyrophoric materials in the manufacturer's container;
3. Avoid heat/ flames, ignition sources, oxidizers, protonating substances (e.g., acids, alcohols, etc.), and water sources; and
4. It should be noted that the storage requirements of the individual materials must be considered (e.g. alkyllithium species should not be stored near strong Lewis acids despite the similar storage requirements for the two species).

V. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for all work with Pyrophorics:

A. Eye Protection:
   1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
   2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
   3. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a flame-resistant (FR) laboratory coat that is NFPA 2112-compliant laboratory coat that fully extends to the wrist is necessary.
   1. Clothing worn under PPE should not be made from synthetic materials;
   2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.
   3. When using/transferring/quenching Pyrophorics in a chemical fume hood a face shield should be considered any time there is a need to raise the sash above the standard 18-inch opening height for any extended period of time.

C. Hand Protection: Hand protection is needed for the activities described in this SOP. Define the type of glove to be used based on: (1) the chemical(s) being used, (2) the anticipated chemical contact (*e.g.,* incidental, immersion, etc.), (3) the manufacturers' permeation/compatibility data, and (4) whether a combination of different gloves is needed for any specific procedural step or task.

   When handling Pyrophorics:
   1. A chemically-compatible glove of at least 10-mil thickness, or double-gloving of gloves at least 5-mil thickness, shall be used;

2. Flame-resistant (e.g., Nomex) gloves may be used in conjunction with a chemically-compatible disposable glove, and should be considered when an elevated risk of Pyrophoric spill exists (e.g., movement of Pyrophorics)
3. See **SafetyNet #135** for further details.

VI. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (posted in the laboratory).

A. Once spilled, liquid or solid Pyrophoric chemicals may ignite.

The primary emergency response is to extinguish Pyrophoric fires using an appropriate extinguishing agent (dry sand, Met-L-X, soda ash or lime). Primary emergency response to extinguish Pyrophoric fires on a person would be to use an emergency eyewash/safety shower.

SEE THE EMERGENCY RESPONSE FLOWCHART AT THE END OF THIS SOP.

Additional considerations for a fire involving Pyrophoric materials include:

1. Use an appropriate extinguishing agent (dry sand, Met-L-X, soda ash or lime) for the Pyrophoric material.
2. Using a Class ABC fire extinguisher may be helpful to manage a lateral fire.
3. Fire extinguishers containing water are not suitable for use in these situations.
4. Fire extinguishers containing water (or that may develop water over time), carbon dioxide, or halons are not suitable for fires involving organolithium compounds as they react violently.

B. If there is an unusual or unexpected occurrence when using Pyrophorics, the occurrence must be documented and discussed with the Principal Investigator or Laboratory Supervisor and others who might be using the material(s). Unusual or unexpected occurrences might include a fire, catastrophic failure, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers. It is also essential that "Lessons Learned" and "Near Misses" incident reports be maintained and shared.

VII. WASTE MANAGEMENT AND DECONTAMINATION

A. Hazardous waste must be managed according to Safety Net #8 and properly labelled, using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

Chemistry Standard Operating Procedure 9: Pyrophorics

B. **Decontamination:**

Carefully inspect work areas to make sure no Pyrophoric materials remain. Clean contaminated work areas with wipers moistened with a dry, non-polar solvent. Be sure all ignition sources are secured before beginning cleaning up with flammable liquids. Be certain that the appropriate quenching procedure is complete before adding materials to a hazardous waste container.

C. Upon completion of work with Pyrophorics and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated Pyrophoric work area, remove all PPE worn and wash hands and forearms as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

VIII. DESIGNATED AREA

Designated area(s) for the use and storage of Pyrophorics shall be established where limited access, special procedures, knowledge, and work skills are required. Signage indicating the materials being used and/or stored and the applicable hazards should be easily visible for the designated work space and/or storage area, for example: DANGER! PYROPHORIC MATERIALS IN USE!

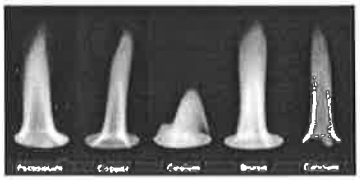
Designated areas for pyrophoric storage and use at CMGI:

- **Storage: Dedicated dessicator in room 0302.**
- **Dispensing: Fume hood in room 0302.**
- **Use in reactions: Rooms 0302 and 0311.**

So You Spilled a Pyrophoric Chemical, What Should You Do?

Appropriate Extinguishing Agents:
- Dry Sand
- Met-L-X
- Soda Ash (Na_2CO_3)
- Lime (CaO)

Pyrophoric Spill



In a Fume Hood

- **Large Spill** > 10 grams
  - Close Sash, Evacuate Lab, Pull Fire Alarm
- **Small Spill** < 10 grams
  - Extinguish with Appropriate Agent (see top left) → Quench: Per Lab Protocol if Controllable

On a Person or in Transport

- Safety Shower IMMEDIATELY
- Remove Lab Coat and ALL Clothing
- Remain in Safety Shower for at Least 15 Minutes
- Once Extinguished Ensure Affected Person is Escorted to a Health Center or Hospital

Ensure ALL Essential Emergency Contacts are Notified

EMERGENCY CONTACT INFORMATION

911

Campus Fire Department:
(530) 752-1236

EH&S:
(530) 752-1493

Pyrophoric Spill Flowchart

UC DAVIS
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v1.0

Chemistry Standard Operating Procedure 10: Reproductive Toxins

I. HAZARD OVERVIEW

There is a broad spectrum of chemicals that pose the potential to be Reproductive Toxins (*e.g.,* mutagenicity, teratogenicity, etc.). Recognition of the hazards associated with the transportation, handling, storage, and disposal of these materials is essential.

II. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

A. Reproductive Toxins are substances or agents that may have adverse effects on various aspects of reproduction in both women and men, including fertility, gestation/pregnancy, birth defects, lactation, genetic effects, and general reproductive performance. Many chemicals used in laboratory study and research, industrial processes, and daily activities pose reproductive hazards.

B. Materials that meet this criteria can be identified using the following Globally Harmonized System Hazard Codes, which should be included on current Safety Data Sheets:

1. H340 - May cause genetic effects
2. H341 - Suspected of causing genetic effects
3. H360 - May damage fertility or the unborn child
4. H361 - Suspected of damaging fertility or the unborn child
5. H362 - May cause harm to breast-fed children.

C. A few examples of common Reproductive Toxins used at the UC Davis campus include, but are not limited to, the following:

1. Chloroform
2. Toluene
3. Benzene
4. Lead
5. Xylenes
6. Anesthetic gases (*e.g.,* halothane, isoflurane, etc.)

Chemistry Standard Operating Procedure 10: Reproductive Toxins

Reproductive Toxins Used at CMGI:

Chemical	Code / Hazard	Room	Use / restrictions
Boric Acid	H360: Reproductive toxicity - may damage fertility or the unborn child, Category 1A, 1B	0302, 0311	**CMGI staff only**, for radiotracer synthesis
Dimethyl-formamide	H360: Reproductive toxicity - may damage fertility or the unborn child, Category 1A, 1B	0302, 0311	Used as an organic solvent by CMGI staff and guest researchers

- **Isoflurane, a reproductive toxin, is used for animal anesthesia in CMGI Imaging labs. Please refer to SOP 11, Isoflurane.**
- **Use of any other reproductive toxins is NOT authorized at CMGI.**
- **If you need to use a reproductive toxin for work at CMGI, please see the Radiochemistry Facility Manager to establish safety procedures.**

III. ENGINEERING/VENTILATION CONTROLS

The following is a general plan for all Reproductive Toxins:

A. Use containment devices (*e.g.,* chemical fume hoods, glove boxes, etc.) when:
   1. Using volatile and/or semi-volatile substances;
   2. Manipulating substances that may generate aerosols; and
   3. Performing laboratory procedures that may result in an uncontrolled release.

B. Use high-efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.

C. Ventilated containment should be used to weigh out solid chemicals (*e.g.,* certified laboratory chemical fume hood). Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a fume hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the fume hood. If a chemical needs to be added or removed, this manipulation is carried out in the fume hood. In this manner, all open chemical handling is conducted in the fume hood.

D. If you must use Reproductive Toxins without engineering or ventilation controls, you must contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for an exposure assessment.

Chemistry Standard Operating Procedure 10: Reproductive Toxins

Engineering and Ventilation Controls at CMGI for the use of:

- **Boric acid and dimethylformamide: Use only in fume hood, room 0302, or ventilated hot cell, room 0311**
- **Isoflurane: Please refer to SOP 11, Isoflurane.**

IV. ADMINISTRATIVE CONTROLS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory;
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer;
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS);
5. Implement good laboratory practices, including good workspace hygiene;
6. Inspect all equipment and experimental setups prior to use;
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor;
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving the Reproductive Toxins described in this SOP; and
10. Abide by the laboratory-specific working alone SOP, if applicable.

B. For Reproductive Toxins, the following are also required:

1. Work surfaces should be protected (*e.g.,* disposable absorbent bench paper, aluminum foil, etc.) and must be decontaminated after each use.

2. Laboratory personnel considering pregnancy or who become pregnant may want to consult the additional information on the Reproductive Health webpage.

Handling and storage requirements at CMGI for the use of:

- **Boric acid: Store in acids cabinet; label appropriately.**
- **Dimethylformamide: store backup stock in the Flammables cabinet.**
- **Isoflurane: Please refer to SOP 11, Isoflurane.**

V. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for work with Reproductive Toxins.

A. Eye Protection: Eye protection is required for all work with Reproductive Toxins.
   1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
   2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
   3. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   1. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
   2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.

C. Hand Protection: When hand protection is needed for the activities described in this SOP define the type of glove to be used based on: (1) the chemical(s) being used, (2) the anticipated chemical contact (*e.g.,* incidental, immersion, etc.), (3) the manufacturers' permeation/compatibility data, and (4) whether a combination of different gloves is needed for any specific procedural step or task.

VI. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are

contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (posted in the laboratory).

VII. WASTE MANAGEMENT AND DECONTAMINATION

A. Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

B. Decontamination

1. Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces and equipment should be wiped with the appropriate cleaning agent following the dispensing or handling of reproductive hazards to prevent accumulation. Decontaminate vacuum pumps or other contaminated equipment before removing them from the designated area or before resuming normal laboratory work in the area.
2. Carefully inspect work areas to make sure no hazardous materials remain. Clean contaminated work areas with an appropriate cleaning agent, and dispose of cleaning materials properly. Be sure all ignition sources are secured before beginning clean-up with flammable liquids.

C. Upon completion of work with Reproductive Toxins and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated Reproductive Toxin work area remove all PPE and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

VIII. DESIGNATED AREA

Designated area(s) are required for use and storage of Reproductive Toxins. Such areas must be clearly marked with signs that identify the chemical hazard and include an appropriate warning; for example: DANGER! REPRODUCTIVE TOXIN WORK AREA!

Designated work areas at CMGI for the use of:

- **Boric acid: Fume hood, room 0302, and ventilated hot cell, room 0311**
- **Isoflurane: Please refer to SOP 11, Isoflurane.**

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CMGI LABORATORY SAFETY PLAN

Chemistry Standard Operating Procedure 11: Isoflurane

Reproductive Toxins

STANDARD OPERATING PROCEDURE (SOP)

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazardous Class

All personnel who are subject to these SOP requirements must review a completed SOP and sign the associated training record. Completed SOPs must be kept with the UC Davis Laboratory Safety Manual or be otherwise readily accessible to laboratory personnel. Electronic access is acceptable. SOPs must be reviewed, and revised where needed, as described in the UC Davis Laboratory Safety Manual. Note that not all hazardous chemicals are appropriately addressed in a single control-banded SOP, and some chemicals are subject to several control-banded SOPs. The unique properties of each chemical must be considered before including it into a control band.

Date SOP Written:	11/2/15	Approval Date:	Click here to enter a date. 12/21/15
SOP Prepared by:	Rowland, Douglas CLSC SOP Task Force		
SOP Reviewed and Approved by (name/signature):	Simon Cherry		
Department:	CMGI		
Principal Investigator/ Laboratory Supervisor:	Simon R. Cherry	Phone:	754-9419
Lab Manager/ Safety Coordinator:	Jennifer Fung	Phone:	754-8846
Emergency Contact(s):	Simon Cherry	Phone:	754-9419
	Jennifer Fung		754-8846
	Charles Smith		754-6639
	Doug Rowland		754-8960
Location(s) covered by SOP:	Building: GBSF Room #(s): 0300-0310	Lab Phone:	754-6633

1. HAZARD OVERVIEW

There is a broad spectrum of chemicals that pose the potential to be Reproductive Toxins (*e.g.*, mutagenicity, teratogenicity, etc.). Recognition of the hazards associated with the transportation, handling, storage, and disposal of these materials is essential.

Chemistry Standard Operating Procedure 11: Isoflurane

2. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

Reproductive Toxins are substances or agents that may have adverse effects on various aspects of reproduction in both women and men, including fertility, gestation/pregnancy, birth defects, lactation, genetic effects, and general reproductive performance. Many chemicals used in laboratory study and research, industrial processes, and daily activities pose reproductive hazards.

Materials that meet this criteria can be identified using the following Globally Harmonized System Hazard Codes, which should be included on current Safety Data Sheets:

1. H340 - May cause genetic effects;
2. H341 - Suspected of causing genetic effects;
3. H360 - May damage fertility or the unborn child;
4. H361 - Suspected of damaging fertility or the unborn child; and
5. H362 - May cause harm to breast-fed children.

A few examples of common Reproductive Toxins used at the UC Davis campus include, but are not limited to, the following:

1. Chloroform
2. Toluene
3. Benzene
4. Lead
5. Xylenes
6. Anesthetic gases (*e.g.*, halothane, isoflurane, etc.)

Isoflurane: This is a volitale anesthetic gas used throughout CMGI as an anesthetic for animal sedation. Prolonged exposure may result in drowsiness or diziness.

3. ENGINEERING/VENTILATION CONTROLS

The following is a general plan for all Reproductive Toxins:

A. Use containment devices (*e.g.*, chemical fume hoods, glove boxes, etc.) when:
   i. Using volatile and/or semi-volatile substances;
   ii. Manipulating substances that may generate aerosols; and
   iii. Performing laboratory procedures that may result in an uncontrolled release.

B. Use high-efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.

C. Ventilated containment should be used to weigh out solid chemicals (*e.g.*, certified laboratory chemical fume hood). Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a fume hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the fume hood. If a chemical needs to be added or removed, this manipulation is carried out in the fume hood. In this manner, all open chemical handling is conducted in the fume hood.

If you must use Reproductive Toxins without engineering or ventilation controls, you must contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for an exposure assessment.

Chemistry Standard Operating Procedure 11: Isoflurane

Use of isoflurane is restricted to the use in approved and maintained vaporizers. Induction chamber exhaust should be directed directly into lab snorkels. Animal anesthesia on the benchtop should be minimized and be used as near as possible to snorkels.

4. ADMINISTRATIVE CONTROLS

The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory;
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer;
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS);
5. Implement good laboratory practices, including good workspace hygiene;
6. Inspect all equipment and experimental setups prior to use;
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor;
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.*, unexpected rise or drop in temperature, color or phase change, evolution of gas) involving the Reproductive Toxins described in this SOP; and
10. Abide by the laboratory-specific working alone SOP, if applicable.

For Reproductive Toxins, the following are also required:

11. Work surfaces should be protected (*e.g.*, disposable absorbent bench paper, aluminum foil, etc.) and must be decontaminated after each use.

Laboratory personnel considering pregnancy or who become pregnant may want to consult the additional information on the Reproductive Health webpage.

Isoflurane bottles should be tightly capped when not in use. Vaporizers should be shutoff when not in use.

N/A

5. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for work with Reproductive Toxins:

Chemistry Standard Operating Procedure 11: Isoflurane

A. Eye Protection: Eye protection is required for all work with Reproductive Toxins.
   i. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
   ii. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
   iii. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   i. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
   ii. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.*, face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.

C. Hand Protection: When hand protection is needed for the activities described in this SOP define the type of glove to be used based on: A) the chemical(s) being used, B) the anticipated chemical contact (*e.g.*, incidental, immersion, etc.), C) the manufacturers' permeation/compatibility data, and D) whether a combination of different gloves is needed for any specific procedural step or task.

Gloves, labcoats and eye protection should be worn when handling isoflurane.

6. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (which must be posted in the laboratory). All other locations must describe detailed emergency procedure instructions below.

Prevent further leakage or spillage if safe to do so. Avoid breathing vapours or mist. Evacuate personnel in the case of large spills.

Due to Isofluranes high vapor pressure, in the case of small spills, allow isoflurane to evaporate and then wipe surface with lab disinfectant.

7. WASTE MANAGEMENT AND DECONTAMINATION

Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

Due to the high volume of use, isoflurane is not typically sent for disposal. Place empty bottles open next to snorkels to allow vapors to dissipate. Dispose of bottles in glass recycling

Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces and equipment should be wiped with the appropriate cleaning agent following the dispensing or handling of reproductive hazards to prevent accumulation. Decontaminate vacuum pumps or other contaminated equipment before removing them from the designated area or before resuming normal laboratory work in the area.

Chemistry Standard Operating Procedure 11: Isoflurane

Carefully inspect work areas to make sure no hazardous materials remain. Clean contaminated work areas with an appropriate cleaning agent, and dispose of cleaning materials properly. Be sure all ignition sources are secured before beginning clean-up with flammable liquids.

Due to its high vapor pressure, decontamination is not necessary. Allows vapors to dissipate and wipe surfaces clean with lab disinfectant

Upon completion of work with Reproductive Toxins and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated Reproductive Toxin work area remove all PPE and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

8. **DESIGNATED AREA**

Designated area(s) are required for use and storage of Reproductive Toxins. Such areas must be clearly marked with signs that identify the chemical hazard and include an appropriate warning; for example: DANGER! REPRODUCTIVE TOXIN WORK AREA!

Use of isoflurane is used throughout the CMGI lab area but is restricted in each room to benchtops and imaging instrumentation.

9. **DETAILED PROTOCOL**

Please see attached MSDS.

TEMPLATE REVISION HISTORY

Version	Date Approved	Author	Revision Notes:
1.0	12/1/14	CLSC Task Force	New template
1.1	4/16/15	Chris Jakober	Changed SDS link, language relating to soiled PPE

LAB-SPECIFIC REVISION HISTORY

Version	Date Approved	Author	Revision Notes:
1	12/14/2015	D Rowland	None

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Chemistry Standard Operating Procedure 11: Isoflurane

Documentation of Standard Operating Procedure Training

(Signature of all users is required)

- ✓ Prior to using **Reproductive Toxins**, laboratory personnel must be trained on the hazards involved in working with this SOP, how to protect themselves from the hazards, and emergency procedures.
- ✓ Ready access to this SOP and to a Safety Data Sheet for each hazardous material described in the SOP must be made available.
- ✓ The Principal Investigator (PI), or the Laboratory Supervisor if the activity does not involve a PI, must ensure that their laboratory personnel have attended appropriate laboratory safety training or refresher training within the last three years.
- ✓ Training must be repeated following **any** revision to the content of this SOP. Training must be documented. This training sheet is provided as one option; other forms of training documentation (including electronic) are acceptable but records must be accessible and immediately available upon request.

Designated Trainer: *(signature is required)*

I have read and acknowledge the contents, requirements, and responsibilities outlined in this SOP:

Name	Signature	Trainer Initials	Date
Jennifer Fung		JYF	12/17/15
Charles Smith		CMS	12/18/15
Dave Kukis		JYF	12/21/15
[illegible]		DJK	12/21/15
Stephen Kendig		SVK	12/21/15
Simon Cheung		SRC	12/21/15

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CMGI LABORATORY SAFETY PLAN

Chemistry Standard Operating Procedure 12: Working Alone

I. HAZARD OVERVIEW

According to Prudent Practices in the Laboratory, the definition of "alone" is beyond visible or audible range of another individual for more than a few minutes at a time.

Incidents are unexpected by definition. If a person is working alone when an incident occurs, their ability to respond appropriately can be severely impaired. This could result in personal injury, death, and/or catastrophic facility damage. Indeed, working alone in any laboratory creates increased risk including not having access to basic first aid and the possibility of being unable to summon help in an emergency.

If the design of your workspace/laboratory makes both audible and visual range questionable, contact the Chemical Hygiene Officer or researchsafety@ucdavis.edu for consultation.

II. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S) RESTRICTIONS

A. Dispensing, manipulating or quenching Pyrophoric Materials are prohibited while alone in the laboratory.

B. Using Acutely Toxic Gases is prohibited while alone in the laboratory.

- **Sodium hydride is the only pyrophoric compound in regular use at CMGI.** Minute amounts (<5 mg) are spooned into dry reaction vials as a base, before addition of other reagents in dry organic solution. Sodium hydride used for this purpose is supplied in 60% dispersion in mineral oil, for safe brief exposure to air. Sodium hydride is stored with water-reactive chemicals in a dessicator under vacuum, in room 0302.

  Although this reagent has been formulated for safe brief exposure to air, the requirement for a safety buddy is NOT waived.

- **No acutely toxic gases are in use at CMGI.**

PLEASE CONSULT WITH THE RADIOCHEMISTRY LABORATORY MANAGER IF YOU PLAN TO WORK WITH PYROPHORIC MATERIALS OR TOXIC GASES, to assure that appropriate safety procedures are established.

III. ENGINEERING/VENTILATION CONTROLS & EQUIPMENT RESTRICTIONS

The following is a general plan for all pyrophorics. Section B is applicable to the use of sodium hydride in 60% dispersion in mineral oil at CMGI.

A. Work under an inert and dry atmosphere (argon, nitrogen) in an enclosed glove box.

B. If work in a glove box is impractical or otherwise not possible:

1. Work inside a properly functioning certified chemical fume hood using air-free (e.g., Schlenk) technique when handling Pyrophoric materials. Work with the sash as low as possible.
2. Work away from water sources or potential water splash.

3. Remove adjacent ignition sources and unneeded flammable/combustible materials.
4. Use fresh dry solvents.

IV. ADMINISTRATIVE CONTROLS & RESTRICTIONS

A. The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory.
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory.
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, or trainer.
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS).
5. Implement good laboratory practices, including good workspace hygiene.
6. Inspect all equipment and experimental setups prior to use.
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labeled, stored in closed containers, in secondary containment, and in a designated location.

B. The following are also required for working alone in a laboratory:

1. Minors (*i.e.*, under age 18) are not allowed to work alone in the laboratory.
2. Mobile contact information (*e.g*, PI/Laboratory Supervisor, Department Safety Coordinator, Laboratory Manager, Laboratory Safety Coordinator, etc.) must be available to any personnel allowed to work alone in the laboratory in case of emergency. Office phone numbers are not sufficient.
3. No deviations from the restrictions described in this SOP are allowed without documented approval from the Principal Investigator/Laboratory Supervisor.

C. The use of pyrophoric materials and acutely toxic gases is **prohibited** while alone in the laboratory.

Chemistry Standard Operating Procedure 12: Working Alone

V. SPILL AND EMERGENCY PROCEDURES

A. Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (which must be posted in the laboratory). All other locations must describe detailed emergency procedure instructions below.

B. If an incident occurs when someone is working alone, the PI/Lab Manager and lab personnel **must** review the process and determine whether or not changes need to be made to the process. The lab policy on working alone should also be reviewed.

C. Cleaning up a chemical spill while alone in the laboratory can present additional challenges. Before proceeding with spill cleanup ensure that you have identified all the hazards associated with the chemical spill and any other ongoing laboratory activities/equipment. Assess the risks posed by the spill and other hazards. Only proceed with spill cleanup if the risks can be effectively managed, you have appropriate Personal Protective Equipment (PPE), you have the skills to clean up the spill properly, and you choose to complete the cleanup procedure. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

VI. AREA RESTRICTIONS

With appropriate training, working alone is allowed in all CMGI laboratories, except work involving pyrogenics or acutely toxic gases.

VII. TRAINING

Prior to working alone in the laboratory, laboratory personnel must be trained on the laboratory-specific activity and chemical restrictions that must be followed when working alone. Training must be documented. Ready access to this SOP must be made available.

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Chemistry Standard Operating Procedure 13: Acutely Toxic Gases: 5% Fluorine in Argon

CMGI-SPECIFIC INTRODUCTORY COMMENTS ABOUT 5% FLUORINE IN ARGON

- This is the **only** acutely toxic gas authorized for use at CMGI.
- Use is restricted to Certified Cyclotron Operators on CMGI, for the production of $[^{18}F]F_2$ radiofluorine gas only.
- There is one gas tank, in a hot cell exhausted to the roof, in room GBSF 0311, which is also exhausted to the roof. Thus, there is little danger of exposure. But, all users of CMGI radiochemistry please be aware of the hazard and emergency procedures.

PERTINENT SDS INFORMATION (ABRIDGED)

SDS SECTION 3: HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: This gas is a colorless, non-flammable, corrosive, toxic gas mixture with a pungent odor (due to the presence of fluorine), which is shipped under pressure. This gas mixture may cause significant, adverse health effects, because of the fluorine content. Pure fluorine is a powerful caustic irritant to all tissues; subsequently, releases of this product should be responded to with extreme caution. Fluorine has a pungent odor and a low odor threshold; the odor of this product provides a good warning of a release of this gas mixture. Persons responding to releases of this gas mixture must protect themselves appropriately.

ROUTES OF ENTRY, SYMPTOMS OF ACUTE EXPOSURE: WARNING - Acute overexposure to this gas mixture may cause the following health effects:

EYE CONTACT: Minor contact with this gas will cause tearing and irritation, including swelling and redness, as fluorine is a lachrymator. Severe overexposure to the eyes has the potential to cause burns if contact is prolonged.

INGESTION: Ingestion of this gas mixture is not a likely route of industrial exposure.

INHALATION: This gas mixture can cause significant, adverse effects, due to the presence of fluorine, which is extremely toxic. Minor inhalation exposure of this gas mixture may cause irritation to the lungs, nose, throat, and mucous membranes, resulting in coughing and breathing difficulty. In the event of prolonged inhalation overexposures, there is the potential for tissue damage. Severe inhalation overexposure may result in pulmonary edema (an accumulation of fluid in the lungs), a potentially fatal condition.

SKIN CONTACT: Contact of this gas mixture with the skin can cause mild to severe irritation, depending on the duration of exposure, due to the presence of fluorine.

OTHER HEALTH EFFECTS: It is important to note that fluorine may react with water or moist air to generate hydrofluoric acid solution or hydrogen fluoride gas. If 20% or more of the body is contaminated with hydrofluoric acid, hypocalcemia (a life-threatening lowering of serum calcium in the body) may result. Though *not expected* to occur from overexposures to this product, individuals should use this product with extreme care.

HMIS RATINGS: HEALTH HAZARD = 3; FLAMMABILITY HAZARD = 0; INSTABILITY = 1

Chemistry Standard Operating Procedure 13: Acutely Toxic Gases: 5% Fluorine in Argon

SDS SECTION 4: FIRST AID MEASURES

EYE CONTACT: If this gas mixture contaminates the eyes, open victim's eyes while under gentle running water. Use sufficient force to open eyelids. Have victim "roll" eyes. Minimum flushing is for 15 minutes. Administer anesthetic eye drops after one minute of flushing if victim suffers from spasms to the eyes, in order to facilitate irrigation. In the event of a severe overexposure, victim should consult with an ophthalmologist.

INGESTION: Ingestion is an unlikely route of exposure for this gas.

INHALATION: Remove victim(s) to fresh air, as quickly as possible. Trained personnel should administer supplemental oxygen and/or cardiopulmonary resuscitation, if necessary. In the event of severe, immediate effects, or delayed symptoms which develop after exposure, victim must seek appropriate medical attention.

SKIN CONTACT: If this gas mixture contaminates the skin, immediately begin decontamination with running water. Minimum flushing is for 15 minutes. If necessary, calcium gluconate gel can be applied to affected areas. Remove exposed or contaminated clothing, taking care not to contaminate eyes. Victim should seek appropriate medical attention if symptoms persist.

1. **HAZARD OVERVIEW**

   There is a broad spectrum of Acutely Toxic Gases. For these materials, a single short-term exposure at low concentrations can cause serious illness or death. Recognition of the hazards associated with the transportation, operation, storage, and disposal of these gases is essential.

2. **HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)**

   Acutely Toxic Gases (ATG) 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. Under the California Fire Code, both "Highly Toxic" and "Toxic" gases are treated similarly with regard to use and storage. As such, for the purposes of this control-banded SOP, ATGs are defined as:

   "A chemical that has a median lethal concentration (LC_{50}) in air of 2000 parts per million by volume or less of gas or vapor, or 20 milligrams per liter or less of mist, fume or dust, when administered by continuous inhalation for one hour (or less if death occurs within **1 hour**) to albino rats weighing between 200 and 300 grams each."

   Applicable ATGs in this control-banded SOP are identified using the Globally Harmonized System Hazard Code H330 (Fatal if inhaled). Some additional gases with a H331 Hazard Code (Toxic if inhaled) are also applicable, but note that the GHS system classifies gases based on a 4 hour LC_{50} concentration. One can calculate a 1-hour Acute Toxicity Equivalent (ATE) value by multiplying a 4-hour LC_{50} value by 2 for gases and vapors, or by 4 for dusts and mists. Some examples of ATGs used at the UC Davis campus include, but are not limited to, the following:

1. Chlorine (CAS – 7782-50-5)
2. Hydrogen Sulfide (CAS = 7783-06-4)
3. Methyl Mercaptan (CAS = 74-93-1)
4. Methyl Bromide (CAS = 74-83-9)
5. Nitric Oxide (CAS = 10102-43-9)

6. Nitrogen Dioxide (CAS = 10102-44-0)
7. Phosphine (CAS = 7803-51-2)

There are additional gases, with 1-hour LC_{50} values greater than 2000 ppmv that may need to be treated as ATGs. This would include gases with very low Immediately Dangerous to Life and Health (IDLH) values or have corrosive properties. Some examples of such materials include:

1. Anhydrous Ammonia (CAS = 7664-41-7)
2. Carbon Monoxide (CAS = 630-08-0)
3. Hydrogen Bromide (CAS = 10035-10-6)
4. Hydrogen Chloride (CAS = 7647-01-0)
5. Sulfur Dioxide (CAS = 7446-09-5)

Whether a material should be treated as an ATG can be influenced by a number of factors (*e.g.*, quantity, ventilation, procedure, etc.). Contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for assistance in assessing your materials.

CMGI-specific list of acutely toxic gases:

5% Fluorine gas in argon, used for the cyclotron production of $[^{18}F]F_2$ radiofluorine gas, is the **only** acutely toxic gas used at CMGI.

Restrictions on use of 5% fluorine:

The only authorized use of this gas is to produce $[^{18}F]F_2$ radiofluorine gas with the CMGI cyclotron, by an automated process. Use of 5% fluorine gas in argon is restricted to certified cyclotron operators on staff in CMGI Radiochemistry.

6. ENGINEERING/VENTILATION CONTROLS

Use a properly functioning, certified chemical fume hood when using ATGs. Contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu to review the adequacy of available ventilation options if you are unable to use ATGs within a chemical fume hood. Regulators, valves, and piping used to transport ATGs must be made of compatible materials capable of withstanding the operating pressures. Piping shall have welded, threaded, or flanged connections throughout except for connections located within an exhausted enclosure. The piping system shall be leak-checked with an inert gas prior to being used for delivery of an ATG. Corrosive gas lines must be purged with dry high-purity gases prior to introducing the gas. ATG piping should be labeled with the contents and direction of flow, including both sides of any wall penetration.

Indoor storage of ATGs must be within a gas cabinet or an exhausted enclosure (*e.g.*, chemical fume hood). The number of cylinders located within an exhausted enclosure is limited to three. Cylinders must be segregated from incompatible materials. Quantities of Highly Toxic Gases (H330) may not exceed 20 cubic feet (ft^3) at normal temperature and pressure (NTP), and Toxic Gases (H331) may not exceed 810 ft^3 at NTP. If you require greater quantities, you must contact the Chemical Hygiene Officer or healthandsafety@ucdavis.edu for consultation on additional storage/use requirements.

The chemical fume hood for ATG storage or use must not be the sole exhaust for the room or area (*e.g.*, the room must contain an additional fume hood or general exhaust). A monitoring device is required on exhausted enclosures used for ATG storage, such as audible and visual alarms,

magnehelic gauge, or other devices that indicate the enclosure is actively ventilated. These devices must be clearly marked to indicate safe pressure limits or minimum air flow requirements.

Electronic toxic gas monitors with alarms should be installed and continuously operated wherever a toxic gas is used in a high concentration, large quantity, and/or has poor physiological warning properties (lack of odor or immediate irritation). A monitoring system is required for continuous operations, and may be needed on a case-by-case basis for long-term research situations.

CMGI-specific ventilation controls and equipment safety features to reduce the risk of fluorine gas exposure:

At CMGI, 5% Fluorine gas in argon is stored and used in a designated hot cell in room GBSF 0311, The hot cell is exhausted to the roof stack, and room GBSF 0311 is also exhausted to the stack at approximately 500 cfm.

The gas is delivered by stainless steel tubing, via subfloor conduits, to the cyclotron in room GBSF 0202. The cyclotron is enclosed in shielding, and the enclosure is exhausted to the roof stack at approximately 500 cfm. Room 0202 itself is exhausted to the roof stack at approximately 500 cfm.

The exhaust in room GBSF 0311 and GBSF 0202 are monitored with wall-mount magnahelic gauges, An audible alarm in room 0311 will sound if the dedicated roof fans servicing the radiochemistry suite (hot cells and room exhaust) fail.

The stainless steel delivery tubing is unbroken from the hot cell to the cyclotron vault. Within the hot cell, and within the cyclotron vault, airtight connections are made with stainless steel connectors with ferrules.

Chemical safety practices are built in to the automated process by which $[^{18}F]F_2$ radiofluoride is produced:

- The cyclotron performs an automated leak check, which verifies the integrity of the connectors, prior to $[^{18}F]F_2$ production, and will not perform the production in the event of a failed leak check. (This process is monitored by radiochemistry staff, who must respond to computer dialog boxes during all gas delivery steps.)
- The gas lines are purged by vacuum, then with high purity argon, before introducing 5% fluorine gas.
- A regulator sets delivery pressure at 70-80 psi in accordance with the program specifications. Gas is delivered by an automated process via a double valve system, until approximately 20 mL at 70 psi has been delivered as detected by pressure sensors; then the valves are closed.
- Only one 26 L tank of 5% fluorine gas is needed and used for $[^{18}F]F_2$ production.

No monitoring system for detection of fluorine gas leaks is used because (1) fluorine has a pungent odor and a low detection threshold, providing good warning of release; (2) the ventilation and engineering controls described above are adequate to mitigate exposure risk by our small stock of 5% fluorine at low pressure.

7. ADMINISTRATIVE CONTROLS

The following elements are required:

Chemistry Standard Operating Procedure 13: Acutely Toxic Gases: 5% Fluorine in Argon

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory;
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, and/or trainer;
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS);
5. Implement good laboratory practices, including good workspace hygiene;
6. Inspect all equipment and experimental setups prior to use;
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI and/or Laboratory Supervisor; and
9. Notify the PI and/or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.,* unexpected rise or drop in temperature, color or phase change, evolution of gas) involving the ATGs described in this SOP.

For ATGs, the following are also required:

10. **DO NOT** use ATGs while alone in the laboratory. At least one other person knowledgeable and proficient with emergency protocols must be present in the same laboratory room when any work involving ATGs is undertaken;
11. Adhere to the general guidance for compressed gases in SafetyNet #60 - Compressed Gas Safety and adequately secure all cylinders, including lecture bottles, for seismic activity;
12. Rooms and storage areas containing ATGs must be locked at all times when unoccupied or unattended;
13. Outdoor storage is allowed on a short-term basis and must be located at least 75 feet from an exterior door, window, or air intake; and
14. ATGs shall only be purchased from vendors which accept returns of unused materials.

CMGI-specific administrative controls: The following sign is posted on the hot cell door containing the gas tank:

DANGER! ACUTELY TOXIC GAS WORK AREA INSIDE!
Tank of 5% Fluorine / 95% Argon inside, for $[^{18}F]F_2$ production
Access limited to Cyclotron Operators only

Chemistry Standard Operating Procedure 13: Acutely Toxic Gases: 5% Fluorine in Argon

15. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for work with ATGs:

1. Eye Protection: Eye protection is required for all work with compressed gases, including ATGs.
    1. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
    2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
    3. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.
2. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
    1. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
    2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.,* face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.
3. Hand Protection: When hand protection is needed for the activities described in this SOP define the type of glove to be used based on: A) the chemical(s) being used, B) the anticipated chemical contact (*e.g.,* incidental, immersion, etc.), C) the manufacturers' permeation/compatibility data, and D) whether a combination of different gloves is needed for any specific procedural step or task.

At CMGI, long pants, closed-toe shoes, a flame-resistant laboratory coat with sleeves extending to the wrist, laboratory googles, and nitrile gloves will be worn when using 5% fluorine gas

4. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual, campus Emergency Response Guide (ERG), and UCD Health System ERG. The applicable ERG must be posted in the laboratory. All other locations must describe detailed emergency procedure instructions below.

An emergency is any actual or potential release of an ATG that cannot be stopped by closing the product's cylinder or container valve. In the event of an emergency, evacuate all personnel from the building, which may be accomplished by pulling the fire alarm. Call 911 to dispatch emergency responders.

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CMGI-specific instructions for repair of a small leak:

A small leak may be caused by a minor breach anywhere from the gas tank, to the regulator, to the delivery line and its connectors within the hot cell, to the valves and connectors within the cyclotron shielding. A small leak is indicated by (1) a failed leak check according the automated cyclotron procedure, or (2) a slight odor of fluorine upon opening the hot cell door or cyclotron shielding. A strong odor with the hot cell door or cyclotron shield open, or *any* odor when they are closed, indicates a major leak requiring emergency procedures.

Only personnel authorized to use this gas may attempt to repair a small leak. Proceed with caution. Work with a qualified partner, never alone. Close the hot cell door, ascertain that there is no longer a detectible odor in the room, and then determine the location of the leak by the usual process of elimination, by pressurizing the system and selectively opening and closing valves from the cyclotron computer console. This can be done most safely with the argon tank, which is connected to the same delivery line and system of valves as the 5% fluorine tank, with the exception of only one valve. If all connections and valves prove to be airtight by this method, the problem probably originates in the tank, the regulator, or the connection between the two. Attempt diagnosis and repair with extreme caution, with the 5% fluorine tank closed as much as possible, using a helium tank and a helium "sniffer" when possible. Whenever the 5% fluorine tank is open, be prepared at all times to close the hot cell door quickly.

5. WASTE MANAGEMENT AND DECONTAMINATION

Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the accumulation time for waste disposal to ensure compliance. Hazardous waste pick up requests must be completed online.

All empty toxic gas cylinders shall be labeled as "empty." Depleted toxic gas cylinders should be returned to the vendor according to their guidelines. 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 high costs (up to thousands of dollars).

CMGI-specific waste management: return used tanks to the supplier, according to its guidelines.

CMGI-specific decontamination: This gas is highly volatile and highly corrosive; it will be exhausted or corrode nearby surfaces. Clean corrosion residue with aqueous solvents, wearing nitrile gloves and lab-appropriate PPE.

Upon completion of work with ATGs and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated ATG work area remove all PPE worn and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

6. DESIGNATED AREA

Designated area(s) for the use and storage of ATGs shall be established where limited access, special procedures, knowledge, and work skills are required. Signage indicating the materials being

Chemistry Standard Operating Procedure 13: Acutely Toxic Gases: 5% Fluorine in Argon

used and/or stored and the applicable hazards should be easily visible for the designated work space and/or storage area, for example: DANGER! ACUTELY TOXIC GAS WORK AREA!

CMGI-specific signage: The following sign is posted on the hot cell door containing the gas tank:

DANGER! ACUTELY TOXIC GAS WORK AREA INSIDE!
Tank of 5% Fluorine / 95% Argon inside, for $[^{18}F]F_2$ production
Access limited to Cyclotron Operators only

DETAILED PROTOCOL

The ONLY approved use of the gas mixture 5% fluorine in argon at CMGI, is for the cyclotron production of $[^{18}F]F_2$ radiofluorine gas.

The protocol for $[^{18}F]F_2$ production is provided in Siemens Field Service Instructions D0001143, Rev. A, "F2 (F18) Manual Conditioning and Running."

Despite the title, the procedure actually involves no "hands on" manipulation of the gas or the tank. It is a fully automated process, controlled by the cyclotron software, during which the Cyclotron Operator primarily responds to computer dialog box prompts, to authorize successive steps. Due to the automated nature of this process, there is no need to attach FSE D0001143 to this safety protocol.

CHANGING THE TANK

Purge the gas lines fully with Argon, exhausting and refilling multiple times, before changing the tank.

For a good seal, use a special lead washer to attach the regulator to the fluorine cylinder.

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CMGI LABORATORY SAFETY PLAN

Chemistry Standard Operating Procedure 14: Nanomaterials

1. HAZARD OVERVIEW

Exposure standards have not been established for engineered nanoparticles in the United States or internationally [Safe Nanotechnology 2008.] Until more definitive findings are made regarding the potential health risks of handling nanomaterials, researchers planning to work with nanomaterials must implement a combination of engineering controls, work practices, and personal protective equipment to minimize potential exposures to themselves and others. For a quick guide to the exposure risks and prudent control measures to be used for common laboratory operations involving nanomaterials, refer to the table below. It is important to consider if the nanoparticles are in an agglomerated or aggregated form, functionalized, suspended in liquid, or bound, as these conditions may affect the exposure potential.

Quick Guide: Exposure Risks and Control Measures for Common Laboratory Operations Involving Nanomaterials

Activity types, by Risk of Exposure	Primary Control Measures
Low Probability: • Non-destructive handling of solid nanoparticle composites or nanoparticles permanently bonded to a substrate	• Disposable nitrile or latex gloves. Do not reuse gloves. • Wet cleaning procedures and/or HEPA vacuum for surfaces/equipment.
Medium / High Probability: • Working w/ nanomaterials in liquid media during pouring or mixing, or where a high degree of agitation is involved (e.g., sonication) • Handling nanostructured powders* • High speed abrading/grinding nano-composite materials • Maintenance on equipment used to produce nanomaterials • Cleaning of dust collection systems used to capture nanoparticles	• Conduct task within a fully enclosed system (e.g., glovebox), or fumehood • Disposable gloves appropriate for the solvent in which the particles are suspended. Do not reuse gloves. • Safety eyewear (+ face shield if splash potential exists) • Wear a respirator if inhalation could occur • Wet cleaning procedures for surfaces/equipment • Keep nanoparticles in suspension to prevent aresol or inhalation risks
High Probability: • Generating nanoparticles in the gas phase or in aerosol (spill or liquid) • Manipulation of nanoparticles in gas stream	• Work in enclosed systems only (e.g., glovebox, glovebag, or sealed chamber).

* EH&S recognizes that low-density nanomaterials (e.g., carbon-based) become aerosolized by even the slightest air movement and may not be practical when weighed or handled in laboratory fume hoods. Consult with EH&S on alternative sets of controls.

Chemistry Standard Operating Procedure 14: Nanomaterials

2. HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)

The hazards associated with nanomaterials is not fully known. One should treat the material as toxic and a carcinogen as inhalation could possibly cause cancer. Two forms of nanoparticles are being worked with in this lab: Azide-catechol functionalized iron oxide nanoparticles size 20 nm and 10 nm and copper oxide nanoparticles of various sizes. The biggest hazard is spreading the material and inhalation.

3. ENGINEERING/VENTILATION CONTROLS

Work Practices:

No nanoparticle fabrication is being carried out in this laboratory. However nanomaterials should be handled with care in a fumehood and only on the bench top if aresol formation is improbable and the material is suspended in an aqueous environment.

Selection of Nanomaterials:

- Whenever possible, handle nanomaterials in solutions or attached to substrates to minimize airborne release.
- Consult the Material Safety Data Sheet (MSDS), if available, or other appropriate references prior to using a chemical or nanomaterial with which you are unfamiliar. Note: Information contained in some MSDSs may not be fully accurate and/or may be more relevant to the properties of the bulk material rather than the nano-size particles.

- ***Safety Equipment:***
  - Know the location and proper use of emergency equipment, such as safety showers, fire extinguishers, and fire alarms.
- ***Hygiene:***
  - Do not consume or store food and beverages, or apply cosmetics where chemicals or nanomaterials are used or stored since this practice increases the likelihood of exposure by ingestion.
  - Do not use mouth suction for pipetting or siphoning.
  - Wash hands frequently to minimize potential chemical or nanoparticle exposure through ingestion and dermal contact.
  - Remove gloves when leaving the laboratory, so as not to contaminate doorknobs, or when handling common use objects such as phones, multiuser computers, etc.
- ***Labeling and Signage:***
  - Store in a well-sealed container, preferable one that can be opened with minimal agitation of the contents.
  - Label all chemical containers with the identity of the contents (avoid abbreviations/ acronyms); include term "nano" in descriptor (e.g., "nano-zinc oxide particles" rather than just "zinc oxide." Hazard warning and chemical concentration information should also be included, if known.
  - Use cautious judgment when leaving operations unattended: i) Post signs to communicate appropriate warnings and precautions, ii) Anticipate potential equipment and facility failures, and iii) Provide appropriate containment for accidental release of hazardous chemicals.
- ***Transporting:***
  - Use sealed, double-contained container when transporting nanomaterials inside or outside of the building.

Chemistry Standard Operating Procedure 14: Nanomaterials

4. ADMINISTRATIVE CONTROLS

The following elements are required:

1. Complete the UC Laboratory Safety Fundamentals (or approved equivalent) training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including any applicable laboratory-specific Laboratory Safety Plan(s), prior to receiving unescorted access to the laboratory;
3. Demonstrate competency to perform the procedures to the Principal Investigator (PI), Laboratory Supervisor, laboratory-specific Safety Officer, or trainer;
4. Be familiar with the location and content of any applicable Safety Data Sheets (SDSs) for the chemicals to be used (online SDSs can be accessed from UC SDS);
5. Implement good laboratory practices, including good workspace hygiene;
6. Inspect all equipment and experimental setups prior to use;
7. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of Prudent Practices in the Laboratory for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
8. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI or Laboratory Supervisor;
9. Notify the PI or Laboratory Supervisor of any accidents, incidents, near-misses, or upset condition (*e.g.*, unexpected rise or drop in temperature, color or phase change, evolution of gas) involving the process, hazardous chemical(s), or hazardous chemical class described in this SOP; and
10. Abide by the laboratory-specific working alone SOP, if applicable.

- Ensure that researchers have general safety training and lab-specific training relevant to the nanomaterials and associated hazardous chemicals used in the process/experiment.

- Lab-specific training includes a review of this SOP and the relevant Material Safety Data Sheets (SDS) (if available), when working with nanomaterial.

Material should be properly labeled and stored according to manufacturer specifications.

5. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, long pants (covered legs) and closed toe/closed heel shoes (covered feet) are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for all work with hazardous chemicals:

A. Eye Protection:
   i. At a minimum ANSI Z87.1-compliant safety glasses are necessary.
   ii. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.

iii. Ordinary prescription glasses will NOT provide adequate protection unless they also meet the Z87.1 standard and have compliant side shields.

B. Body Protection: At a minimum a chemically-compatible laboratory coat that fully extends to the wrist is necessary.
   i. If a risk of fire exists, a flame-resistant laboratory coat that is NFPA 2112-compliant should be worn.
   ii. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (*e.g.*, face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.

C. Hand Protection: When hand protection is needed for the activities described in this SOP define the type of glove to be used based on: A) the chemical(s) being used, B) the anticipated chemical contact (*e.g.*, incidental, immersion, etc.), C) the manufacturers' permeation/compatibility data, and D) whether a combination of different gloves is needed for any specific procedural step or task.

6. SPILL AND EMERGENCY PROCEDURES

Follow the guidance for chemical spill cleanup from SafetyNet #13 and/or the UC Davis Laboratory Safety Manual, unless specialized cleanup procedures are described below. Emergency procedure instructions for the UC Davis campus and UCD Medical Center are contained in the UC Davis Laboratory Safety Manual and the Emergency Response Guide (which must be posted in the laboratory). All other locations must describe detailed emergency procedure instructions below.

If a spill of nanomaterial occurs soak up the material with a paper towel and follow EH&S proper disposal technique.

Contact EH&S if any concerns or questions about disposal arises.

7. WASTE MANAGEMENT AND DECONTAMINATION

Hazardous waste must be managed according to Safety Net #8 using the appropriate label. In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date; refer to the timeline for waste disposal. Hazardous waste pick up requests must be completed online.

The nanomaterials are disposed of as solid waste or kept in aqueous suspension and denoted as such during waste removal.

Decontamination procedure would be to wash materials with soap and water. Bag paper towels used to clean the material and send out as solid waste exposed to nanoparticles and then describe the size and nanomaterial composition.

Upon completion of work with hazardous chemicals and/or decontamination of equipment, remove gloves and/or PPE to wash hands and arms with soap and water. Additionally, upon leaving a designated hazardous chemical work area remove all PPE worn and wash hands, forearms, face and neck as needed. Contaminated clothing or PPE should not be worn outside the lab. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE and disposable gloves must not be reused.

Chemistry Standard Operating Procedure 14: Nanomaterials

8. **DESIGNATED AREA**

   Work with nanoparticles in the fumehood, but can be used on the benchtop if kept in aqueous suspension performing experiments that would limit aresolization.

9. **DETAILED PROTOCOL**

   Nanoparticles experiments must be carried out in aqueous environment at no more than 1 mg/mL concentration of a total volume of 10 mL. General handling requires proper PPE stated above and wearing gloves. If any nanomaterial comes in contact with the researchers gloves, the gloves should be replaced with a new pair.

Additional Safety Resources: UC Davis Safety Net #132

Nanotechnology: Guidelines for Safe Research Practices

Introduction

This Safety Net provides environmental, health and safety information to researchers working with engineered nanoparticles, and should be incorporated as a standard operating procedure in each laboratory's chemical hygiene plan. Given the evolving knowledge base regarding health effects of nanoparticles, this fact sheet may be updated. Always check with EH&S (530-752-1493) for the latest information.

Nanoparticles are materials that have at least one dimension between 1-100 nanometers. Particles in this size range have always been present in Earth's air. Nanoparticles may be naturally occurring (such as in volcanic ash), produced as unintentional byproducts (such as in auto emissions) or intentionally created or "engineered." These very small particles often have properties radically different from those of larger particles of the same composition, making them of interest to researchers and of potential benefit to society. This Safety Net focuses on lab practices researchers should follow to protect themselves from the hazards of engineered nanoparticles.

Nanoparticles can be spheres, rods, tubes, and other geometric shapes or mixtures with various shapes. Any nanoparticle hazards may depend on shape. The small particles may be bound to surfaces or substrates, put into solution or suspension, attached to a polymer, or in a few cases handled as a dry powder. Various nanoparticles can be created in the laboratory under experimental procedures, and some can be purchased from commercial vendors. Often in research the amount of material used is small, generally less than a gram.

It is believed that some engineered nanoparticles may present health effects following exposure, based in part on air pollution studies that show smaller particles get deep into the lungs and can cause human illness. However, laboratory research commonly involves handling nanoparticles in liquid solutions or other forms that do not become easily airborne, and even free formed nanoparticles tend to agglomerate to a larger size. Materials that are comprised (in

part) of nanoparticles may be sources of airborne nanoparticles, for example, as a result of abrasion or cutting of the materials.

When research involves work with engineered nanoparticles for which toxicity is not yet known completely, it is prudent to assume the nanoparticles may be toxic, and to handle the nanoparticles using the laboratory safety techniques outlined below.

Potential Routes of Occupational Exposure to Researchers

There are four possible routes of workplace exposure to nanoparticles: inhalation, ingestion, skin absorption, and injection.

Skin absorption. In some cases nanoparticles have been shown to migrate through skin and be circulated in the body. If the particle is carcinogenic or allergenic, even tiny quantities may be biologically significant. Skin contact can occur during the handling of liquid suspensions of nanoparticles or dry powders or as a result of tranpsort of the nanoparticles through air. Skin absorption is much less likely when the nanoparticles are solid bound or matrixed. Researchers should use double nitrile gloves to protect themselves from skin absorption and contamination, as well as protect their research materials from being contaminated. Outer gloves should always be removed inside a fume hood or under the influence of a local exhaust ventilation system/device and placed into a sealed bag. This procedure will help prevent the particles from becoming airborne in the laboratory.

Ingestion. As with any material, ingestion can occur if good hygiene practices are not followed. Once ingested, some types of nanoparticles might be absorbed and transported within the body by the circulatory system. To prevent ingestion, eating, drinking and chewing of gum are not allowed in areas where hazardous materials are used or stored. Also, spills of nanoparticles should be quickly and properly cleaned up, as detailed below.

Inhalation. Respiratory absorption of airborne nanoparticles may occur through the mucosal lining of the trachea or bronchioles, or the alveolus of the lungs. Because of their tiny size, certain nanoparticles appear to penetrate deep into the lungs and may translocate to other organs following pathways that are not significant when particles are larger. Thus, whenever possible, nanoparticles are to be handled in a form that is not easily made airborne, such as in a solution, on a substrate, or inside an isolated environment.

Injection. Exposure by accidental injection (skin puncture) is also a potential route of exposure, especially when a person is working with animals or needles. To prevent this exposure, wear double nitrile gloves and a lab coat, and apply the standard practices for working with sharps.

Laboratory Safety Guidelines for Handling Engineered Nanoparticles

The current practices for working with engineered nanoparticles safely are essentially the same as one would use when working with any research chemical of unknown toxicity.

The current practices for working with engineered nanoparticles safely are essentially the same as one would use when working with any research chemical of unknown toxicity.

1. Use good general laboratory safety practices as stated in your chemical hygiene plan. Wear double gloves (preferably nitrile gloves), safety glasses or goggles, and

appropriate protective clothing. Place Tacki-Mat (or similar sticky walk-off mat) at the exit to reduce the likelihood of spreading nanoparticles.

2. All personnel participating in research involving nanoscale materials need to be briefed on the potential hazards of the research activity, as well as on proper techniques for handling nanoparticles. The contents of this Fact Sheet can serve as a useful component of this training. As with all safety training, written records need to be maintained to indicate who has been trained on this topic.
3. **Storage, consumption, and use of food, beverage, medicines, tobacco, chewing gum, and the application of cosmetics or handling of contact lenses are prohibited in areas where hazardous chemicals, including engineered nanoparticles, are used or stored.**
4. When purchasing commercially available nanoscale materials, be sure to obtain the Safety Data Sheet (SDS) and to review the information in the SDS with all persons who will be working with the material. Note, however, that given the lack of complete knowledge of toxicity of nanoparticles, the information on an SDS may be more applicable to the properties of the bulk material.
5. In some cases, the manufacture of nanomaterials involves the use of chemicals that are known to be hazardous or toxic. Be sure to consider the hazards of the precursor materials when evaluating the process hazard or final product. Users of any chemicals should make themselves familiar with the known chemical hazards by reading the SDS or other health hazard literature.
6. To minimize airborne release of engineered nanoparticles to the environment, nanoparticles are to be handled in solutions, or attached to substrates so that dry material is not released. When this is not possible, nanoscale materials should be handled with engineering controls such as a HEPA-filtered local capture hood or glove box. If neither is available, work should be performed inside a laboratory fume hood. HEPA-filtered local capture systems should be located as close to the possible source of nanoparticles as possible, and the installation must be properly engineered to maintain adequate ventilation capture.
7. Use fume exhaust hoods to expel any nanoparticles from tube furnaces or chemical reaction vessels. Do not exhaust aerosols containing engineered nanoparticles inside buildings.
8. If you must work outside of a ventilated area with nanomaterials that could become airborne, wear a respirator with NIOSH-approved filters that are rated as N-, R- or P-100 (HEPA). EH&S will work with researchers to provide the most appropriate type of respirator. Refer to the UC Davis Respiratory Protection Program for requirements.
9. Lab equipment and exhaust systems used with nanoscale materials should be wet wiped and HEPA vacuumed prior to repair, disposal, or reuse. Construction/maintenance crews should contact EH&S for assistance.

10. Spills of engineered nanoparticles are to be cleaned up immediately.
    - Personnel should wear double nitrile gloves and either vacuum up the area with a HEPA-filtered vacuum or wet wipe the area with towels, or both.
    - For spills that might result in airborne nanoparticles, proper respiratory protection should be worn (see item 8 above). For assistance with cleaning up any chemical spill contact EH&S.
    - Do not brush or sweep spilled/dried nanoparticles.
    - Place Tacki-Mat at the exit to reduce the likelihood of spreading nanoparticles.
11. Because many engineered nanoparticles are not visible to the naked eye, surface contamination may not be obvious. Work surfaces should be wet-wiped regularly – daily wiping is recommended. Alternatively, disposable bench paper can be used.
12. All waste engineered nanoparticles should be treated as chemical hazardous waste unless the waste determination shows it to be non-hazardous. Dispose and transport waste nanoparticles in solution according to the hazardous waste procedures for the solvent. Waste nanoparticles on a substrate or as a result of decomissioning equipment used with nanoparticles should also be treated as chemical hazardous waste. Wipers, bench paper, gloves, and other lab debris contaminated with nanoparticles should be disposed as hazardous waste. If you have questions on how to dispose a specific nanoparticle waste, call EH&S for more information.

For more information on Health and Safety of Nanotechnology visit the following web sites:

- NIOSH (http://www.cdc.gov/niosh/topics/nanotech/)
- National Nanotechnology Initiative (http://www.nano.gov/)
- EPA (http://www3.epa.gov/)
- Woodrow Wilson International Center for Scholars (http://nanotechproject.org/)
- Rice University (http://cnst.rice.edu/)

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