Chemical Hygiene Plan
ESB Building, Room 3314
Stemmer and York group sputter lab
Phone: x4829

Date: March 27, 2012
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Authorized researchers using the lab:

Signatures and date (confirming that they have read the plan):

Varistha Chobpattana (Stemmer group): _________________________________________
Evgeny Mikheev (Stemmer group): _____________________________________________
Christopher Freeze (Stemmer group): ___________________________________________
Brian Hoskins (Strukov group): _______________________________________________
Cedric Meyers (York Group): _________________________________________________
Eric Rappeport (Stemmer Group): _____________________________________________
Section I

1.1 Wet Chemicals in the Lab

List of Chemicals:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Quantity</th>
<th>Form</th>
<th>Use</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichloromethane</td>
<td>1 × 4 L</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Solvents Cabinet</td>
</tr>
<tr>
<td>Isopropyl Alcohol</td>
<td>1 × 4 L</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Solvents Cabinet</td>
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<tr>
<td>Methanol</td>
<td>3 × 4 L</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Solvents Cabinet</td>
</tr>
<tr>
<td>Acetone</td>
<td>1 × 4 L</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Solvents Cabinet</td>
</tr>
<tr>
<td>Acetic Acid Glacial</td>
<td>1 × 4 L</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Corrosives Cabinet</td>
</tr>
<tr>
<td>Zirconium Silicate</td>
<td>500 g</td>
<td>Solid</td>
<td>Cleaning</td>
<td>Corrosives Cabinet</td>
</tr>
<tr>
<td>Silver Powder</td>
<td>50 g</td>
<td>Solid</td>
<td></td>
<td>Corrosives Cabinet</td>
</tr>
<tr>
<td>H2O:Glacial Acetic Acid (5:1)</td>
<td>1 squeeze bottle</td>
<td>Liquid</td>
<td>Cleaning</td>
<td>Corrosives Cabinet</td>
</tr>
<tr>
<td>Permatite Acrylic Sealant</td>
<td>1 tube (305 ml)</td>
<td>Gel/liquid</td>
<td>Sealant</td>
<td>Solvents Cabinet</td>
</tr>
<tr>
<td>Hazardous Waste Container</td>
<td>1 × 4 L</td>
<td>Liquid</td>
<td>Waste</td>
<td>Solvents Cabinet</td>
</tr>
</tbody>
</table>

Read the documents at the end of this Section for handling these chemicals.

Dichloromethane (Methylene Chloride) is a known human carcinogen. Please note that hand protection from dichloromethane cannot be satisfactorily achieved by common types of lab gloves. The following gloves do offer sufficient protection: “Silver Shield”, Polyvinyl alcohol, Viton, or “Barrier” (available from vendors like Fisher Scientific). Given its volatility and low PEL (25 ppm), dichloromethane must always be used in a fume hood, glove box, or in sealed containers. Please read the fact sheet about Dichloromethane, which is also attached to this plan:


No other wet chemicals are allowed in this lab.
1.2 Forming Gas Annealing Furnace

Qualified users of the forming gas annealing furnace (no other users allowed):

- Varistha Chobpattana
- Evgeny Mikheev
- Brian Hoskins

Forming Gas Anneal Protocol

Forming gas: 5% H₂ 95% N₂

Read and follow the documents attached at the end of this section for proper handling of flammable gases.

Additional precautions:

- Wear a fire retardant lab coat.
- Only start flowing gas in when the furnace is cool.
- Turn on the forming gas before loading samples.
- Use plastic gloves inside heat-proved gloves when handling end cap of glass tube.
- Keep the forming gas flow when unloading.

Procedures

1. Check the fume hood following the fume hood usage guide. Always work with the sash at or below the level of the red arrow sticker.
2. Turn on the main switch of the furnace and check the temperature.
3. Only continue if the furnace is cool.
4. Turn on the forming gas by,
   a. Turn on the main cylinder valve
   b. Turn on the gauge valve
   c. Check the forming gas is not empty
   d. Adjust the flow meter to ~5 on the scale
   e. Wait for 5 min.
5. Remove furnace end cap.

6. Using plastic gloves, load samples on to the center of a glass carrier and use a glass rod to push to carrier to the center of the tube.

7. Replace the furnace end cap.

8. Adjust temperature controller of the furnace to the desire temperature. (The ramping rate is 10°C/min.)


10. After the time is done, adjust the temperature controller to the minimum (10°C).

11. Wait until the temperature read below 60°C.

12. Using heat-proved gloves, remove the end cap and pull the boat back from the center using the glass rod.

13. Replace the end cap and wait 5 min to allow wafers to cool down before they are exposed to air on removal from the furnace.

14. Remove the end cap and unload the carrier and the wafers.

15. Replace the carrier and the end cap.

16. Turn off the forming in the reverse order:
   a. Adjust the flow meter to 0 on the scale
   b. Turn off the gauge valve
   c. Turn off the main cylinder valve

17. Turn off the main switch of the furnace.

18. Record the use in the logbook.
1.3 Oxide Sputter System #1 (operated by Stemmer group)

Qualified users for Sputter System 1 (no other users allowed):

- Evgeny Mikheev
- Christopher Freeze

Read and follow the documents attached at the end of this section for safe operating procedures of vacuum systems.

Additional Guideline for Safe Operation:

- Use gloves when handling the sputter.
- Always check water leak before starting the growth.
- Never have both the exchange chamber door and the cryo gate valve opened at the same time. Doing this will increase the risk of having the cryo pump become oversaturated and the temperature of the pump to increase.
- If the pressure is too high in the main chamber and airlock then you will have to close the cryo gate valve switch and use the roughening pump to pump the main chamber and airlock. If the pressure is too high in the airlock compared to the chamber then you should pump the airlock to a lower pressure before opening the exchange chamber door and pumping both the main and airlock chambers. While pumping the chamber system, the cryo pump will hopefully begin to cool itself down. After the roughening pump reaches a low pressure (around 60 mTorr to as high as 80mTorr) then close the exchange chamber door and open the cryo gate valve switch.

Operating Procedures

Loading the sample

1. Airlock switch should be in the CLOSED position
2. OPEN the nitrogen valve to vent the airlock chamber. When the airlock door opens, immediately CLOSE the nitrogen valve.
3. Exchange samples in the airlock chamber.
4. CLOSE airlock door. (At this time, door will not be closed completely)
5. Turn ON the mechanical pump.
6. Move airlock switch to the OPEN position.
7. Pump down the airlock chamber to approximately 85 to 100 mTorr (8.5 × 10^{-2} Torr on the pressure gauge) ***May have to open and close the nitrogen valve to the airlock chamber to get the chamber to pump down.

8. Turn the airlock switch to the CLOSED position

9. Turn OFF the mechanical pump

10. Turn cryo switch to the CLOSED position to close the cryo gate valve. (should hear a click)

11. Turn off the chamber high gauge.

12. Place shutter in front of the gun (Currently, we don’t have gun shutter)

13. Open exchange chamber door and move sample into the chamber carefully.


15. Raise heater to the sample height, turn stage to remove sample from rod holder, and remove bar.

16. Close the exchange chamber door

17. Lower the sample height to the green line.

18. Turn the cryo switch to the OPEN position

19. Turn ON chamber high gauge and allow pressure to reach at least 10^{-8} Torr(WAIT)

**Sputtering**

20. Turn OFF chamber high gauge

21. COVER sample with shutter and START sample rotation (make sure that sample is close enough to the bottom of the shutter BUT that it does not touch the shutter or else sample holder will get flung off the heater)

22. Set heating rate and temperature on the heater controller system. May have to increase the min and max output knobs to obtain temperature above 700°C (Try not to have heater exceed 11 DC amps on controller) (WAIT about 1 hour)

23. When near to set temperature, BEGIN pre-sputtering process.

24. Turn cryo switch to the MANUAL position.

25. OPEN the 3 gas valves (First, Valve into the main chamber. Next, Ar and O_2 valve. Make sure valves to N_2 controller and small chamber are closed. Ar, O_2 valve should be open slowly while check pressure)

26. Turn ON gas flow and heater controller systems
27. Set the gas flow to the desired values. (i.e. an 80/20 Ar/O₂ gas flow mixture requires setting Ar to 40 and O₂ to 10 in the gas controller) This flow value does not have to be changed. Press Select, Ch1(or Ch2 for O₂), Set, Enter, Start.

28. Set pressure in chamber low gauge to desired value (2.5×10⁻²) by using the manual crank on the cryo pump. (Rotate screw in manual cryo. Make sure the cryo safety lock is in place.)

29. If we have gun shutter, OPEN shutter covering plasma gun.

30. Turn ON plasma controller (main switch in back, 2 switches on front of controller)

31. CHECK that RF set point is at 15. If not, keep pressing setpoint and raise setpoint up to 15.

32. RF power ON. Presputter starts at this point for 10 min.

33. SLOWLY raise plasma power to desired level (150) using knob. (Usually pre-sputter for between 5 and 10 minutes)

34. AFTER pre sputtering, lower heater to level one (1) position.

35. MOVE shutter away from sample and BEGIN sputter time simultaneously.

**Stopping the growth**

36. Turn RF power off (can turn off the power to the RF controllers after you turn off the plasma). Turn left power knob all the way.

37. Lower min output on heater up to 0.

38. Lower heater temperature to 20°C

39. When temperature is below 100°C, turn off the argon and oxygen gas flow and close the Ar, O₂, and main chamber gas valves.

40. When temperature reaches 20°C turn off heater and gas flow controllers. (Typically, if temperature is below 100°C, it is fine to remove sample)

41. If we have gun shutter, move shutter in front of gun.

42. Remove the safety lock from the cryo pump and move switch to the CLOSED position.

43. OPEN exchange chamber door.

44. Insert rod for sample removal.

45. Position sample for removal. (Carefully turn stage to get sample substrate fitted in rod)

46. Lower heater and remove sample from main chamber.

47. CLOSE exchange chamber door.
48. Move the cryo switch to the OPEN position.

49. Turn ON the high pressure gauge.
1.4 RF/DC Sputter System #3 (operated by Stemmer group)

Qualified users for Sputter System 3 (no other users allowed):

- Evgeny Mikheev
- Christopher Freeze
- Cedric Meyers

Read and follow the documents attached at the end of this section for safe operating procedures of vacuum systems.

Additional Guideline for Safe Operation:

- Use gloves when handling the sputter.
- Always check water leak before starting the growth.
- Never have both the exchange chamber door and the cryo gate valve opened at the same time. Doing this will increase the risk of having the cryo pump become oversaturated and the temperature of the pump to increase.
- If the pressure is too high in the main chamber and airlock then you will have to close the cryo gate valve switch and use the roughening pump to pump the main chamber and airlock. If the pressure is too high in the airlock compared to the chamber then you should pump the airlock to a lower pressure before opening the exchange chamber door and pumping both the main and airlock chambers. While pumping the chamber system, the cryo pump will hopefully begin to cool itself down. After the roughening pump reaches a low pressure (around 60 mTorr to as high as 80mTorr) then close the exchange chamber door and open the cryo gate valve switch.

Procedures

Loading the sample

1. Vent the loading lock using the N₂ gas valve (open valve slowly)
2. Open the loading lock door
3. Take out sample holder and Place sample on sample holder and Put sample holder on fork
4. Close the loading lock
5. Pump down the loading lock: a) Turn on mechanical pump b) Open the handle valve c) Open the knob valve slowly
6. Allow pressure to reach < 75 mTorr \((7.5 \times 10^{-2})\) on the pressure gauge

7. Close knob valve and handle valve and Turn off mechanical pump

8. Purge vacuum line by opening and the closing value

9. Close cryo gate valve and Turn off high vacuum ion gauge

10. Open gate valve separating the loading lock from the chamber slowly

11. Move the fork with sample into the chamber and position the sample holder into the designated area on the rotation stage

12. Raise the rotation stage and Remove the fork. Check for levelness of the sample holder on the rotation stage

13. Completely Remove the fork

14. Close the gate valve separating the loading lock and chamber

15. Raise the heater to the bottom of the rotation stage all the way (will automatically stop)

16. Set the height of the substrate upto ‘-‘ mark

17. Close the shutter of the substrate

18. Check to make sure pressure in the chamber is < 75 mTorr (if so, proceed to next step)

19. Open the gate valve to the cryo pump slowly and turn on high vacuum ion gauge

20. Allow base pressure in system to reach < 5 \times 10^{-8} \text{Torr} before beginning a growth

**Sputtering**

21. Raise heater temperature using LabView program to set the temperature and ramp rate

22. Turn on heater rotation to 30 rpm by turning the knob on the heater controller’s panel slowly and wait for the set temperature

23. Before opening gas valves, you should close the cryo gate valve more than half way depending on the gas pressure.

24. Open Ar (or O\(_2\)) gas valve and Turn on Ar (or O\(_2\)) gas switch on gas controller

25. Slowly open or close the cryo gate valve and set the pressure to the desired valve.

26. Turn on the controllers to the gun. If RF sputtering, slowly ramp the plasma power to the desired level by increasing watt. If DC sputtering, the controller automatically ramps to desired level. (Pt: set point control: 30, power on and output on and then wait)

27. Presputtering for the desired time

28. Remove the shutter from over the sample
29. Begin timing the growth

**Stopping the growth**

30. When time is up, Turn off the plasma
31. Close the shutter
32. Lower the heater temperature to 20 °C by hitting arrow in LabView program
33. Allow temperature to cool to < 100 °C before removing the sample
34. Turn off 1) gas switches and 2) valves
35. Close the cryo gate valve
36. Turn off rotation
37. Lower the heater
38. Open the gate valve separating the loading lock and chamber slowly.
39. Move the fork in and align with the rotation stage.
40. Lower the rotation stage when the fork and stage are properly aligned.
41. Move the fork out
42. Close the gate valve between chamber and loading lock
43. Check the pressure in the system and make sure it is < 75 mTorr before Opening the cryo gate valve.
44. Vent the loading lock slowly.
1.5 BST Sputter System #2 (operated by York Group)

Qualified users for Sputter System 2 (no other users allowed):

- Christopher Freeze

Read and follow the documents attached at the end of this section for safe operating procedures of vacuum systems.

A.1 Sample loading

1. Open load lock door
2. Flow nitrogen through the load lock.
3. Take sample holder out.
4. Place sample on holder and mount it in place using given clips.
5. Place sample holder back into load lock.
6. Turn off flow of nitrogen.
7. Close load lock door.
8. Pump down load lock to less than 100 mTorr.
   a. Turn on roughing pump.
   b. Open valve between roughing pump and load lock.
   c. Pump down to less than 100 mTorr.
   d. Close valve between roughing pump and load lock.
   e. Turn off roughing pump.
9. Lower heater stage in sputter chamber.
10. Close the gate valve between the cryo-pump and the chamber.
11. Open the valve between the load lock and chamber gently and slowly.
12. Gently slide transfer arm to move the sample holder into the chamber and over the heater.
13. Slowly raise the heater until the sample holder is resting on the heater and align the locking taps on the heater stage with the grooves in the bottom of the sample holder.
14. Slowly rotate the heater in the clockwise direction to unlock and disengage the sample holder from the loading arm.

15. Slide the transfer arm back into the load lock.

16. Close the gate valve between the load lock and the chamber.

17. Adjust the heater height to the desired deposition height.

18. Open the gate valve between the Cryo-pump and the chamber gently and slowly.

A.2 BST or STO Deposition

1. Wait for the chamber to reach the desired base pressure (\(< 5 \times 10^{-8}\)).

2. Turn on the sample rotation and set to 10 rpm.

3. Turn on heater and set temperature ramp rate to 10°C.

4. Set the desired temperature.

5. When the heater temperature display reaches 100°C start gas flow.
   a. Check the gas flow setting on the mass flow controller (argon is the sputtering gas and oxygen is needed for oxides) 80 sccm for argon and 20 sccm for oxygen.
   b. Almost close the gate valve between the chamber and the cryo-pump
   c. Turn on the argon gas flow from the mass flow controller.
   d. Open the argon gas valve.
   e. Using the gate valve adjust the pressure to ~ 20 mTorr.
   f. Turn on the oxygen gas flow from the mass flow controller.
   g. Open the oxygen gas valve.

6. Adjust the chamber pressure to the desired value.

7. Make sure the shutter is over the sample.

8. Make sure the cooling water is turned on for the sputtering guns and the chamber.

9. Turn on the tuner to the sputtering guns (Make sure they are set to auto).

10. Turn on the controller for the sputtering gun.

11. Slowly ramp up the sputtering gun power to 20W.

12. Check the chamber to make sure the plasma is on (wear UV goggles).
13. Slowly ramp up the power to the sputtering gun to 150W (over 10 min: if everything is timed right you should reach the desired power when the heater reaches the set temperature).

14. Open the shutter and start the deposition timer.

15. Keep an eye on the chamber pressure and adjust it accordingly.

16. Log the deposition conditions.

17. When the timer goes off close shutter.

18. Slowly ramp the power down for the sputtering guns.

19. Turn off the sputtering gun controller

20. Turn off the sputtering gun tuner.

21. Set the desired heater ramp down rate, if different from the ramp up rate.

22. Set the heater temperature to 200°C.

23. When the heater temperature reaches 200°C turn off the gases.
   a. Close the argon and oxygen gas flow valves.
   b. Turn off the argon and oxygen flow from the mass flow controller.

24. Turn off the heater rotation.

25. Turn off the heater temperature controller.

A.3 Unloading the sample

1. Make sure the heater rotation stage is off.

2. Lower heater stage.

3. Close the gate valve between the cryo-pump and the chamber.

4. Pump down the load lock to less than 100 mTorr.

5. Open the gate valve between the load lock and the chamber.

6. Slide the transfer arm into the chamber.

7. Adjust the heater stage height to match the transfer arm.

8. Rotate the heater stage to engage the sample holder with the transfer arm.

9. Lower the heater stage.

10. Gently move the transfer arm back out of the chamber.
11. Close the gate valve between the load lock and the chamber.
12. Open the door to the load lock.
13. Turn on the nitrogen flow to the load lock.
14. Take the sample holder out of the load lock.
15. Remove sample.
16. Return the sample holder into the load lock.
17. Turn off the nitrogen gas.
18. Close the door to the load lock.
19. Pump down the load lock to less than 100 mTorr.

Chamber #2: Changing sputtering target procedure

A.1 Venting the sputter chamber

19. Pump down load lock to less than 100 mTorr.
a. Turn on roughing pump.
b. Open valve between roughing pump and load lock.
c. Pump down to less than 100 mTorr.
d. Close valve between roughing pump and load lock.
e. Turn off roughing pump.
20. Close the gate valve between the cryo-pump and the chamber.
21. Open the valve between the load lock and chamber gently and slowly.
22. Turn on the nitrogen flow to the load lock.
23. Wait for the load lock and chamber to reach atmospheric pressure (760 Torr).
24. Turn off the nitrogen flow.

A.2 Removing the sputtering gun & old target

26. Wait for the chamber to reach the desired base pressure (760 Torr).
27. Disconnect RF cable from sputtering gun.
28. Turn off cooling water and disconnect water lines.
29. Unscrew the nuts and bolts of the desired sputtering gun.
30. Turn on the nitrogen flow.
31. Carefully remove the sputtering gun from the chamber.
32. Place sputtering gun on sputtering gun holder.
33. Carefully remove old sputtering target from sputtering gun.
34. Clean the sputtering gun with isopropanol.

A.3 Installing new target and sputtering gun

20. Remove new target from plastic bag.
21. Apply thermal grease to the target and the sputtering gun.
22. Carefully mount the target to the sputtering gun.
23. Place a new copper gasket at the chamber port where the sputtering gun will be installed.
24. Carefully insert the sputtering gun into the chamber port.
25. Once the sputtering gun makes contact with the copper gasket insert bolts and hand tighten the nuts.
26. Tighten nuts and bolts using the appropriate tools.
27. Connect water lines and turn on cooling water (check for leaks).
28. Connect RF cable.
25. Pump down load lock and sputter chamber to less than 100 mTorr.
   a. Turn on roughing pump.
   b. Open valve between roughing pump and load lock.
   c. Pump down to less than 100 mTorr.
   d. Close gate valve between sputter chamber and load lock.
   e. Open gate valve between cryo-pump and sputter chamber.
   f. Close valve between roughing pump and load lock.
   g. Turn off roughing pump.

Chamber #2: Cryo-pump Regeneration Procedure

A.1 Onboard cryo-pump regeneration
Cryo-pump regeneration should be done if the system base pressure is above normal, cryo-pump temperature >20K, or the system is off due to power outage.

1. Close the gate valve between cryo-pump and chamber.
2. Turn on the roughing pump.
3. Open the UHP N₂ purge valve connected to the cryo-pump 1/6 to 1/4 of turn. Opening the valve more than this, wastes UHP N₂.
4. At the UHP N₂ cylinder open the regulator valve 3 full turns.
5. If necessary, adjust the pressure to be between 60 and 80 PSI,
6. Open the black valve one full turn.
7. At the cryo-pump control panel start the regeneration by pressing “Regen”, then “1” to start, and “2” to confirm the start.
8. The cryo-pump will warm up to 310K while purging. Once the cryo-pump reaches 310K, it will purge for 5 min and then rough out to 100 mTorr and begin a series of rate of rise tests (ROR).
9. A set number of ROR tests are performed, when the cryo-pump passes the tests it will begin to cool down
10. Turn off the UHP N₂ valve at the cryo-pump, the UHP N₂ cylinder regulator valve and the black valve.
11. When the cryo-pump reaches its normal operating temperature (≤ 11K), the gate valve between the cryo-pump and the chamber can be opened (make sure the base pressure is below 100 mTorr before opening the gate valve).
1.6 Heat Exchanger Cooling Water Filter

Water filter should be replaced once every two months.

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ACIDS (Non-oxidizing)
STANDARD OPERATING PROCEDURE TEMPLATE

Type of SOP:  □ Process  □ Hazardous Chemical  ◐ Hazard Class

1. HAZARD OVERVIEW

Acids are corrosive to eyes, skin, and mucous membrane and are generally immediately painful. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, in the case of ingestion, in the gastrointestinal tract as well. The international symbol (GHS system) for a corrosive to skin/eyes (acid or base) is:

The pH range of acids is 0 to 6.9 (water = 7.0 = neutral). A pH of approximately 0 to 3 represents a strong acid. Some inorganic acids fall within this range. Weak acids (pH of 3 to 7) include dilute acetic acid solutions and boric acid. Weak acids irritate the skin with short contact and can cause burns with prolonged contact.

Heat is released when strong acids are mixed with water. When water is added to acid, an extremely concentrated solution of acid is initially formed and the solution may boil very violently, splashing concentrated acid. When acid is added to water, the solution formed is dilute and the small amount of heat released is not significant to vaporize and spatter it. Always add acid to water, and never the reverse. Aqueous solutions of inorganic acids are not in themselves flammable. Acids also react with many metals, resulting in the liberation of hydrogen, a highly flammable gas.

Some acids like nitric and perchloric are strong oxidizing agents and can react destructively and violently when in contact with organic solvents and organic acids like acetic. Due to the unique and highly reactive nature of oxidizing acids, there are separate UCSB SOP templates for nitric and perchloric acids that labs should adopt. Numerous accidents have occurred on campus via the mishandling of nitric acid. There is also a separate SOP for hydrofluoric acid given its unique hazards.

2. HAZARDOUS NON-OXIDIZING ACIDS

All acid solutions are considered hazardous. The following is a list of the common non-oxidizing acids used: hydrobromic acid; hydrochloric; hydrofluoric; acetic; benzoic; chloroacetic; formic; phosphoric; sulfuric; trifluoroacetic

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Given the severe and immediate effects of acids on the eyes and skin, it is essential that proper PPE always be employed. This is the law and UC policy.
See the PPE information under Sec. II of the *UCSB Chemical Hygiene Plan* regarding:
- the UC PPE Policy and policy summary (what a PPE is needed and when/where to use)
- obtaining your PPE via use of the *Laboratory Hazard Assessment Tool*
- glove selection criteria
- respirator use, etc.

4. ENGINEERING/VENTILATION CONTROLS

In general, acids should always be used in a properly functioning fume hood.

For further information see these pages in Sec. II of the UCSB Chemical Hygiene Plan:
- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Acids can be only used in areas properly equipped with a certified eye wash/safety shower that can be reached within ten seconds. It is essential that all strong corrosives be stored separately from other laboratory chemicals with which they may react. Ensure secondary containment and segregation of incompatible chemicals. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.

The corrosive properties of these materials and their ability to produce fires or explosions by combination with combustible materials make the following considerations mandatory in the selection of a storage site:
- A relatively cool, dry environment free from extremes of temperature--humidity should be maintained.
- Acids must be stored in a manner that separates them from other materials
- Stored acids in material that is acid-resistant; this facilitates flushing and other cleanup procedures in the event of leaks or spills.
- Store on low shelves or in acid/base storage cabinets.
- **Segregate oxidizing acids from organic acids, and flammable and combustible liquids. This is crucial to avoid fires/explosions!**
- Segregate acids from active metals such as sodium, potassium, magnesium, etc.
- Use bottle carriers for transporting materials when possible.
• When mixing acids and water, always add acid to water. **NEVER add water to acid!**

• Store mineral acids together, separate from oxidizing agents and organic materials.

• Store acetic acid and other organic acids with the combustible organic liquids.

6. **SPILL AND INCIDENT PROCEDURES**

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the UCSB Emergency Information Flipchart – should already be posted in all labs.

7. **DECONTAMINATION**

Wear proper PPE, decontaminate equipment and bench tops using sodium bicarbonate and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. **WASTE DISPOSAL**

See “Chemical Waste Disposal” in Sec. II of the UCSB Chemical Hygiene Plan.
9. PRIOR APPROVAL/REVIEW
Before using any non-oxidizing acids, proper training and approval is required from the lab safety coordinator.

10. DESIGNATED USE AREA
Acids must be used in the fume hood.

11. SAFETY DATA SHEETS
Found online at: http://ehs.ucsb.edu/labsafety/msds

12. LAB-SPECIFIC INFORMATION (required) (Examples of appropriate content)
Acids are used in experimental processes at a scale within the range of 1 mL to 500 mL. Acid use should be conducted at room temperature and atmospheric pressure. Due to their fuming nature, they are generally handled in a fume hood or other ventilated area, however diluted quantities may be handled carefully in the general lab areas. Remember, the clean hood in the middle of the lab is NOT A FUME HOOD and does not protect the user from dangerous fumes.

When creating dilute aqueous solutions, always add acid to water. NEVER add water to acid, as this creates a risk of splattering concentrated acid due to the heat of solvation.

When neutralizing acids, cool the reaction flask with an ice/water bath and add the neutralizing agent (base) slowly while stirring. Avoid allowing heat buildup in the reaction vessel as this can lead to splattering.

Eye protection must be worn at all times: safety glasses for small quantities, splash goggles for quantities of 500 mL or greater. Disposable nitrile gloves are adequate to protect from risk of incidental contact, such as when handling milliliter quantities, but more resistant butyl or viton gloves should be used when handling or transferring volumes 500 mL or larger. A standard lab coat is required when handling acids, but a flame resistant lab coat should be used if handling acids in conjunction with flammable materials.
FLAMMABLE and COMBUSTIBLE LIQUIDS
STANDARD OPERATING PROCEDURE TEMPLATE

(See also these related UCSB SOPs: “Solvent Use: Extractions, Distillations & Still Quenching” and “Peroxide-Forming Chemicals”)

Type of SOP: □ Process □ Hazardous Chemical □ Hazard Class

1. HAZARD OVERVIEW

Flammable and combustible organic solvents are amongst the most dangerous chemicals in the lab. A measure of how ignitable a particular solvent is the flashpoint; defined as the lowest temperature at which a material can form an ignitable mixture with air and produce a flame when a source of ignition is present. The lower the flashpoint, the more easily the liquid can be ignited. Most common organic solvents in the lab are readily ignited, with the exception of chlorinated solvents like dichloromethane which require more extreme conditions to burn.

Flammable liquids (flash point < 100°F) are divided into three classes:

<table>
<thead>
<tr>
<th>Class</th>
<th>Flash Point</th>
<th>Boiling Point</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Below 73°F</td>
<td>Below 100 °F</td>
<td>Ethyl Ether</td>
</tr>
<tr>
<td>IB</td>
<td>Below 73 °F</td>
<td>At or above 100 °F</td>
<td>Acetone, Benzene, Toluene</td>
</tr>
<tr>
<td>IC</td>
<td>At or above 73°F and below 100°F</td>
<td></td>
<td>Isopropanol, Xylene</td>
</tr>
</tbody>
</table>

Combustible liquids (flash point > 100°F) are divided into three classes:

<table>
<thead>
<tr>
<th>Class</th>
<th>Flash Point</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>100-139 °F</td>
<td>Acetic acid, cyclohexane, and mineral spirits</td>
</tr>
<tr>
<td>IIIA</td>
<td>140-199 °F</td>
<td>Cyclohexanol, formic acid and nitrobenzene</td>
</tr>
<tr>
<td>IIIB</td>
<td>200 °F or above</td>
<td>Formalin and vegetable oil</td>
</tr>
</tbody>
</table>

A particular organic solvent may have other hazards beyond their flammability. For example, benzene is recognized carcinogen. Check the Safety Data Sheet for the particular solvents in use.
The international symbol \(\text{(Globally Harmonized System)}\) for a flammable liquids/gases/solids is:

![Globally Harmonized System](image)

Diethyl ether initiated fire

2. PERSONAL PROTECTIVE EQUIPMENT (PPE)

See the PPE information under Sec. II of the UCSB Chemical Hygiene Plan regarding:
- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your PPE via use of the Laboratory Hazard Assessment Tool (LHAT)
- glove selection criteria
- respirator use, etc.

In general, workers who use flammable liquids will be issued a free fire-resistant Nomex lab coat via the LHAT process.

3. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow indicator should be checked to be operating correctly prior to using the hood. For further information see the following pages in Sec. II of the UCSB Chemical Hygiene Plan:

- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls

- Safety Shielding: Shielding is required any time there is a significant risk of explosion, splash hazard or a highly exothermic reaction. All manipulations of
flammable liquids which pose this risk should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.

- **Special Ventilation**: Manipulation of flammable liquids outside of a fume hood may require special ventilation controls in order to minimize exposure and reduce the fire risk. Fume hoods provide the best protection against exposure to flammable liquids in the laboratory and are the preferred ventilation control device. If your research does not permit the handling of large quantities of flammable liquids in your fume hood, contact EH&S to review the adequacy of all special ventilation.

### 4. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Use in an area that is properly equipped with a certified eye wash and safety shower that is available within ten seconds of travel.

Store in a tightly closed, labeled container and in a cool, dry, well-ventilated area. Segregate from incompatible materials. Repackaged chemicals must be labeled clearly. For example, squirt bottles and acid/base cleaning baths. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

- **Flammable Liquid Storage Cabinets**
  - One or more Flammable Liquid Storage Cabinets (FLSC) are required by CA Fire Code for laboratories which store, use or handle more than 10 gallons of flammable or combustible liquids.
  - Containers of flammable liquids that are one gallon and larger must be stored in a flammable-liquids storage cabinet.
  - The storage of flammable and combustible liquids in a laboratory, shop, or building area must be kept to the minimum needed for research and/or operations. FLSC are not intended for the storage of highly toxic materials, acids, bases, compressed gases, or pyrophoric chemicals.
  - In most UCSB laboratories, flammable liquids storage is provided under the chemical fume hood. These cabinets are clearly marked “Flammable Storage” and are often ventilated via a stainless steel hose into the fume hood exhaust duct. Flammable liquids storage cabinets are constructed to limit the internal temperature when exposed to fire. When additional storage is needed, NFPA-approved FLSC may be purchased. All containers of flammable liquids must be stored in a FLSC when not in use. The following requirements apply:

  **General Requirements**
  - Cabinets shall be marked “Flammable - Keep Fire Away”
  - Cabinets should be kept in good condition. Doors that do not close and latch must be repaired or the cabinet must be replaced.
  - Flammable liquids storage cabinets are equipped with a grounding system
that can be connected to a building ground. If you are pouring from a container in the storage cabinet and if the container being poured into is conductive then a bonding strap must be attached between them as explained in PROCEDURES TO AVOID STATIC ELECTRICITY.

FLSC involved in fire

- **Transferring/Dispensing**

**STATIC ELECTRICITY HAZARDS IN THE LABORATORY**

The flow of flammable and combustible liquids can cause the buildup of static electricity. When enough of a charge is built up a spark can result and potentially cause a fire or explosion. The likelihood of this happening is dependent upon how well the liquid conducts electricity, the flash point, and the capacity to generate static electricity.

**Static electricity can be generated when liquid is transferred from one metal container to another.** Liquids have the ability to generate static electricity when they move in contact with other materials during pouring, pumping, or agitating. The buildup of this static electricity can cause a spark to form where the solvent exits the container. This could result in a fire or explosion.

**PROCEDURES TO AVOID STATIC ELECTRICITY**

To avoid the buildup of static electricity that may cause a spark, it is important to bond and ground metal containers, particularly for larger quantities, e.g. 55 or 5 gal. drums. **Bonding** eliminates the electrical potential between two containers, therefore eliminating the likelihood of sparks. A bonding wire is connected to two conductive objects as seen in the drums pictured below.
Bonding wires between drums

**Grounding** eliminates the difference in static potential charge between the conductive object and ground. Grounding is accomplished by connecting the conductive object directly to the earth, usually using cold water copper pipes, building steel, or a grounding bus/bar.

Bonding and grounding require good electrical connections. Remove any dirt, paint or rust, ensuring **metal to metal** contact.
Bonding and Grounding wires come in a variety of styles/lengths. They can be purchased through Fisher Scientific; Justrite Manufacturing; and through Lab Safety Supply:

Hand Clamp

‘C’ Clamp and Alligator Clip

Static hazards may also exist in non-metallic plastic or glass containers that cannot be grounded. Static may be generated by the free fall and turbulence of the liquid being poured. To minimize this hazard, pour as slowly as possible and use a grounded nozzle extension that allows filling the container from the bottom.

DISPENSING FLAMMABLE LIQUIDS FROM 5 GALLON PAILS

Manual dispensing pumps for 5-gallon pails/cans are available. These pumps are specifically designed to dispense liquids into small laboratory-size bottles without spilling. If you are pouring into a conductive container, a bonding wire should be attached from the 5-gallon pail to the container being filled. The 5-gallon pail should be grounded.
The dispenser shown in the picture below can be purchased through Fisher Scientific. The metal strap in the picture hooks over the bottom of the pail and secures the dispenser while pumping.

![Metal Strap](image)

Two adapters are provided with the dispensing pump from Fisher (grey and black). Use the appropriate adapter to achieve the correct seal with the solvent container you have. Some solvent containers have a grey fitting at the opening, and others have a black one.

**DISPENSING FLAMMABLES FROM SAFETY CANS**

Safety cans have self-closing air tight lids and a flame arrestor that protects the contents from an external ignition source. Bonding and grounding is still required on safety cans since static electricity generation is possible. The nozzle provides a bonding path to a receiving metallic vessel.
If either of the containers is non-metallic (non-conductive) it is still important to follow the limited velocity and grounded nozzle extension information given previously.

Safety cans do not offer protection from heat when exposed to fire and should be stored in a flammable liquids storage cabinet when not in use.

- **Labeling**
  - All flammable liquids must be clearly labeled with the correct chemical name.
  - Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable.
  - The label on any containers of flammable liquids should say “Flammable” and should include any other hazard information, such as “Corrosive” or “Toxic”, as applicable. Example: lab squirt bottles, or acid/base baths.

- **Heating/Open flame**
  - Do not permanently store flammable liquids in chemical fume hoods or allow containers of flammable liquids in proximity to heating mantles, hot plates, or torches.
With the exception of vacuum drying ovens, laboratory ovens rarely have any means of preventing the discharge of material volatilized within them. Thus it should be assumed that these substances will escape into the laboratory atmosphere, but may also be present in sufficient concentration to form explosive mixtures within the oven itself. Venting the oven to an exhausted system will reduce this hazard.

Drying ovens should not be used to dry glassware that has been rinsed with organic solvents until all of the solvent has had the opportunity to drain or evaporate at room temperature.

5. SPILL AND INCIDENT PROCEDURES

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the UCSB Emergency Information Flipchart – should already be posted in all labs.

For those that routinely use flammable liquids, it is strongly recommended that they attend the live version of the EH&S Fundamentals of Laboratory Safety class, where hands-on fire extinguisher training is conducted. All campus labs should have a fire extinguisher already on-site, generally near the exit door.

6. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using [soap and water]. Dispose of all used contaminated disposables as hazardous waste per below.

7. WASTE DISPOSAL

See “Chemical Waste Disposal” in Sec. II of the UCSB Chemical Hygiene Plan.

8. PRIOR APPROVAL/REVIEW REQUIRED

For small quantities of flammable materials under atmospheric pressure and at room temperature, no prior approval is required. Any other use requires review from the PI or lab safety manager.
9. **DESIGNATED AREA**

Work should be completed in a laboratory fume hood given the volatility and flammability of most solvents.

10. **SAFETY DATA SHEETS and OTHER REFERENCES**

Online SDS can be found at: [http://ehs.ucsb.edu/labsafety/msds](http://ehs.ucsb.edu/labsafety/msds)


11. **LAB-SPECIFIC INFORMATION (required) (Examples of appropriate content)**

These materials should be used in relatively small quantities (less than 500 mL) at room temperature under atmospheric pressure, such as in the dispensing bottles. For each of these bottles, only the chemical shown on the printed should be used in the bottle. Do NOT fill a bottle with another chemical and make a separate label. After use, these chemicals should be disposed of in the proper waste bottles immediately.
Gases Under Pressure (Excluding toxic and highly toxic gases)

Standard Operating Procedure Template

Type of SOP:  [ ] Process  |  [ ] Hazardous Chemical  |  X Hazardous Class

Purpose

The purpose of this standard operating procedure is to acquaint you with the proper and safe handling, use, storage and disposal of compressed gases. However, the following gases are excluded from this SOP:

- those that considered toxic, or highly toxic

The common toxic and highly toxic gases are listed in APPENDIX A. Given their high hazard and special regulations that apply to their use, these materials should have their OWN GAS-SPECIFIC SOP, rather than this generic gas SOP. Contact EH&S for assistance. In some cases, the volume or concentration of toxic/highly toxic gas may allow less rigorous control measures.

So, this SOP would typically apply to inert gases like nitrogen, argon and helium, flammable gases like hydrogen, methane, propane, plus oxygen (oxidizer; fluorine and chlorine are also strong oxidizers, but because of their high toxicity should have their own SOP).
Properties & Hazards

Chemicals in this category present hazards based on one, or more of these characteristics:

- the pressurized nature of their storage and use
- flammability
- oxidizing ability
- high toxicity (as stated above these do not fall under this SOP, but should be addressed separately given their extreme hazard)

All chemicals in this band are considered generally hazardous and the band is general

- gases which are contained in a receptacle at a pressure of 29 p.s.i. (200 kPa) or more at 20 °C
- gases which are liquefied or liquefied and refrigerated

The [Globally Harmonized System of Chemical Classification](https://ghs.chemicals.gov/) symbol and hazard codes for compressed gases are:

![H280: compressed, liquefied, or dissolved gas](https://ghs.chemicals.gov/assets/images/hazards/H280.gif)

Controls

Basic pressurized gas control measures are noted here. For further information, see Sec. 7D of [Prudent Practices in the Laboratory](https://www.nap.edu/read/13384/chapter/6) by the National Research Council. Gas vendors are another good source of information on gas equipment and handling.

**A. Administrative Controls**
General practices:

1. Be sure to review the Safety Data Sheet (SDS) for all chemicals to be used in the experiment.

2. Avoid working alone. At least one other person must be present in the same laboratory when any work involving hazardous chemicals is being done.

3. Eliminate or substitute for a less hazardous material when possible.

4. Design your experiment to use the least amount of material possible to achieve the desired result.

5. Verify your experimental set-up and procedure prior to use. Be familiar with the Safety Data Sheets for all chemicals in use. Assess the hazards to ensure that appropriate controls are in place to minimize risk and address emergency shutdown procedures as appropriate.

6. Consult with the PI if the work involves procedure scale-up or other large quantities or there are any questions regarding appropriate safety procedures.

B. Engineering Controls

1. In general, it is preferable to perform all work with hazardous chemicals in a fume hood. Sash height should be kept as low as possible to avoid the escape of vapors, gases and particulates.

2. Supplemental equipment such as blast shields should be used when working with chemicals or processes that may result in explosions or pressure releases.

3. Consider the use of a glove box, toxic gas cabinet or other local exhaust in order to further contain hazards as appropriate. Gas cabinets may be required for some toxic gas applications.

For further information on engineering controls see the following pages in Sec. II of the Chemical Hygiene Plan:

- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls
C. Personal Protective Equipment (PPE)

See the PPE information under Sec. II of the UCSB chemical Hygiene Plan regarding:
- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your free PPE via use of the Laboratory Hazard Assessment Tool
- glove selection criteria
- respirator use, etc.

Special Handling & Storage Requirements

Hazard-specific practices:

Storage Areas

1. Store full and empty cylinders separately to avoid confusion. Serious back flow can occur when an empty cylinder is attached to a pressurized system.

2. Select a cool, dry, and well-ventilated area.
   a. Cool areas minimize pressure increases that can result from heat or direct sunlight.
   b. Dryness deters rust and corrosion.
   c. Ventilation is essential in case of leaks.
   d. Never store compressed gas cylinders (with the exception of compressed air) in environmental rooms (i.e., refrigerated cold rooms or warm rooms). These rooms are not well ventilated and could pose a serious safety concern should a cylinder fail.
3. Arrange storage facilities to permit inventory rotation, using cylinders in order as received from the supplier.

4. Do not store cylinders next to doors or in corridors where they could possibly obstruct emergency exit from the building.

5. Designate an area to store empty cylinders for return to the supplier. An area on or adjacent to your building's loading dock is suitable.

6. Separate oxidizers or other incompatibles (e.g., oxygen) from flammables by at least 20 feet, or by a non-combustible wall.

**Storage Guidelines**

1. Implement these ideal storage practices:
   a. Restrain cylinders - During the 1994 Northridge earthquake, gas cylinders that had been double-chained and bolted to a secure surface stayed in place. Single-chain restraints were not as successful. C-clamps did not work at all. Restrained cylinders as follows:
      i. Store cylinders upright and secure them to a substantial, fixed surface with upper and lower restraints made of non-combustible material, preferably chain and Unistrut®.
      ii. Position the upper restraint no less than 1 foot from the shoulder of the cylinder. Position the lower restraint no less than 1 foot from the floor.
      iii. C-clamps or bench mounting brackets are not allowed!
      iv. Multiple cylinder restraint - Limit 3 cylinders to each double-chain restraint system.
   b. Properly label the cylinders and storage area.
   c. Cap cylinders when not in use.
   d. Store cylinders away from non-compatibles.
   e. Store empty cylinders separately from full cylinders.

2. Do not keep non-corrosive gases longer than 5 years from the last hydrostatic test date (usually stamped just below the neck of the cylinder) unless otherwise regulated.

3. Return all cylinders that appear unsafe or show signs of corrosion, dents, dings, pitting, bulging, etc.

4. Review your cylinder inventory regularly.
   a. Return cylinders to the vendor if they're no longer being used. This removes potential hazards and saves on cylinder rental fees (cylinders are typically rented or leased, rather than purchased) and possible reconditioning fees.
b. Note: Some vendors charge a reconditioning fee on each cylinder that is not returned within 2 years. This fee may be significant in relation to the actual cost of the gas.

5. In addition to standard storage requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below
   a. Flammable gases
      i. Separate from cylinders containing oxidizing gases by a minimum distance of 20 feet or by a noncombustible partition
      ii. When approved gas storage cabinets are used, the cabinets must be equipped with fire sprinklers. (Note: Fire code piping and connection requirements may apply for your facility. Consult the EH&S Chemical Hygiene Officer.
      iii. Never store flammable gas near ignition or heat sources, or unprotected electrical connections.
      iv. Keep quantities to a minimum. There may be circumstances where using a pure flammable gas may pose unacceptable risks. It may be necessary to purchase a reduced concentration mixture (e.g., 1% hydrogen and 99% argon).
      v. If you need large volumes (more than 1 large cylinder), contact the EH&S Chemical Hygiene Officer,
   b. Oxidizing gases
      i. Do not permit oil or grease to come in contact with compressed oxidizing gases — explosions may occur!
      ii. Separate oxidizers from cylinders containing flammable gases by a minimum distance of 20 feet or by a noncombustible partition extending not less than 18 inches above and to the sides of the stored material.
      iii. Never store oxidizers near flammable solvents, combustible materials, unprotected electrical connections, or ignition or heat sources. (Note: Fire code piping requirements may apply in your facility. Consult the EH&S Chemical Hygiene Officer,)
   c. Corrosive gases
      i. Never store lecture bottles of corrosives longer than 6 months and cylinders more than 2 years. (e.g., ammonia, hydrogen chloride, chlorine, and methylamine). Cylinders containing corrosives degrade over time.

Operational Guidelines

1. Know the hazard classification of particular gases you are working with and specific safety requirements as discussed above.

2. Label both the cylinder and gas line with the name of the gas. Do not depend on color codes.
3. Work in a well-ventilated area when using compressed gases.

4. Use the correct regulator. Ensure that each gas in use has its own dedicated regulator. Never use adapters.

5. Never permit a flame or spark to come in contact with any part of a compressed gas cylinder. Have flashback protectors installed on cylinders of flammable gases, such as oxy-acetylene torch units.

6. Use a trap or suitable check valve when discharging gas into a liquid to prevent liquid from getting back into the cylinder or regulator.

7. Lecture bottles use universal threads and valves, and some of them are interchangeable. This increases the risk of accidentally mixing incompatible materials.

8. In addition to standard operational requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below.
   a. **Flammable gases**
      i. Use flow restrictors to prevent a sudden large unexpected release.
      ii. Detection systems may be required.
   b. **Oxidizing gases**
      i. Diligently clean regulators and tubing used with oxidizing gases to remove oil and other reducing agents.
   c. **Corrosive gases**
      i. Inspect cylinder valves periodically for corrosion.
         1. If a cylinder or valve is noticeably corroded, contact the gas vendor and follow their instructions.
         2. Alert the vendor to any damage that might impair the integrity of the cylinder before the cylinder is returned.
      ii. Use caution if flow does not immediately start when a valve is opened slightly — there could be a plug in the valve.

**Transporting Gas Cylinders**

1. Leave the valve protection cap in place until the cylinder has been secured against a wall or bench or placed in a cylinder stand, and is ready for use.

2. Use a hand truck or other suitable device to transport cylinders, even for short distances. Secure the cylinder to the hand truck with a chain or strap.
   a. Do not roll, drag, or slide containers.
   b. Do not lift cylinders by cylinder caps.

3. Before returning empty cylinders to the supplier:
a. Close the valve. Leave some positive pressure in the cylinder.
b. Replace any valve outlet and protective caps originally shipped with the cylinder.
c. Mark or label the cylinder "empty" and store it in a designated area for the supplier.

4. Move any cylinders that have been left unattended into a secure location as soon as possible.

**Spill and Incident Procedures**

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the UCSB Emergency Information Flipchart – should already be posted in all labs.

**Hazard-specific Incident Practices:**

1. In case of cylinder leaks that can't be stopped by tightening the valve gland or packing nut, do the following:
   a. For hazardous gases:
      i. Leave the room, closing the door behind you.
      ii. Secure the room to prevent entry.
      iii. Sound the fire alarm, unless the gas leak is relatively slow and contained within a gas cabinet, or fume hood.
      iv. Call for emergency assistance. Dial 9-1-1, preferably from a cell phone. Tell the dispatcher the name of the gas.
   b. For non-hazardous gases:
      i. Close the leaking valve. If it is still leaking, replace the cylinder cap
and notify EHS.

Waste Disposal Procedure

See “Chemical Waste Disposal” in Sec. II of the UCSB Chemical Hygiene Plan.

Safety Data Sheet (SDS) Location

Online SDSs can be accessed at http://ehs.ucsb.edu/labsafety/msds

PRIOR APPROVAL/REVIEW REQUIRED
A person needed to be trained on tube furnace operation before using forming gas (5 % H₂ + 95 % N₂). Other gases (argon, nitrogen, oxygen, and helium) do not require prior training or approval.

DESIGNATED AREA
Forming gas (5 % H₂ + 95 % N₂) is used with the tube furnace in the fume hood.

LAB-SPECIFIC INFORMATION (required) (Examples of appropriate content)
Forming gas (5 % H₂ + 95 % N₂) is used with the tube furnace in the fume hood. It is used about one time per week. The flow rate is usually set to 5 sccm for about 2 hours. The gas can only be started only when the furnace is cool. Typical operating temperature is 400 °C.

Other gas tanks supply the sputtering systems in the room. They should be left closed when not in use.

All gas tanks should be chained to the wall in the appropriate fashion at all times (unless changing tanks, in which case it should be put immediately onto the dolly to transport back to the gas cage).
APPENDIX A:

Hazardous Gas Classification Table

(Because of their acute toxicity and high level of regulatory oversight, the gases listed here should not use this generic SOP, but rather a gas-specific version – contact EH&S)

<table>
<thead>
<tr>
<th>Gas and Formula</th>
<th>CAS and UN or NA No.</th>
<th>UBC / CFC Class(^1)</th>
<th>IDLH(^2)</th>
<th>LC50(^3)</th>
<th>PEL(^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia – NH(_3)</td>
<td>7664–41–7, UN1005</td>
<td>Corrosive(^5,6), flammable</td>
<td>300 ppm</td>
<td>4000 ppm</td>
<td>50 ppm</td>
</tr>
<tr>
<td>Arsine – AsH(_3)</td>
<td>7784–42–1, UN2188</td>
<td>Highly toxic, flammable</td>
<td>3 ppm</td>
<td>20 ppm</td>
<td>0.05 ppm</td>
</tr>
<tr>
<td>Boron Tribromide – Bbr(_3)</td>
<td>10294–33–4, UN2692</td>
<td>Toxic</td>
<td>50 ppm</td>
<td>380 ppm</td>
<td>1 ppm(^{4(C)})</td>
</tr>
<tr>
<td>Boron Trichloride – BCl(_3)</td>
<td>10294–34–5, UN1741</td>
<td>Corrosive(^5)</td>
<td>25 ppm(^7)</td>
<td>2541 ppm</td>
<td>5 ppm</td>
</tr>
<tr>
<td>Boron Trifluoride – BF(_3)</td>
<td>7637–07–2, UN1008</td>
<td>Toxic</td>
<td>25 ppm</td>
<td>806 ppm</td>
<td>1 ppm(^{4(C)})</td>
</tr>
<tr>
<td>Bromine – Br(_2)</td>
<td>7726–95–6, UN1744</td>
<td>Highly toxic, corrosive, oxidizer</td>
<td>3 ppm</td>
<td>113 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Carbon Monoxide – CO</td>
<td>630–08–0, UN1016</td>
<td>Flammable(^5)</td>
<td>1200 ppm</td>
<td>3760 ppm</td>
<td>50 ppm</td>
</tr>
<tr>
<td>Chlorine – Cl(_2)</td>
<td>7782–50–5, UN1017</td>
<td>Toxic, corrosive, oxidizer</td>
<td>10 ppm</td>
<td>293 ppm</td>
<td>1 ppm(^{4(C)})</td>
</tr>
<tr>
<td>Chlorine Dioxide – ClO(_2)</td>
<td>10049–04–4, NA9191</td>
<td>Toxic, oxidizer</td>
<td>5 ppm</td>
<td>250 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Chlorine Trifluoride – ClF(_3)</td>
<td>7790–91–2, UN1749</td>
<td>Toxic, oxidizer</td>
<td>20 ppm</td>
<td>299 ppm</td>
<td>0.1 ppm(^{4(C)})</td>
</tr>
<tr>
<td>Diborane – B(_2)H(_6)</td>
<td>19278–45–7, UN1911</td>
<td>Highly toxic, flammable</td>
<td>15 ppm</td>
<td>80 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Gas and Formula</td>
<td>CAS and UN or NA No.</td>
<td>UBC / CFC Class(^2)</td>
<td>IDLH(^{2}) ppm</td>
<td>LC50(^{2}) ppm</td>
<td>PEL(^{4}) ppm</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Dichlorosilane – SiH(_2)Cl(_2) (HCl)</td>
<td>4109–96–0, UN2189</td>
<td>Toxic, corrosive, flammable</td>
<td>50</td>
<td>314</td>
<td>5 ppm (4(C))</td>
</tr>
<tr>
<td>Ethylene Oxide – C(_2)H(_4)O</td>
<td>75–21–8, UN1040</td>
<td>Flammable(^{2})</td>
<td>800</td>
<td>4350</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Fluorine – F(_2)</td>
<td>7782–41–4, UN1045</td>
<td>Highly toxic, oxidizer</td>
<td>25</td>
<td>185</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Germane – GeH(_4)</td>
<td>7782–65–2, UN2192</td>
<td>Toxic, flammable</td>
<td>6 ppm(^7)</td>
<td>622</td>
<td>0.2 ppm(^{2})</td>
</tr>
<tr>
<td>Hydrogen Bromide – HBr</td>
<td>10035–10–6, UN1048</td>
<td>Corrosive(^{2})</td>
<td>30</td>
<td>2860</td>
<td>3 ppm</td>
</tr>
<tr>
<td>Hydrogen Chloride – HCl</td>
<td>7647–01–0, UN1050</td>
<td>Corrosive(^{2})</td>
<td>50</td>
<td>2810</td>
<td>5 ppm (4(C))</td>
</tr>
<tr>
<td>Hydrogen Cyanide – HCN</td>
<td>74–90–8, UN1051</td>
<td>Highly toxic, flammable</td>
<td>50</td>
<td>40</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Hydrogen Fluoride – HF</td>
<td>7664–39–3, UN1052</td>
<td>Toxic</td>
<td>30</td>
<td>1300</td>
<td>3 ppm</td>
</tr>
<tr>
<td>Hydrogen Selenide – H(_2)Se</td>
<td>7783–07–5, UN2202</td>
<td>Highly toxic, flammable</td>
<td>1 ppm</td>
<td>2 ppm</td>
<td>0.05 ppm</td>
</tr>
<tr>
<td>Hydrogen Sulfide – H(_2)S</td>
<td>7783–06–4, UN1053</td>
<td>Toxic, flammable</td>
<td>100</td>
<td>712</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Methyl Bromide – CH(_3)Br</td>
<td>74–83–9, UN1062</td>
<td>Toxic, flammable</td>
<td>250</td>
<td>1007</td>
<td>20 ppm (4(C))</td>
</tr>
<tr>
<td>Methylisocyanate – CH(_3)NCO</td>
<td>624–83–9, UN2480</td>
<td>Highly toxic, flammable</td>
<td>3 ppm</td>
<td>22 ppm</td>
<td>0.02 ppm</td>
</tr>
<tr>
<td>Methyl Mercaptan – CH(_3)SH</td>
<td>74–93–1, UN1064</td>
<td>Toxic, flammable</td>
<td>150</td>
<td>1350</td>
<td>10 ppm (4(C))</td>
</tr>
<tr>
<td>Nickel Carbonyl – Ni(CO)(_4)</td>
<td>13463–39–3, UN1259</td>
<td>Highly toxic, flammable</td>
<td>2 ppm</td>
<td>18 ppm</td>
<td>0.001 ppm</td>
</tr>
<tr>
<td>Nitric Oxide – NO</td>
<td>10102–43–9, UN1660</td>
<td>Highly toxic, oxidizer</td>
<td>100</td>
<td>115</td>
<td>25 ppm</td>
</tr>
<tr>
<td>Gas and Formula</td>
<td>CAS and UN or NA No.</td>
<td>UBC / CFC Class</td>
<td>IDLH</td>
<td>LC50</td>
<td>PEL</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------</td>
<td>-----------------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Nitrogen Dioxide – NO₂</td>
<td>10102–44–0, UN1067</td>
<td>Highly toxic, oxidizer</td>
<td>20 ppm</td>
<td>115 ppm</td>
<td>5 ppm&lt;sup&gt;4(C)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosgene – COCl₂</td>
<td>75–44–5, UN1076</td>
<td>Highly toxic</td>
<td>2 ppm</td>
<td>5 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Phosphine – PH₃</td>
<td>7803–51–2, UN2199</td>
<td>Highly toxic, pyrophoric</td>
<td>50 ppm</td>
<td>20 ppm</td>
<td>0.3 ppm</td>
</tr>
<tr>
<td>Phosphorus Oxychloride – POCl₃</td>
<td>10025–87–3, UN1810</td>
<td>Highly toxic</td>
<td>0.96 ppm&lt;sup&gt;7&lt;/sup&gt;</td>
<td>96 ppm</td>
<td>0.1 ppm&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphorus Pentfluoride – PF₅</td>
<td>7647–19–0, UN2198</td>
<td>Toxic, oxidizer</td>
<td>2.6 ppm&lt;sup&gt;7&lt;/sup&gt;</td>
<td>260 ppm</td>
<td>3 ppm</td>
</tr>
<tr>
<td>Phosphorus Trichloride – PCl₃</td>
<td>7719–12–2, UN1809</td>
<td>Toxic, oxidizer</td>
<td>25 ppm</td>
<td>208 ppm</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>Selenium Hexafluoride – SeF₆</td>
<td>7783–79–1, UN2194</td>
<td>Highly toxic</td>
<td>2 ppm</td>
<td>50 ppm</td>
<td>0.05 ppm (as Se)</td>
</tr>
<tr>
<td>Silicon Tetrachloride – SiCl₄ (HCl)</td>
<td>10026–04–7, UN1818</td>
<td>Toxic, corrosive</td>
<td>50 ppm</td>
<td>750 ppm</td>
<td>5 ppm&lt;sup&gt;4(CI)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Silicon Tetrafluoride – SiF₄ (HF)</td>
<td>7783–61–1, UN1859</td>
<td>Toxic</td>
<td>30 ppm</td>
<td>450 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Stibine – SbH₃</td>
<td>7803–52–3, UN2676</td>
<td>Highly toxic, flammable</td>
<td>5 ppm</td>
<td>20 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Sulfur Dioxide – SO₂</td>
<td>7446–09–5, UN1079</td>
<td>Corrosive&lt;sup&gt;6&lt;/sup&gt;</td>
<td>100 ppm</td>
<td>2520 ppm</td>
<td>5 ppm</td>
</tr>
<tr>
<td>Sulfuryl Fluoride – SO₂F₂</td>
<td>2699–79–8, UN2191</td>
<td>Corrosive&lt;sup&gt;6&lt;/sup&gt;</td>
<td>200 ppm</td>
<td>3020 ppm</td>
<td>5 ppm</td>
</tr>
<tr>
<td>Tellurium Hexafluoride – TeF₆</td>
<td>7783–80–4, UN2195</td>
<td>Highly toxic</td>
<td>1 ppm</td>
<td>25 ppm</td>
<td>0.02 ppm (as Te)</td>
</tr>
<tr>
<td>Titanium Trichloride – TiCl₄</td>
<td>7550–45–0, UN1838</td>
<td>Highly toxic, corrosive</td>
<td>1.3 ppm</td>
<td>119 ppm</td>
<td>—</td>
</tr>
<tr>
<td>Tungsten Hexafluoride – WF₆ (HF)</td>
<td>7783–82–6, UN2196</td>
<td>Toxic, corrosive</td>
<td>30 ppm</td>
<td>217 ppm</td>
<td>0.1 ppm</td>
</tr>
</tbody>
</table>

(Table adapted from Santa Clara County's Hazardous Gas Table.)
Footnotes:

1. **UBC/ CFC Class.** Gases listed as either toxic or highly toxic should not use this SOP, but develop a gas-specific SOP
   a. UBC (Uniform Building Code)
   b. CFC (California Fire Code)
   c. Class as defined in CFC:
      i. Health hazards per Article 2
      ii. Highly toxic = < 200 LC50
      iii. Toxic = 201–2000 LC50
   d. Physical hazards per CFC Standard 7903.

2. **IDLH (Immediately Dangerous to Life and Health) values published in 1994 by the National Institute for Occupational Safety and Health (NIOSH).**

3. **LC50 data (Lethal concentration 50%):** Lowest reported value, 1 hour adjusted, taken from Dept. of Transportation, Compressed Gas Association, Registry of Toxic Effects of Chemical Substances.

4. **PEL (Permissible Exposure Limit) values published by Occupational Safety & Health Administration (OSHA).** OSHA values used if available; otherwise, Threshold Limit Values (TLV) from ACGIH. (C) = TLV-ceiling limit, an exposure limit not to be exceeded under any circumstances.

5. Moderately toxic per cities of San Jose, Santa Clara, and Milpitas: LC50 = 2,000–5000.

6. When used as a refrigerant, Uniform Building Code Class does not apply.

7. IDLH determined by 0.01 of LC50.

8. Cal/OSHA PEL, Title 8, Section 5155, 9/1/95
IRRITANTS AND SENSITIZERS
STANDARD OPERATING PROCEDURE TEMPLATE

Type of SOP:  □ Process  □ Hazardous Chemical  ■ Hazard Class

OVERVIEW
This SOP deals with two classes of related materials:

- Skin/eye irritants
- Sensitizers

Although the mechanism/target of their toxicity may vary, these materials are similar in that they generally don’t present a physical hazard (fire, explosion, high reactivity) and are of less concern than “Particularly Hazardous Substances” (acute toxins, reproductive toxins, carcinogens – see SOP library). Their primary hazard are their short-term and reversible affects via skin contact (usually) or inhalation. Therefore, the engineering controls and personal protective equipment used to protect an individual are generally the same for these substances. The individual Safety Data Sheet for a particular material should always be consulted before beginning work.

DEFINITIONS AND HAZARDS

- Irritants are chemicals which are not corrosives, but which can cause a reversible inflammatory effect on living tissue at the site of skin or eye contact. Examples: chlorine, alkalis, some solvents.

- Sensitizers are chemicals which cause a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical. Poison oak is a good example of a natural sensitizer.

Labelling
Irritants and sensitizers are now identified by the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Irritant or sensitizer containers manufactured after the implementation of GHS will have this symbol:

Skin and eye irritation, category 2; Skin sensitization, category 1; acute toxicity (oral, dermal, inhalation); Specific Target Organ Toxicity – single exposure
WORK PRACTICES

These materials have in common the fact that direct contact must be avoided. Careful handling and stringent controls are essential in order to minimize risk to researchers and the environment. **Note that this standard operating procedure describes the baseline requirements for handling these classes of compounds.** There are many cases where specific chemical entities require additional or modified handling procedures.

General information about working with hazardous chemicals can be found free in *Prudent Practices in the Laboratory, National Research Council, 2011* Chapters 4 to 6. Specific information on these two classes of materials are in Sec. 4.C.3.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

See the PPE information under Sec. II of the *UCSB Chemical Hygiene Plan* regarding:
- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your PPE via use of the *Laboratory Hazard Assessment Tool*
- glove selection criteria
- respirator use, etc.

*At minimum, complete protection of the eyes and skin is essential.*

ENGINEERING/VENTILATION CONTROLS

Should always be used in a fume hood, glove box, or in totally-sealed containers. For further information see the following pages in Sec. II of the *UCSB Chemical Hygiene Plan*:
- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls

SPECIAL HANDLING PROCEDURES

- Avoid working alone with hazardous materials.
- Eliminate or substitute for a less hazardous material when possible.
- Design your experiment to use the least amount of material possible to achieve the desired result.
- Do not exceed the scale or deviate from the experimental parameters which may be outlined in the lab-specific information section below without the approval of the PI.

STORAGE REQUIREMENTS

All hazardous materials must be labeled with their identity as well as all applicable warning statements. Manufacturer labels will contain all the necessary information.
However, if material is repackaged or synthesized in the laboratory, please follow the protocols described in the CHEMICAL LABELLING section in Section II of the *UCSB Chemical Hygiene Plan*.

**SPILL AND INCIDENT PROCEDURES**
See directions under the “Chemical Incident” tab of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.

**DECONTAMINATION**
Using proper personal protective equipment as outlined above, decontaminate equipment and bench tops using soap and water and properly dispose of all chemical and contaminated disposables as hazardous waste following the guidelines below.

**WASTE DISPOSAL**
See “Chemical Waste Disposal” in Sec. II of the *UCSB Chemical Hygiene Plan*.

**PRIOR APPROVAL/REVIEW**
Seek proper training from the lab safety coordinator prior to use of irritants.

**DESIGNATED AREA**
Irritants should primarily be used in the fume hood, but some (i.e. sealants) require use outside the fume hood. In these cases ensure proper ventilation by opening the door or using a fan to circulate air, and try to limit exposure to as little as possible.

**SAFETY DATA SHEETS**
Found online at: [http://ehs.ucsb.edu/labsafety/msds](http://ehs.ucsb.edu/labsafety/msds)

**LAB-SPECIFIC INFORMATION (required)** *(Examples of appropriate content)*
Irritants and sensitizers should be used very infrequently in the laboratory, and even then typically in small amounts (less than 500g).
Methylene Chloride / Dichloromethane

Standard Operating Procedure Template

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

For more information, consult a Safety Data Sheet for this material.

Usage

Methylene chloride, also known as dichloromethane (DCM) is commonly used as a reaction solvent, a solvent for extractions in isolating organic compounds, and as an eluent for flash and thin-layer chromatography.

Hazard Overview

Acute Effects: Hazardous in case of eye contact (irritant), of ingestion, of inhalation. In case of ingestion, DCM may cause irritation of the gastrointestinal tract with vomiting. If vomiting results in aspiration, chemical pneumonia could follow. Absorption through gastrointestinal tract may produce symptoms of central nervous system depression ranging from light headness to unconsciousness. Hazardous in case of skin contact (irritant, permeator). Inflammation of the eye is characterized by redness, watering, and itching. Eye contact may cause temporal eye damage.

Chronic Effects: Can cause headache, mental confusion, depression, liver effects, kidney effects, bronchitis, loss of appetite, nausea, lack of balance, and visual disturbances. Can cause dermatitis upon prolonged skin contact.

Mutagenic Effects: Methylene chloride may cause cancer in humans.

Developmental Toxicity: The substance is toxic to lungs, the nervous system, liver, mucous membrane
Due to its carcinogenicity and toxicity, DCM is specifically regulated by Cal-OSHA. It has designated Permissible Exposure Limits via inhalation which cannot legally be exceeded in the workplace:

- **Permissible Exposure Limit (inhalation):** 25 ppm (8 hr time weighted average)
- **Short-term Exposure Limit (inhalation):** 125 ppm (15 minutes)
- **Action Level (inhalation):** 12.5 ppm

Therefore, given its volatility, it should always be used in a fume hood, glove box, or sealed containers.

**Personal Protective Equipment (PPE)**

See the PPE information under Sec. II of the UCSB Chemical Hygiene Plan regarding:

- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your free PPE via use of the Laboratory Hazard Assessment Tool
- glove selection criteria
- respirator use, etc.

Gloves – the most common gloves found in campus labs/storerooms (nitrile, neoprene and latex) are not recommended for use with DCM due to the ease with which it permeates through the glove material. The recommended gloves are “Silver Shield”, polyvinyl alcohol, Viton, or “Barrier” (available from vendors like Fisher Scientific). Some of these gloves have poor dexterity characteristics, but their utility can be increased by wearing a more dexterous glove over the inner glove.

**Engineering Controls**

All operations involving DCM should be carried out in a certified chemical fume hood to keep airborne level below recommended exposure limits.

For further information on engineering controls see the following pages in Sec. II of the UCSB Chemical Hygiene Plan:

- UCSB Fume Hood Usage Guides
- Criteria for Implementing Engineering Controls

**Spill and Incident Procedures**

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the UCSB Emergency Information Flipchart – should already be posted in all labs. For chemical-specific first-aid information, see the Safety Data Sheet.
Special Handling and Storage Requirements

- Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from any source of heat or ignition.

- Segregate the chemicals from incompatible materials

Decontamination/Waste Disposal Procedure

No waste streams containing methylene chloride shall be disposed of in sinks. Wash hands and arms with soap and water after finished. Contaminated pipet tips, eppendorf tubes, and gloves should be discarded as hazardous waste according to UCSB EH&S waste disposal procedures - see “Chemical Waste Disposal” in Sec. II of the UCSB Chemical Hygiene Plan.

Safety Data Sheet (MSDS) Location

Found online at: http://ehs.ucsb.edu/labsafety/msds

Designated Area

Methylene chloride should be used in the fume hood at all times due to its volatility.

Prior Approval/Review Required

Prior to the use of methylene chloride, the lab safety coordinator must give training and approval to use it in the lab.

LAB-SPECIFIC INFORMATION (required) (Examples of appropriate content)

Methylene chloride is used very rarely and in small quantities less than 200 mL. It should be used at room temperature.
13. HAZARD OVERVIEW

- An implosion and the possible hazards of flying glass, spattering chemicals and fire

- Cold traps can condense air/oxygen into a system which becomes an explosion hazard when warmed, or when in contact with organics.

- The belt on the pump can catch fingers or clothing

- Improper venting of pump exhaust when using hazardous materials

- The systems are typically complicated and require extensive training prior to use
14. PERSONAL PROTECTIVE EQUIPMENT (PPE)
Use a face-shield or explosion shield or work behind the sash of a fume hood, particularly with larger glass systems under vacuum.

See the PPE information under Sec. II of the UCSB Chemical Hygiene Plan regarding:
• the UC PPE Policy and policy summary (what a PPE is needed and when/where to use)
• obtaining your PPE via use of the Laboratory Hazard Assessment Tool
• glove selection criteria
• respirator use, etc.

15. ENGINEERING/VENTILATION CONTROLS
For further information see these pages in Sec. II of the UCSB Chemical Hygiene Plan:
• Fume Hood Usage Guide
• Criteria for Implementing Engineering Controls

16. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS
• Understand the type of vacuum pumps being used and their limitations. Always check with the manufacturer for the appropriate application.

• Prepare for power outages whether you are present or not. Some valves close upon loss of power, some open. Understand the effects that a series of valve openings and closings will have upon the system's integrity.

• Always replace the pump belt guard to prevent catching fingers or clothing in the mechanism.

• Be aware of the hot surface in oil diffusion pumps

• If a glass vacuum line is ever used above ambient pressure, it should be shielded from personnel to prevent glass shards from flying if the line were to shatter.

• Glass vessels that are evacuated should be round-bottomed and/or thick-walled and designed for low-pressure work. They should be regularly checked for star cracks and scratches.

• The use of safety glasses is mandatory.

Traps and Venting
• Use of house vacuum systems must employ appropriate traps to prevent chemical, radioactive or biohazardous material from contaminating the building
pump and lines. Likewise, use of an aspirator should also employ a suitable trap to avoid contaminating the water stream.

- Mechanical vacuum pumps should be protected by cold traps – generally liquid nitrogen based.

- If hazardous materials are used with the vacuum system they should be located in, and vented to, a fume hood.

- Pump oil from vacuum system exhaust has been known to accumulate in building ductwork systems increasing the likelihood of fire spread. Pump exhaust should only be done into the fume hood proper, or if exhausted directly into building ductwork, an oil trap must be installed.

- Operation of low temperature traps must be thoroughly understood. Both the cooling and warming phases deserve undivided attention. For example, when using liquid nitrogen, the condensation of air due to an open valve may cause a serious explosion when the air vaporizes upon warming. The increase in volume/pressure is huge (factor of about 200).

- Dewar flasks are insulated by being under high vacuum and are therefore subject to implosion. They should be wrapped in tape or plastic sheathing and generally come that way.

**Chemical Hazards**

- Mechanical pump oil can become contaminated with hazardous materials that were being pumped on. During maintenance, proper protective equipment must be employed. A ventilated area should be used for changing pump oil, as harmful vapors may be released. Clean or contaminated pump oil must be disposed of as hazardous waste via EH&S.

- Mechanical pump exhaust may require suitable scrubbing for volatile highly toxic materials. This may involve a relatively simple filter or liquid bubbler.

**Practices**

Turning ON a High Vacuum System:
- Make sure all valves are closed.
- Turn on vacuum pump.
- Place Dewar around trap flask
- Submerge trap flask in liquid nitrogen. **Make sure system is under vacuum before cooling trap to avoid condensation of liquid oxygen.**

Turning OFF a High Vacuum System
- Remove all samples and experiments from vacuum line.
- Remove trap flask from Dewar. Allow to warm to room temperature
• Open vacuum system to atmosphere. **Do not do this while trap is cold to avoid condensation of liquid oxygen.**
• Turn off pump.

17. **SPILL AND INCIDENT PROCEDURES**
See directions under the “Chemical Incident” and “Medical Emergency” tabs of the UCSB Emergency Information Flipchart – should already be posted in all labs.

18. **WASTE DISPOSAL**
See “Chemical Waste Disposal” in Sec. II of the UCSB Chemical Hygiene Plan.
When using a “house vacuum” system or an aspirator to generate vacuum, you must protect from contamination the vacuum pump for the building and waste water lines. Use a trap such as a vacuum flask. Chemicals pulled into a building vacuum pump can damage the pump.

19. **PRIOR APPROVAL/REVIEW REQUIRED**
Prior to use or maintenance of any vacuum systems, proper training is required from the lab safety coordinator

20. **DESIGNATED AREA**
n/a

21. **SAFETY DATA SHEETS**
Found online at: [http://ehs.ucsb.edu/labsafety/msds](http://ehs.ucsb.edu/labsafety/msds)

22. **LAB-SPECIFIC INFORMATION (required)** *(Examples of appropriate content)*


Standard operating procedures should be consulted prior to any use of vacuum equipment, as improper use can be very dangerous.
Directions to Laboratory Personnel

This section of the document is now provided to laboratories in an electronic version only, rather than a hard copy – Web address provided below. Please remove older versions of Sec. II from your binder and replace with this single page. In contrast, Section I of the document (lab-specific portion) will temporarily remain as hard copies within the binder.

Web address for Section II:

http://www.ehs.ucsb.edu/labsafety-chp/sec2

Per Cal-OSHA requirements, this document needs to be reviewed and updated annually. Therefore, we ask that this section NOT be printed out as a hard copy, as it becomes very difficult to locate hundreds of hard copies across the campus when the next update needs to occur. Questions can be directed to David.Vandenberg@ehs.ucsb.edu, or for the following departments to Moretto@chem.ucsb.edu: Chemistry & Biochemistry, Materials, Electrical and Computer Engineering, Chemical Engineering
**UCSB Laboratory Safety Manual and Chemical Hygiene Plan**

Prepared by UCSB Environmental Health & Safety

SECTION III (3):
REGULATORY FRAMEWORK
(revised March 2013)

Directions to the Laboratory

This section of the document is now provided to laboratories only in an electronic version, rather than a hard copy – Web address provided below. Please remove older versions of Sec. III from your binder and replace with this single page. In contrast, Section I of the document (lab-specific portion) will temporarily remain as hard copies within the binder.

Web address for Section III:

[http://www.ehs.ucsb.edu/labsafety-chp/sec3](http://www.ehs.ucsb.edu/labsafety-chp/sec3)

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