CEBC LABORATORY SAFETY MANUAL

Enforcement of laboratory safety rules

In order to cultivate a "culture of safety," every researcher is expected to not only adhere to the policies set forth in this document, but is expected to help enforce them. Regularly scheduled inspections will identify issues related to chemical hygiene, etc., but cannot always identify issues of practice and procedure. Specific responsibilities of each researcher include:

1. If you witness another lab worker not following one or more safety procedures, you are *obligated* to politely request that person follow the rule in question. Imagine how you would feel if someone were to be injured and you could have helped prevent it.
2. If someone points out a violation you are committing, please politely acknowledge your error and take corrective action. Do not be offended or take it personally — it is the rule.
3. If you witness that someone repeatedly violates safety procedures, or if you witness any action that you consider reckless, you may send a *confidential* e-mail to the CEBC Administrative Director (Chris Lyon, lyon@ku.edu) citing the violation(s). Such reports will be handled on a case-by-case basis, but may involve a meeting with the AD, the violator, and his/her faculty advisor, and may result in disciplinary action.

1.0 Introduction

This document is intended to be a condensed reference for good laboratory practices used by CEBC researchers. This document was created by the CEBC

Laboratory Safety Committee as a *complement to the KU-EHS laboratory manual*, and shall be reviewed and updated on at least a yearly basis. At any time, researchers may suggest additions or clarifications for consideration by the safety committee.

All CEBC training materials must be read and understood by research personnel prior to working in the laboratories. Researchers will not receive laboratory keys until all training is completed and documented. Additional references are provided at the end of this document, and should be consulted as necessary.

1.1 History
Created: 8-15-08
Approved: 12-08-08
Revised: 7-27-09 (Clarification added to sections 5.2, 5.6, 5.11, 8.1.1. Appendix F added.)
Revised: 10-7-09 (Edits to introduction, sections 4.0, 5.2 thru 5.5, 5.11, 5.14, 5.15, 5.17, 5.18, 6.0, 7.0, 8.2 thru 8.4. Appendix H added.)

1.2 Definitions:
Lab – the actual room where experiments are conducted
Building – the whole building, including labs, offices, and meeting areas (e.g. CEBC Building B)
CEBC or *center* – the whole Life Sciences Research Labs site, including Buildings A, B, and C
Researcher or *user* or *lab personnel* or *worker* – someone who works in a particular lab, even if they are not physically present in the lab
Visitor – anyone present in a lab who does not conduct work in that particular lab. A researcher from one research group is a visitor in the labs of another research group unless they have been trained on the specific procedures and/or equipment they are/will be using in that lab

2.0 Emergency procedures:
Emergency procedures are presented in general form in Section 2.2 under "General procedures." These procedures are the guidelines for all emergency responses and are subdivided into emergencies requiring a building evacuation, emergencies not requiring a building evacuation, and medical emergencies. For information on dealing with specific types of emergencies, refer to Section 2.1 under "Emergency categories." In that section, specific procedures are given for dealing with fires, chemical spills, and building emergencies. We have provided redundant information in several cases so that these procedures are as clear and thorough as possible.

Important: *Be prepared! Be aware of potential hazards in your laboratory. Be familiar with the procedures in this section. Know the location of multiple escape routes and safety equipment. In an emergency, you must be ready to act immediately!*

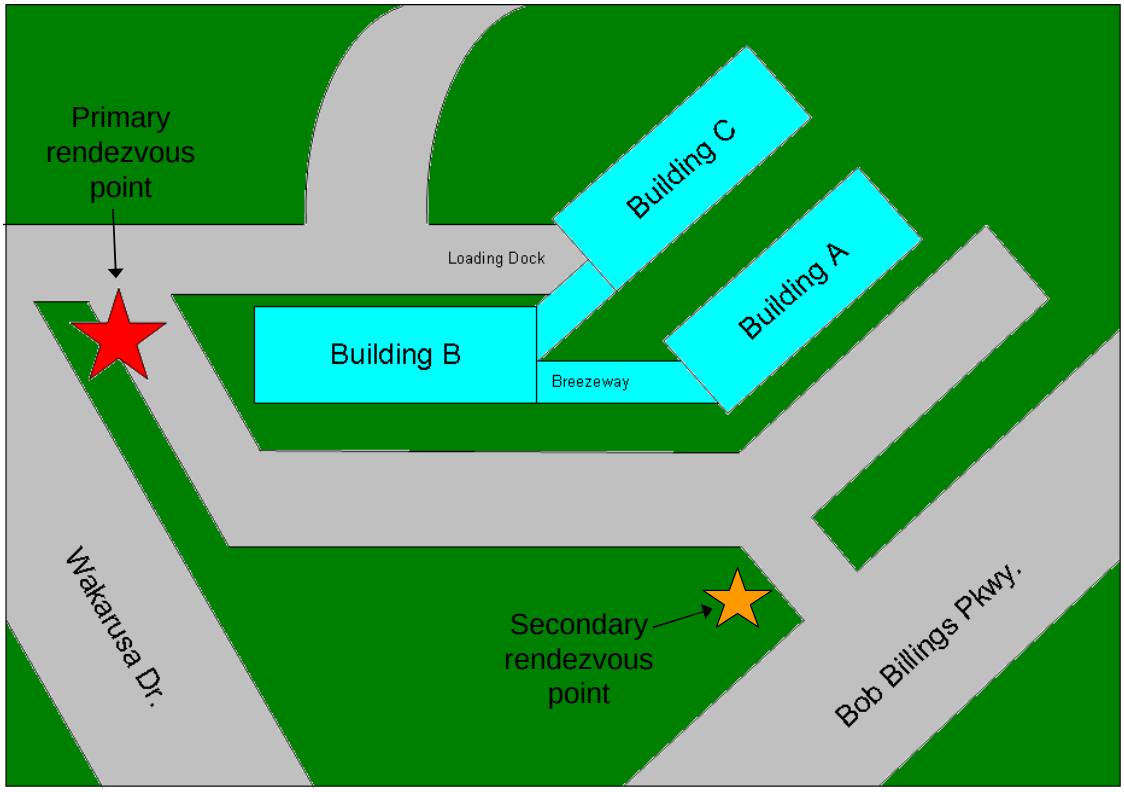


Figure 1. CEBC map showing primary emergency rendezvous point (red star) and secondary rendezvous point (orange star). The secondary rendezvous point should only be used if it is dangerous to use the primary rendezvous point due to smoke or other hazards. Always follow the instructions of emergency personnel.

2.1 Emergency categories: The following procedures are given to address the types of emergencies that are deemed most likely to occur at CEBC based on the experiments being conducted here. For general emergency procedures, refer to Section 2.2.

2.1.1. Fire or Explosion procedures:

A. Immediately notify others in the lab of emergency
B. If trained to use fire extinguisher, control and extinguish fire.
    1. Do not attempt to fight a fire if it is large, out of control, or contains toxic fumes
    2. If first attempt fails, evacuate the building
C. Evacuate lab, closing doors behind you.
D. Verify evacuation of all lab occupants – check to see if everyone in your lab safely evacuated. NOTE: Do not attempt to check other labs in the building; you just need to know whether anyone in your lab is injured, incapacitated, or otherwise incapable of evacuating and provide that information to first responding emergency personnel. Remember that you must protect yourself first!
E. Verbally notify building occupants of the need to evacuate the building. Yell or shout “EVACUATE THE BUILDING!” down hallways to spread the word.

1. If it is safe to do so, send someone to a fire alarm pull station in Building A or C to activate the fire alarm.

F. Call 911 and follow any instructions given by dispatcher. Use a cell phone or a land-line telephone away from immediate danger. Also notify EHS (864-4089).
G. Evacuate the building through nearest safe exit
H. Assemble at the southeast corner of CEBC Building B near the driveway (see Figure 1), upwind of facility, and remain there until dismissed by police. If the primary rendezvous point is obstructed or otherwise dangerous, proceed to the secondary rendezvous point at the north driveway between Buildings B and C. Account for everyone in the building by performing a head-count or roll-call.
I. If the emergency/accident happened in your lab, report to Emergency Services Field Command (usually first responding police officer) to provide additional information about the accident. Be sure to notify them if anyone was not able to evacuate the lab due to injury or incapacitation.
J. Report to Building Manager and Lab Safety Director

2.1.2. Chemical Spill or Gas/Vapor Release[1] procedures:

A. Emergency
   1. If spill or gas release results in injury, fire hazard, release outside lab or to environment, involves a toxic or unknown substance, or cannot be controlled by lab personnel, it is considered an emergency
   2. Evacuate lab, closing doors behind you.
   3. Verify evacuation of all lab occupants – check to see if everyone in your lab safely evacuated. NOTE: Do not attempt to check other labs in the building; you just need to know whether anyone in your lab is injured, incapacitated, or otherwise incapable of evacuating and provide that information to first responding emergency personnel. Remember that you must protect yourself first!
   4. Verbally notify building occupants of the need to evacuate the building. Yell or shout "EVACUATE THE BUILDING!" down hallways to spread the word.
      a. If it is safe to do so, send someone to a fire alarm pull station in Building A or C to activate the fire alarm.
   5. Call 911. Also notify EHS (864-4089).
   6. Evacuate the building through nearest safe exit
   7. Assemble at the southeast corner of CEBC Building B near the driveway (see Figure 1), upwind of facility, and remain there until dismissed by police. If the primary rendezvous point is

[1] Many laboratories feature "single-pass air" which means room air is exhausted outside. Some labs and all common areas, however, circulate part of the room air back to the HVAC system, meaning that toxic or flammable vapors may be spread to other parts of the building. Check with the Lab Director or Facilities Manager for specifics on your laboratory or other questions.

obstructed or otherwise dangerous, proceed to the secondary rendezvous point at the north driveway between Buildings B and C. Account for everyone in the building by performing a head-count or roll-call.

8. If the emergency/accident happened in your lab, report to Emergency Services Field Command (usually first responding police officer) to provide additional information about the accident. Be sure to notify them if anyone was not able to evacuate the lab due to injury or incapacitation.
9. Report to Building Manager and Lab Safety Director

B. Non-emergency – follow these instructions if and only if the conditions in Section 2.1.2.A.1. are not met.
    1. Attend to individuals who have been contaminated by spill
    2. Notify others in the area, and evacuate non-essential personnel to safe area away from spill
    3. Open the spill kit provided by EHS and follow the instructions given in the kit to control the volume and/or spread of the spill. Briefly,
        a. Wear proper protective clothing, gloves, safety glasses
        b. Place miniboom around spill to keep it from spreading
        c. Place sorbent pillows on top of spill to absorb chemical
        d. Wipe up remaining chemical with absorbent pads
        e. After spill is absorbed, place all absorbents in the trash bag provided, and place the trash bag in the bucket
        f. Notify EHS for pickup and replacement of the spill kit
    4. If spill is flammable, turn off ignition sources[2]
    5. Avoid skin contact, breathing vapors
    6. Contact EHS for disposal of spilled materials and absorbents
    7. Notify supervisor and Lab Safety Director

2.1.3. Building malfunction procedures:

Building malfunctions include problems with the fume hood, electrical, plumbing, HVAC, etc.

A. If a building malfunction results in a fire, chemical, spill, or other emergency, follow the specific procedures outlined in those sections
B. Take any low risk actions to minimize the effect of the building malfunction (dependent on type of malfunction and type of experiments or equipment affected). An example would be moving volatile chemicals from a malfunctioning fume hood to a working one.
C. Contact Building Manager and follow his instructions
    1. Scott Jeffress 785-864-1675, cell 785-423-1259, beeper 785-691-0258
    2. Mike Beerbower 785-864-1684, cell 785-423-0275, beeper 785-691-0073

[2] Remember that turning on or off electrical switches can also be an ignition source.

2.2 General procedures: These procedures are provided because some emergencies may not fall into the specific categories presented in Section 2.1. These procedures should be generally applicable regardless of the type of accident/emergency encountered.

2.2.1. Building evacuation is required when any of the following occurs:

- Fire: even if put out by a fire extinguisher, evacuate until cleared by fire department to re-enter building
- Chemical spill or gas release that results in a fire hazard, release outside the lab, involves a toxic or unknown substance, or cannot be controlled by lab personnel
- Structural damage to the building
- University officials or emergency personnel require it
- Fire alarm is pulled for any reason
- Any other situation that make the building unsafe or uninhabitable

NOTE: When in doubt, evacuate. Evaluate the situation (with the help of emergency personnel or EHS if applicable) before re-entering the building

2.2.2. Emergency/accident response:

A. If building evacuation is necessary

1. Immediately notify others in the lab of emergency
2. Evacuate lab, closing doors behind you.
3. Verify evacuation of all lab occupants – check to see if everyone in your lab safely evacuated. NOTE: Do not attempt to check other labs in the building; you just need to know whether anyone in your lab is injured, incapacitated, or otherwise incapable of evacuating and provide that information to first responding emergency personnel. Remember that you must protect yourself first!
4. Verbally notify building occupants of the need to evacuate the building. Yell or shout "EVACUATE THE BUILDING!" down hallways to spread the word.
    a. If it is safe to do so, send someone to a fire alarm pull station in Building A or C to activate the fire alarm.
5. Call 911 and follow any instructions given by dispatcher. Use a cell phone or a land-line telephone away from immediate danger. Also notify EHS (864-4089).
6. Evacuate the building through nearest safe exit
7. Assemble at the southeast corner of CEBC Building B near the driveway (see Figure 1), upwind of facility, and remain there until dismissed by police. If the primary rendezvous point is obstructed or otherwise dangerous, proceed to the secondary rendezvous point at the north driveway between Buildings B and C. Account for everyone in the building by performing a head-count or roll-call.

8. If the emergency/accident happened in your lab, report to Emergency Services Field Command (usually first responding police officer) to provide additional information about the accident. Be sure to notify them if anyone was not able to evacuate the lab due to injury or incapacitation.
9. Report to Building Manager and Lab Safety Director

B. If building evacuation is not necessary – follow these instructions if and only if none of the conditions in Section 2.2.1 are met.

1. Immediately notify others in the lab of emergency
2. Take any quick, low risk actions to minimize the emergency
3. Notify supervisor, appropriate emergency personnel
4. Notify Laboratory Director

C. In the event of a medical emergency

1. Immediately notify others in the lab of emergency
2. Call 911 if necessary and follow any instructions given by dispatcher.
3. Keep injured person still and calm
4. Only move the injured person if it is necessary to prevent further harm
5. Do not endanger yourself
6. Assist injured person only if properly trained to administer first aid
7. Notify Laboratory Director
8. Serious work-related injuries must be treated at Lawrence Memorial Hospital. If emergency treatment is required, go to LMH Emergency Room. If it is not an emergency, call the LMH Occupational Health Clinic at 749-6467 to schedule an appointment. An 1101-A accident report must be sent to KU Human Resources.
9. Laboratory Director will assist in submitting accident reports to KU.

General emergency precaution: Protect yourself first! Don't be a hero. Do not attempt to help others if doing so puts you at risk of serious injury. Emergency personnel are on the way, and the fewer people that need rescue/assistance, the better.

3.0 Chemical safety

3.1. **Chemical Inventory** – Lab supervisor has the responsibility to maintain an accurate chemical inventory. Inventory must include, at minimum, chemical name, manufacturer, location, quantity.

- All chemical users should be familiar with inventory CambridgeSoft Inventory software, and must either make updates to the database or provide such information to the lab supervisor

3.2. **Labeling** – All chemical containers, including temporary sample containers, must be labeled with, at minimum, chemical identity and appropriate hazard warning.

- Whenever possible, also include the name or initials of the user, and the date corresponding to the lab notebook entry for the experiment involving that chemical
- Label small sample vials with, at minimum, initials of the user, sample date, and a number or code that allows the sample to be easily and quickly identified by the user (for example, a lab notebook page number or experiment number)
    - If possible, use a secondary container to hold sample vials, and label this container with additional information that cannot fit on the individual vial labels
- It is your responsibility to ensure that your container labels are legible. Frequently check that your labels are not smeared or rinsed off. Re-label if necessary.

3.3. **Compatibility of Materials** – It is the responsibility of the researcher to verify the compatibility of all materials (chemicals, cleaning agents, vessels, and all wetted parts) prior to any experiment.

- Different reactor materials may corrode or catalyze reaction of some reaction systems.
- Verify the types of seals/gaskets used in reaction vessels, pumps, etc. O-rings may swell or dissolve in your reaction system.
- Ensure that any solvents or cleaning agents do not react with residues from your experiment.
- If in doubt, ask your colleagues and do a literature search. If no data are available, plan a small controlled test to ensure materials compatibility.

3.4. **Material Safety Data Sheets (MSDS)** – The lab supervisor must maintain, and students/employees must be able to locate quickly all MSDS forms for the lab. Hard or soft copies of MSDS meet this requirement provided that they are easily and quickly accessible within or near the lab.

- Researchers must read and understand MSDS for each chemical before using it for the first time. Links to online MSDS sheets can be found in the chemical inventory system.
- Additional guidance from EHS: hard copies of MSDS for top 10-20 “most hazardous” chemicals should be available on site.

4.0 Fire prevention and protection

- Use proper extinguisher for a given type of fire. The wrong type of fire extinguisher can either have no effect or a negative effect (fire spreads) on the fire.
    - **Class A** extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics.
    - **Class B** fires involve flammable or combustible liquids such as gasoline, kerosene, grease and oil.
    - **Class C** fires involve electrical equipment, such as appliances, wiring, circuit breakers and outlets. Never use water to extinguish class C fires - the risk of electrical shock is far too great!

    - **Class D** extinguishers are for fires that involve combustible metals, such as magnesium, titanium, potassium and sodium.
- Fire prevention – properly ground all electrical circuits and check wires for worn insulation to avoid sparks; no combustibles near open flames; properly store all waste materials, check experiments before leaving them unattended.

5.0 General laboratory safety

5.1. Helpful reminders:

- Wear safety glasses at all times in the lab
- Be aware of surroundings and especially of nearby lab personnel and equipment. Your safety may depend on whether other lab personnel are working safely. If you see others using unsafe practices, it is your duty to remind them of the correct procedures. Safety only works if each person does his/her part.
- Wear safety glasses at all times in the lab!
- Think first, then act
- Wear safety glasses at all times in the lab!!
- If it doesn't feel safe, don't do it
- Always think about or discuss with your colleagues the potential safety hazards before starting an experiment
- Ask questions if you're not sure about something. PIs and group members are happy to help. No question is a stupid question.
- Wear safety glasses at all times in the lab!!!

5.2. General rules for safety and cleanliness:

- Know lab-specific emergency procedures, including spill cleanup for hazardous materials
- Know location of safety equipment and how to use it
- No food, drink, chewing gum, cosmetics, etc. in the lab
- Keep all chemical containers properly stored in cabinets or drawers unless actively using them
    - Benchtops and hoods should not be used to store chemicals
    - Flammable liquids must be kept in a flammable storage cabinet when you leave your workspace, even for a short time
- Label all chemical containers
- Keep bench tops and labs clean and organized
- Keep drawers and cabinets closed
- Don't block eye-wash areas or other safety equipment
- Keep aisles/walkways clear
- Securely chain all gas cylinders using a chain or approved cylinder strap. Make sure cylinder is secured tightly and above the center-of-gravity (preferably around the top 1/3 of the cylinder).
- Keep cylinder valves closed unless you're using them
- Return tools, glassware, and other general use items to proper storage areas when you're done with them

- Dispose of waste chemicals properly
- Clean up your work area at the end of each lab activity
- Check electricity, gases, and water before you leave the lab
- Turn off the lights when you leave the lab
- No "hand to face or body" contact when working with hazardous materials
- Always dispose of sharps, such as needles or broken glass, in proper waste receptacles

5.3. Hazards should be kept *As Low As Reasonably Achievable* (ALARA), meaning that proper planning and precautions should be taken to minimize exposure and/or risk associated with chemicals or other hazards. Work "well below" any limits for exposure or experiment/equipment stability.

- Use least hazardous equipment, materials, or processes to perform the required task
- Physically isolate the process and/or operator when appropriate
- Provide appropriate exhaust ventilation
- Provide appropriate shielding

- **Standard Operating Procedures (SOPs)** must be developed for all experiments involving hazardous materials or conditions. A template for preparing SOPs is available on the CEBC website, and shown in appendix G.

5.4. Hazardous Materials:

A **hazardous chemical** is any chemical which is or presents a physical hazard – including combustible liquids, explosives, flammable liquids, flammable solids, oxidizers, organic peroxides, pyrophorics (air reactives), water reactives, and unstable reactives – or a health hazard – including carcinogens, corrosives, irritants, hepatoxins, nephrotoxins, neurotoxins, reproductive toxins, hematopoietic system agents, sensitizers, toxic or poisonous agents, and any agent which can damage the lungs, skin, eyes, or mucous membranes. A hazardous chemical becomes a **hazardous waste** when you decide to dispose of it.

- Store and dispose of hazardous materials properly – see Section 8.0 of this lab manual for additional details
    - Follow manufacturer and/or supplier guidelines
        - Check specifically for temperature requirements and aerobic/anaerobic requirements
    - Do not store incompatible materials in the same storage unit
- Use secondary containment (spill trays, flammable storage cabinets, etc.) to protect against container breakage and/or spills
    - If chemicals are stored on open shelves (not cupboards with doors), the shelves must have a 1-inch leak proof lip.
    - Alternatively, the chemicals may be placed in secondary containers such as plastic spill trays.
- Check periodically for container integrity
- Separate incompatible materials

5.5. Housekeeping:

Remember that cleaning and maintenance personnel, as well as emergency responders may need to enter labs after hours when students/faculty are not present. Proper housekeeping (putting away chemicals, maintaining clear walkways, proper disposal of chemicals and materials) provides additional safety for everyone who enters the lab. In addition, we have frequent, unannounced visitors to the lab from industries, who have a keen eye for those who do or do not follow generally accepted safety practices—we should collectively put our best foot forward at all times.

- Always clean up after your experiments (put chemicals, equipment, and glassware in proper storage unit, dispose of garbage, clean equipment, reactors, vessels, and glassware
- Always label chemical containers in the lab
- Do not leave solvent bottles or other chemical containers on the benchtops
- Make sure empty containers are promptly cleaned and disposed of. If you are reusing an empty solvent bottle, remove the old label and clearly label the new contents
- Reduce or eliminate clutter. If you have excessive trash, take it to the dumpster and do not wait for housekeeping
- Clear aisles, exits, access to safety equipment
- Dispose of sharps and broken glass in approved containers. Securely tape closed full glass containers and promptly dispose in dumpster
- Wash hands after working with hazardous materials

5.7. Clothing, personal protective equipment:

5.7.1. Always wear safety glasses/goggles in the lab

A. If you already wear prescription corrective lenses:
   - Standard prescription lenses are not safety glasses unless clearly marked as such
   - Contact lenses are not allowed in the lab
   - Prescription safety glasses must meet ANSI Z87.1 specifications
     - Includes side-shields or wrap-around splash protection
   - Alternatives to prescription safety glasses include wearing standard safety glasses over your prescription glasses or wearing a face shield or goggles over your prescription glasses

B. If you are using hazardous liquids outside of a fume hood, you should wear full goggles or a face shield.

5.7.2. No open toed shoes

5.7.3. Wear lab coat when working with hazardous materials or whenever not wearing full-length pants

A. Do not wear lab coat in break room or where food or drink are present

B. If a lab coat is contaminated from a spill, do not remove/wear coat outside of laboratory

5.7.4. Avoid loose-fitting clothing

5.7.5. Gloves:

A. Select and wear appropriate chemical-resistant gloves when handling hazardous materials (see Appendix B for more information)

B. Gloves are not permitted outside the lab, except as described in item C below
C. If you need to move hazardous materials from one lab to another, ask someone not wearing gloves to escort you. Alternatively, remove one glove and use your bare hand to interact with door handles, light switches, or any other items in the hallway.
D. Remove contaminated gloves before interacting with common equipment such as computers, telephones, etc.
E. Change gloves often and avoid reuse of contaminated gloves
F. Wash hands after removing gloves

5.8. Accident prevention:

- Actively avoid conditions causing splashes or aerosol formation
- No solvent use outside the fume hood
- Use the "buddy system" when working with hazardous materials
- Be aware of surrounding people, experiments, and conditions and encourage others to use good safety practices

5.9. Overnight/weekend experiments, before leaving experiments unattended:

- Obtain permission from supervisor
- Check water lines, electric heaters, other equipment for stability, proper lubrication, appropriate set points, tight connections, etc.
- For high pressure or high temperature experiments, see additional precautions in sections 6 and 7.
- Fill out "Experiment in Progress" form (see Section 5.16 for more details) with contact and hazard information and display prominently near experiment

5.10. After hours policies:

- No new experiments (untried procedures)
- Don't work alone if possible, arrange for periodic checks (at least hourly) otherwise
- No undergrads, REUs, etc. working unsupervised
- Avoid hazardous conditions and materials

5.11. Gas cylinders:

- Keep secured to a wall, bench, or in a cylinder cabinet
  - Secure cylinders individually tightly with a chain or sturdy strap. Loose straps or straps below the cylinder's center of gravity may not prevent it from being knocked over
  - Keep valves closed when cylinders are not in use
  - Small cylinders must also be secured, even when working in a hood or on a bench-top. Seek assistance from the lab director if necessary
- Use a cylinder cart with a safety chain when moving cylinders
- Attach the cylinder cap prior to moving to prevent stem breakage
  - Gas cylinders should always have either a cap or regulator
  - Broken valve stems can turn a cylinder into a missile!

- Do not connect tubing directly to gas cylinders
    - Either a regulator or a shutoff valve must be used at or near the valve stem connection (within 1 foot)
- Inspect the valve connection and gas regulator connection for damage. Once a regulator or valve is applied, check for leaks using the leak testing procedures described in Section 6.0. Do not use excessive force or "Teflon tape" to attach a regulator—both are signs that the connection is damaged.
- Empty cylinders should be capped, tagged as empty, and stored in the outdoor cylinder storage bay. The Laboratory Director should be informed of empty cylinders.
- Cylinders with liquefied gases (CO_2, N_2, Ar, NH_3, etc.) can cause cold "burns" if the liquid leaks—use extra care when opening cylinder valve.
- When using cylinders with toxic gases (CO, NO, etc.), a gas monitor/alarm must be used in the vicinity.
- Cylinders containing flammables (such as hydrocarbons or H_2) should be physically separated from cylinders containing oxidants (such as O_2) by several feet if possible. Compressed air is not considered an "oxidizing" gas because it is not more reactive than the ambient air.
- Ask for assistance if you are uncomfortable with transporting or connecting cylinders.

5.12. Chemical storage cabinets:

- Cabinet doors should be closed unless actively removing or replacing containers
- No more than 60 gallons (~240 liters) of flammable/combustible materials can be stored in an individual chemical storage cabinet
- Acids, bases, and flammable materials should not be stored in a single cabinet. Store each type of material separately so that their vapors do not mix.

5.13. Chemical refrigerators:

- Properly seal and label all containers in the refrigerator
- No food or drinks stored in chemical refrigerator

5.14. Fume hoods:

- Verify that the fume hood is functioning properly (some hoods have a digital air flow monitor, others do not) prior to working in the hood. If there is insufficient air flow, refer to section 2.1.3. If safe to do so, move hazardous chemicals from the non-functioning hood to a working one.
- Must be used for (a) flammable vapors approaching 10% of the lower explosive limit (b) materials of unknown toxicity (c) gases, fumes, vapors, mists, dusts, or odors that are potential irritant or nuisance
- Keep experimental apparatus at least 6 inches from hood face. Elevate 2-3 inches when possible to allow airflow under the apparatus.
- Never put your head into the hood when hazardous materials are present
- Do not use the hood for chemical or equipment storage
- Do not use the hood as a disposal mechanism for volatile materials

- Keep the hood sash as low as practical while working in it, keep fully closed when not actively working in hood
- Follow safety procedures for working at high pressure (including safety shields, see Section 6.0 for more details) when working in the hood. The hood sash will only provide protection if it is down, so if anyone will be working in the hood while the experiment is under high pressure, an additional safety shield is required.
- Working in the hood is no excuse for failure to follow proper safety precautions regarding hazardous materials, high pressure or temperature, or proper lab attire

5.15. Laboratory clean areas

- A laboratory clean area is an area of the lab (e.g. student desk) set aside for use that is free of hazardous materials. Food or drink are not allowed in any part of the laboratory.
- Clean areas must be marked clearly with "CLEAN AREA – NO CHEMICALS ALLOWED."
- Chemical-resistant gloves may not be worn in designated clean areas.
- Hazardous chemicals may not enter the clean areas at any time.
- Boundaries of clean areas should be clearly identified (e.g. bright-colored tape on the floor) to designate the area as clean.

5.16. Personal safety

- Always read MSDS before working with new chemicals
- Always know your nearest building evacuation route

5.17. "Experiment in Progress" sheets are required if any off the following are true:

- Experiment will be unattended for more than 5 minutes
- Experiment is conducted after hours or on weekend (even if attended)
- Experiment involves high pressure (>500 psi), high temperature (>100ºC), hazardous materials (flammable, explosive, acid or base) or any other conditions which could result in an accident or injury to others in the lab

5.18 Laboratory Security

- Some exterior doors to LSRL are unlocked during regular business hours. KUCR staff are responsible for locking and unlocking these doors. CEBC researchers must not unlock or prop open any exterior door.
- Visitors to CEBC should call their host from the entrance telephone to gain access to the building. Visitors to the labs should be escorted at all times.
- Researchers should not allow unknown persons into the building.
- If you see any unfamiliar people in your laboratory, question them to make sure they have proper approval from the Laboratory Director or a supervisor to work in that lab. Contact the Laboratory Director, or 911 if appropriate, if an unauthorized person is in the laboratory.
- Interior laboratory doors should be locked when unoccupied.

- Incoming shipments of hazardous chemicals should be checked in (entered into inventory) and properly stored as soon as possible. Do not leave them at the loading dock.
- Keep the outdoor cylinder cage locked.

6.0 High pressure safety

- High pressure systems should have a manual pressure gauge in addition to electronic pressure measurement in case of computer/power failure
- Always use rupture disks or other pressure-relief devices
    - Use multiple pressure-relief devices if possible
    - Ensure that pressure rating for this device is the lowest (preferably by 10% or more) of all vessel components
    - Should be connected to external vent duct (preferred) or routed to fume hood using tubing rated for high-pressure. Tubing connected to pressure relief device should be secured to bench or apparatus to avoid "whip" action.
    - Ensure that the size of the rupture disk/relief valve/tubing is sufficient. Compressed CO_2 in particular can form dry ice and prevent proper venting in small lines or relief valves.
- Periodically check pressure-relief devices for rust formation, clogging/blockage to ensure it will perform as expected in an emergency
    - Checking every 6 months is appropriate for most experimental equipment, but more frequent checks should be made if the apparatus is exposed to corrosives, viscous liquids, slurries or other high-particulate liquids, or other extreme environments
    - Seek guidance from your advisor and/or the lab safety committee if you are unsure if your experimental conditions require more frequent testing
- Never operate at high pressures without a safety shield (shatter proof fume-hood sash or 1/4-inch minimum Plexiglas enclosure)
    - If the fume-hood sash will not be down while you are working under pressure, an additional safety shield is required.
    - Do not modify experimental apparatus in such a way that the safety shield can not be used.
- Work in the hood or with other adequate ventilation (e.g. "snorkel" hose) in case of vessel rupture
    - Make sure when venting high-pressure/temperature mixtures that you do not have materials that can condense/crystallize in the vent lines or duct work. Use appropriate condensers/crystallizers before venting if necessary.
- Check pressure rating of vessels, windows, valves, rupture disks to ensure compatibility of equipment at high pressure
- High-pressure zones should be separated from low-pressure zones with check valves and/or pressure regulators. Check valves should periodically be inspected/tested for leaks

- Pumps should have functioning over-pressure auto-shut-off alarms. If there is no such function on your pump (some older Isco pumps for example), experiment should not be left unattended
- Always pressure-test vessels before running an experiment
    - **Rupture test:** for vessels that may rupture catastrophically at high pressures, such as windowed vessels, a rupture test is required. Fill the vessel with water to a pressure at least 10% higher than the maximum operating pressure to verify that the vessel and all fittings and windows are secure and do not fail at high pressures. Repair or replace any component that fails this test, and repeat this test until no failures occur. Note: water is recommended for rupture tests because a catastrophic failure such as a broken window will result in only a squirt or trickle of water rather than a burst of pressurized gas.
    - **Leak test:** if the vessel is not prone to catastrophic rupture/failure, or if a rupture test has already been performed, a leak test is required. This test will determine whether material will leak from the vessel under the normal operating conditions. Fill the vessel with helium (or other inert gas) to at least 10% higher than the maximum operating pressure for the vessel and verify that no leaks occur using a TCD-type leak detector/sniffer and/or by checking all fittings and windows using a soap and water mixture (such as "snoop"). Identify and replace or tighten any leaky fittings, and repeat this test until no leaks are detected.

7.0 High temperature safety

- Post an appropriate warning sign near your experimental workspace when high temperatures are used.
- Calculate the maximum adiabatic temperature rise for exothermic reactions, and make sure your apparatus (vessel, seals, tubing) is rated for that temperature
- Never use your hand or body to check the temperature of a heated vessel.
- Work in the fume hood or safety enclosure if possible when heating.
- Properly secure vessels or containers (using ring-stand clamps or other appropriate means) when using hot water/oil baths to avoid accidental spills. Ensure that tubing to or from a circulating temperature bath is secured and leak-free.
- Avoid rapid/extreme temperature changes unless equipment is specifically designed for that purpose. Glassware can crack and fittings/seals may leak if subjected to temperature shocks.
- Allow adequate ventilation when heating glassware to avoid over-pressurization
- Always double-check to make sure heaters are off, and preferably unplugged when not in use
- Always use automatic shutoffs and temperature overrides to prevent overheating and runaway reactions. The temperature override/shutoff must be an independent thermocouple connected to a device that will automatically and irreversibly shut off the heating unit.

- In particularly hazardous reactions an emergency source of cooling should be available to quench run-away reactions, such as flooding the reactor with liquid CO_2.
    - Seek guidance from your advisor and/or the lab safety committee if you are unsure if your experimental conditions require an emergency cooling source
- When practical or when temperatures above 300ºC are used, a second, independent temperature measurement to verify primary thermocouple/measurement is functioning properly. The temperature override/shutoff may also function as the secondary thermocouple.
- Make sure when venting high-pressure/temperature mixtures that you do not have materials that can condense/crystallize in the vent lines or duct work. Use appropriate condensers/crystallizers before venting if necessary.

8.0 Chemical storage, inventory, and disposal

A **hazardous chemical** is any chemical which is or presents a physical hazard – including combustible liquids, explosives, flammable liquids, flammable solids, oxidizers, organic peroxides, pyrophorics (air reactives), water reactives, and unstable reactives – or a health hazard – including carcinogens, corrosives, irritants, hepatoxins, nephrotoxins, neurotoxins, reproductive toxins, hematopoietic system agents, sensitizers, toxic or poisonous agents, and any agent which can damage the lungs, skin, eyes, or mucous membranes. A hazardous chemical becomes a **hazardous waste** when you decide to dispose of it.

8.1. Storage and inventory

CEBC is committed to providing a healthy, safe and secure environment for all of its workers and neighbors. An inventory of all chemicals within the Center is a necessary part of that commitment. The inventory will;

- Assist emergency responders in the event of a fire or other emergency.
- Enable workers to determine the location and extent of hazardous materials.
- Provide a central location for MSDS data for hazardous materials.
- Prevent overstocking of potentially dangerous chemicals.
- Satisfy legal requirements for the reporting of hazardous material storage.
- Provide a quick method of locating chemicals throughout the Center.

The safe storage of chemicals within the laboratory is integral to any laboratory safety policy. Therefore, before the Inventory can be established, it is necessary to review our chemical storage methods. Each laboratory should set up the storage of its chemicals according to the segregation of hazards principle outlined below. Once that is done, a list of storage spaces within the laboratory should be given to the Inventory administrator. This information should include the location, name of location and type of material to be stored at the location. To emphasize the Hazard separation principle, the name of the location should include the storage group type, *e.g. Laboratory 3, Cupboard 6, Shelf 2 (Poisons Non-volatile).* The Inventory administrator will then set up the Inventory database to include all storage spaces within the Center. It will then be the responsibility of the individual laboratory personnel to enter the chemicals into the Inventory database

and maintain its accuracy using the guidelines in the CEBC's "Maintaining the Chemical Inventory" document.

8.1.1 Principles of Safe Chemical Storage.

The proper storage of chemicals controls health and safety hazards posed by chemicals by minimizing risks associated with their accidental release into the laboratory environment. It is designed to prevent; (i) exposure to poisons, (ii) protect flammables from ignition, (iii) separate incompatible materials to prevent their accidental mixing and subsequent reaction.

Basic Storage Principles

- Each chemical should have designated storage place.
- Label chemicals properly.
- Store chemicals away from sun and heat.
- Each stock container of a chemical compound should be returned to its designated storage place after each use.
- **Do not store chemicals on the bench top. Only chemicals in use should be on bench tops.**
- **Do not store chemicals in the fume hood.**
- Flammable liquids must be kept in a flammable storage cabinet when you leave your workspace, even for a short time
- Do not store chemicals in alphabetical order except within "Chemical Storage Groups".
- Do not store chemicals under the sink.
- Liquid chemicals. Be aware that the storage of liquid chemicals is more hazardous than storage of solids.
- Flammable liquids. All containers of flammable liquids should be stored in a flammable cabinet or explosion-safe/proof refrigerator/freezer.
- Peroxide formers. Peroxide forming chemicals must be stored in the flammable cabinets and must be regularly inventoried to track their age.
- Acids and bases should be physically separated. All acids should be stored in a corrosives cabinet. Oxidizing acids (nitric, sulfuric, phosphoric, perchloric) should have secondary containment and, as a group, stored separately from other acids (organic and mineral).
- Poisons. All chemicals should be considered poisons, but those with high toxicity and volatility should be stored in a vented cabinet.
- Refer to Appendix C for additional information on chemical storage groups

8.1.2 Building and Maintaining the Chemical Inventory

When a chemical storage plan for each laboratory is complete and the Inventory Administrator has entered the storage locations into the database, the procedure of entering chemicals into the Inventory can begin.

The software to be used is CambridgeSoft's Inventory 11.0 program. This software should be installed on at least one computer with internet access in each research group. The data will be stored on a remote server. Once Inventory 11.0 is installed and set up,

the responsible person should obtain a username and password from the Inventory Administrator. Once logged on, the storage locations in your laboratory within the database should be noted and checked against the actual storage locations in the laboratory. Any discrepancies should be brought to the attention of the database administrator for correction.

Instructions for using Inventory 11.0 can be found in the Help menu and also online at http://www.cambridgesoft.com.

Entering Chemicals

When entering a new container, as many fields as possible should be completed in the database. Chemical name, location and quantity are a minimum. Using the built in ChemACX database to search for chemicals by CAS number or chemical name will greatly reduce the amount of work necessary to enter the required data.

To facilitate inventory reconciliation, a barcode labeling system is used. A barcode label should be attached to each container and the barcode label number should be entered into the database.

What should be included on the database?

- All chemicals obtained from a commercial source.
- All chemicals stored for as yet unplanned experimental procedures.
    - Examples include catalysts or substrates synthesized in the laboratory. All must be labeled correctly and stored appropriately.

Notes:

Analytical samples.

- Small samples collected for analysis can be stored together and placed on the inventory under a group designation. Individual samples should still be labeled clearly.

Solutions for analysis or synthesis.

- Solutions prepared in the laboratory need not be entered into the database unless they are to be stored for long periods of time. All must be labeled correctly and stored appropriately.

Solvents.

- Quick turnaround containers need not be individually entered into the database, but a total maximum volume for each workspace should be.

8.2. EHS Waste containers

- Only one EHS-approved waste container is allowed per category of waste per lab (halogenated, non-halogenated, aqueous).
- If your waste contains a mixture of halogenated and non-halogenated compounds that are not easily separated or decanted, add entire mixture to halogenated waste container.
- Identity and quantity of materials transferred to the waste container must be logged into the contents data sheet

- Promptly contact EHS when waste container is full:
  - Attach EHS Hazardous Material Label to container: http://www.ehs.ku.edu/files/forms/hazmat/hazmatlabel08092007.pdf
  - Fill out EHS pickup request online: http://www.ehs.ku.edu/documents/ehs_forms/hazardous_materials_pickup_Requests.aspx
  - Data needs: name, location, waste type and contents, container number (if applicable)

8.3. Waste transfer containers

- A waste transfer container may be used to temporarily store small quantities of waste while working. Transfer containers should be emptied into EHS waste containers at the end of each work day.
- Only one waste transfer container is allowed per category of waste (halogenated, non-halogenated, aqueous, solid)
- Reuse or recycle empty containers if possible
  - Clean thoroughly prior to reuse
  - Remove or deface old labels and re-label appropriately
- If container must be disposed:
  - Rinse or clean of hazardous material
  - Remove lids before disposing
  - Place any glass containers smaller than 1 liter in the broken glass disposal bin
  - Place any glass containers larger than 1 liter in the dumpster

8.4. Waste chemicals – includes waste/spent solvents, unknown materials, solid waste, acid/base waste, waste oil, spill cleanup materials, etc.

- Contact EHS for disposal of hazardous or unknown material (unknown wastes are a tremendous headache and possibly costly for EHS. Proper labeling protocols must be followed.)
  - Attach EHS Hazardous Material Label to container: http://www.ehs.ku.edu/files/forms/hazmat/hazmatlabel08092007.pdf
  - Fill out EHS pickup request online: http://www.ehs.ku.edu/documents/ehs_forms/hazardous_materials_pickup_Requests.aspx
  - Data needs: name, location, waste type and contents, container number (if applicable)

9.0 Items that should be available in or near every lab:

- Telephone
- Fire extinguisher
- Safety shower
- Eyewash station
- First aid kit

- Spill kit
- Broken glass disposal bin
- Sharps disposal bin (if appropriate)
- MSDS for top 10-20 “most hazardous” materials
- Safety map showing location of nearest safety equipment and emergency evacuation routes (preferably also shows chemical storage locations and other permanent hazards)

Appendix A: Lab safety training

A.1 Introduction

This document is a checklist of the minimum safety training requirements needed before laboratory personnel are allowed to start work at the CEBC. It shall be provided to all personnel before beginning laboratory work and annually thereafter at the safety training seminar. Completion of the required tasks should be acknowledged by initialing each item on the line to the left. The completed form should be given to the Laboratory Director.

A.2 For new researchers

1. Read, understand and follow the CEBC laboratory safety manual
2. Read standard Operating Procedures and Practices for Laboratories Using Chemicals in Part II-Chpt 2, Sec 2.3-2.4 in Reference 2
3. Read safety procedures for any compound you work with which falls under a specific chemical hazard class identified in Part II-Chpt 2, Sec 2.5-2.8 in Reference 2
4. Read medical factors to consider for chemical safety Part II-Chpt 5 in Reference 2
5. Read safe Disposal of Hazardous Chemical Waste Part II-Chpt 6 in Reference 2
6. Take complete on-line fire extinguisher training at: www.fireextinguisher.com and get a certificate
7. Attend EHS Web-Based Laboratory Safety Training, such as:
   (EHS TM 10) -- General Campus Safety and Emergency Procedures.
   (EHS TM 15) -- Chemical Hazard Communication & Safety
   (EHS TM 18) -- Lab Safety Awareness
8. Take the Lab safety training quiz and sign the training documentation form
9. Turn in the certificate and the signed training form to Lab director

A.3 For continuous researchers

1. Read the CEBC laboratory safety manual annually
2. Attend lab safety training seminar
3. Sign the updated training document

A.4 References

1. CEBC laboratory safety manual

2. Lab Safety Manual
   http://www.ehs.ku.edu/Documents/ehs_manuals/lab_safety_manual/index.aspx

3. Requirements for Gas Cylinder Safety
   http://www.ehs.ku.edu/Files/Forms/Lab_Safety/2008_GasCylinders.pdf

Appendix B: Glove selection

Many types of chemical-resistant gloves are available. No gloves are perfect for every chemical. For some chemicals, multiple types of gloves may perform equally well. More likely, several types of gloves will provide varying levels of protection for a given chemical.

Types of gloves typically found in chemical laboratories:

- Butyl – good choice for aldehydes, ketones, esters, and water vapors
- Silver Shield – laminated material resistant to a wide range of toxic and hazardous chemicals. Wear under reusable gloves.
- Viton – resistant to chlorinated and aromatic solvents, gas and water vapors, and polycholorinated biphenyls (PCBs)
- Nitrile – wide range of chemical resistance, as well as puncture and abrasion resistance; this is the most common glove worn by CEBC personnel.
- Neoprene – resistant to acids, caustics, and alcohols
- PVC – resistant to acids and alcohols, but not to organic solvents
- Natural rubber/Latex – **minimal chemical resistance**, but frequently used for biological applications

Important variables to consider in glove selection:

- Degradation – will the chemical degrade or destroy the glove?
- Breakthrough time – how long can the glove provide protection when exposed to the chemical?
- Permeation rate – what is the steady state flow of the chemical through the glove?

To choose the appropriate gloves for a specific chemical, consult the MSDS for that chemical and/or refer to the following websites:

- http://www.northsafety.com/ClientFormsImages/NorthSafety/CorpSite/E8D15F2E-1F59-454F-B8F0-147FA2B9D81D.pdf
- http://www.des.umd.edu/ls/gloves.html
- http://www.directsafety.com/tech/glovechemchart.html

Appendix C: Chemical storage groups

There are many methods used to satisfy the principle of Hazard Separation in chemical storage. The information below outlines one method. In this plan there are nine storage groups. Seven of these groups cover storage of liquids because of the wide variety of hazards posed by these chemicals. Specific instructions must be followed for metal hydrides (Group VIII) and certain individual compounds, but otherwise, dry solids are in Group IX.

Many liquid chemicals pose hazards that correspond to more than one storage group. These chemicals should be stored in the lowest group number.

Group I Flammable Liquids

Group II Poisons - volatile

Group III Acids - Oxidizing

Group IV Acids - Organic and Mineral

Group V Bases - Liquid

Group VI Oxidizer - Liquid

Group VII Poisons - Non-volatile

Group VIII Reactives

Group IX Solids

Storage Group Definitions

Group I ***Flammable Liquids***

Includes liquids with flashpoints < 100 F. Examples: all alcohols, acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, hexane, hydrazine, methyl butane, picolene, piperidine, propanol, pyridine, all silanes, tetrahydrofuran, toluene, triethylamine, xylene

Primary Storage Concern: To protect from ignition

Recommended Facilities/Measures:
1. Flammable cabinet
2. Refrigerator: for containers less than 1 liter.

Compatible Storage Groups: Volatile poisons may be in the same compartment of the flammable cabinet as flammables if bases are not present.

Group II ***Volatile Poisons***

Includes poisons, toxics and known and suspected carcinogens with strong odor or evaporation rate greater than 1 (butyl acetate = 1): Examples: carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formal dehyde, mercaptoethanol, methylene chloride, phenol.

Primary Storage Concern: To prevent inhalation exposures.

Recommended Facilities/Measures:
1. Vented flammable cabinet
2. Refrigerator: for containers less than 1 liter.

Compatible Storage Groups: Volatile poisons may be in the same compartment of the flammable cabinet as flammable if bases are not present.

Group III ***Acids – oxidizing***

All oxidizing acids are highly reactive with most substances and each other. Examples: nitric, sulfuric, perchloric, phosphoric acids, and chromic acids.

Primary Storage Concern: Preventing contact and reaction with each other and other substances and corrosive action on surfaces.

Recommended Facilities/Measures:
Safety Cabinet. Each oxidizing acid must be double-contained (the primary container must be kept inside a canister or polyethylene/polypropylene tray or tub).

Compatible Storage Groups: Oxidizing acids must be double-contained and should be segregated in their own compartment in a safety cabinet. When quantities are small (e.g., 1 or 2 bottles) they do not warrant a separate compartment. Small quantities may be double-contained and stored with Group IV Organic and Mineral Acids. Store oxidizing acids on bottom shelf below Group IV.

Group IV ***Organic and Mineral Acids***

Examples: acetic, butyric, formic, glacial acetic, hydrochloric, isobutyric, mercaptoproprionic, proprionic, trifluoroacetic acids.

Primary Storage Concern: To prevent contact and reaction with bases and oxidizing acids and corrosive action on surfaces.

Recommended Facilities/Measures:
Safety cabinet.

Compatible Storage Groups: Small amount of double-contained oxidizing acids can be stored in the same compartment with organic acids if the oxidizing acids are stored on the bottom shelf. Exceptions: acetic anhydride and trichloroacetic anhydride are corrosive. These acids are very reactive with other acids and should not be stored in this group. It is better to store these with organic compounds as in Group VII Non-volatile Liquid Poisons.

Group V ***Liquid Bases***

Examples: sodium hydroxide, ammonium hydroxide, calcium hydroxide, glutaraldehyde

Primary Storage Concern: Preventing contact and reaction with acids.

Recommended Facilities/Measures:
1. Safety cabinet;
2. In tubs or trays in normal cabinet.

Compatible Storage Groups: Liquid bases may be stored with flammables in the flammable cabinet if volatile poisons are not also stored there.

Group VI ***Oxidizing liquids***

Examples: ammonium persulfate, hydrogen peroxide (if greater than or equal to 30%)
Primary Storage Concern: To isolate from other materials since they react with everything potentially causing explosions or corrosion of surfaces.

.

Recommended Facilities/Measures:
1. Total quantities exceeding 3 liters should be kept in a cabinet housing no other chemicals.
2. Smaller quantities must be double-contained if kept near other chemicals, e.g., in a refrigerator.

Compatible Storage Groups: None

Group VII ***Non-Volatile Liquid Poisons***

Includes highly toxic (LD50 oral rat < 50 mg/kg) and toxic chemicals (LD50 oral rat < 500 mg/kg), known carcinogens, suspected carcinogens and mutagens Examples: acrylamide solutions; diethylpyrocarbonate; diisopropyl fluorophosphate; uncured epoxy resins; ethidium bromide; triethanolamine

Primary Storage Concern: To prevent contact and reaction with other substances.

Recommended Facilities/Measures:
Cabinet or refrigerator. Do not store on open shelves in the laboratory. Liquid poisons in containers larger than 1 liter must be stored below bench level on shelves closest to the floor. Smaller containers of liquid poison can be stored above bench level only if behind sliding (non-swinging) doors.

Compatible Storage Groups: Non-hazardous liquids (e.g., buffer solutions).
Exceptions: Anhydrides, e.g., acetic and trichloroacetic, are organic acids, however it is better to store with this group than with Group IV Organic Acids, since they are highly reactive with other organic or mineral acids.

Group VIII ***Reactives Metal Hydrides and Pyrophorics***

Examples of metal hydrides; sodium borohydride, calcium hydride, lithium aluminum hydride. Other pyrophorics are boron, diborane, dichloroborane, 2-Furaldehyde, diethyl aluminum chloride, lithium, white or yellow phosphorus and trimethyl aluminum. Other water reactives include aluminum chloride-anhydrous, calcium carbide, acetyl chloride, chlorosulonic acid, sodium, potassium, phosphorous pentachloride calcium, aluminum tribromide, calcium oxide, and acid anhydrides.

Primary Storage Concern: To prevent contact and reaction with liquids and, in some cases, air. Most metal hydrides react violently with water, some ignite spontaneously in air (pyrophoric).

Recommended Facilities/Measures:
1. Secure, water-proof double-containment according to label instructions.
2. Isolation from other storage groups.

Compatible Storage Groups: If securely double-contained to prevent contact with water and/or air, metal hydrides may be stored in the same area as Group IX Dry Solids.

Group IX ***Dry Solids***

Includes all powders, hazardous and non-hazardous. Examples: benzidine, cyanogen bromide, ethylmaleimide, oxalic acid, potassium cyanide, sodium cyanide

Primary Storage Concern: To prevent contact and potential reaction with liquids.

Recommended Facilities/Measures:
1. Cabinets are recommended, but if not available, open shelves are acceptable.
2. Store above liquids.
3. Warning labels on highly toxic powders should be inspected and highlighted or amended if they do not cause the containers to stand out against less toxic substances in this group.
4. It is recommended that the most hazardous substances in this group be segregated.
5. It is particularly important to keep liquid poisons below cyanide-or sulfide-containing poisons (solids). A spill of aqueous liquid onto cyanide - or sulfide - containing poisons would cause a reaction that would release poisonous gas.

Compatible Storage Groups: Metal hydrides, if properly double-contained may be stored in the same area.
Exceptions: Solid picric or picricsulfonic acid can be stored with this group, but should be checked regularly for dryness. When completely dry, picric acid is explosive and may detonate upon shock or friction. Picric acid in contact with some metals may form explosive metal picrates. Use non-metal caps.

Appendix D. Experiment in Progress sheet

Experiment in Progress

Name/emergency phone# _____

Alt. name/emergency phone# _____

Lab notebook name/page number _____

Start date/time _____

End date/time _____

Extra hazard: Yes/No

SPECIFY HAZARD(S):

___ Flammable ___ Explosive

___ High pressure ___ Toxic fumes

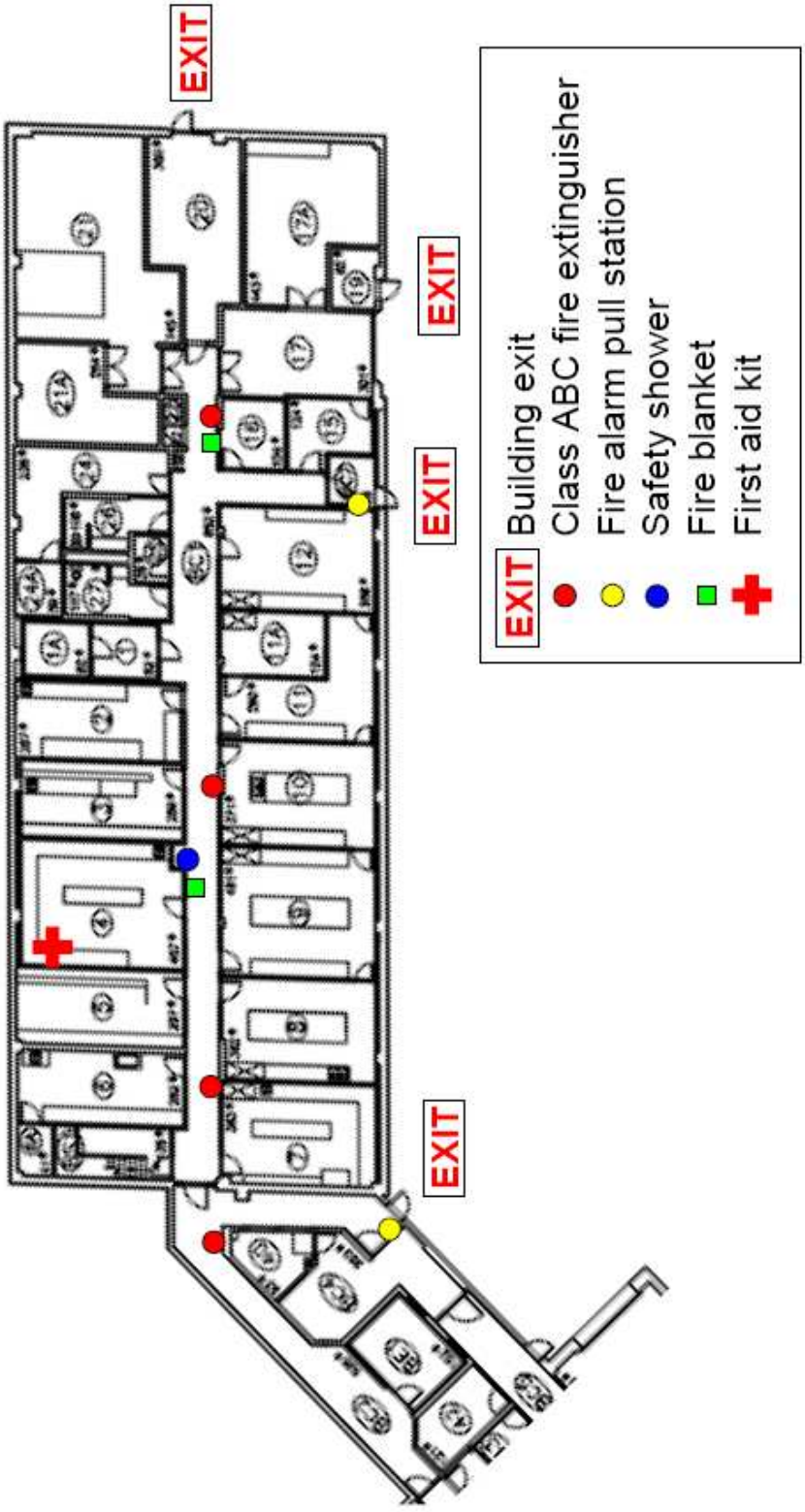
___ High temperature ___ Strong acid

___ Potential water leak ___ Strong base

___ Other: _____

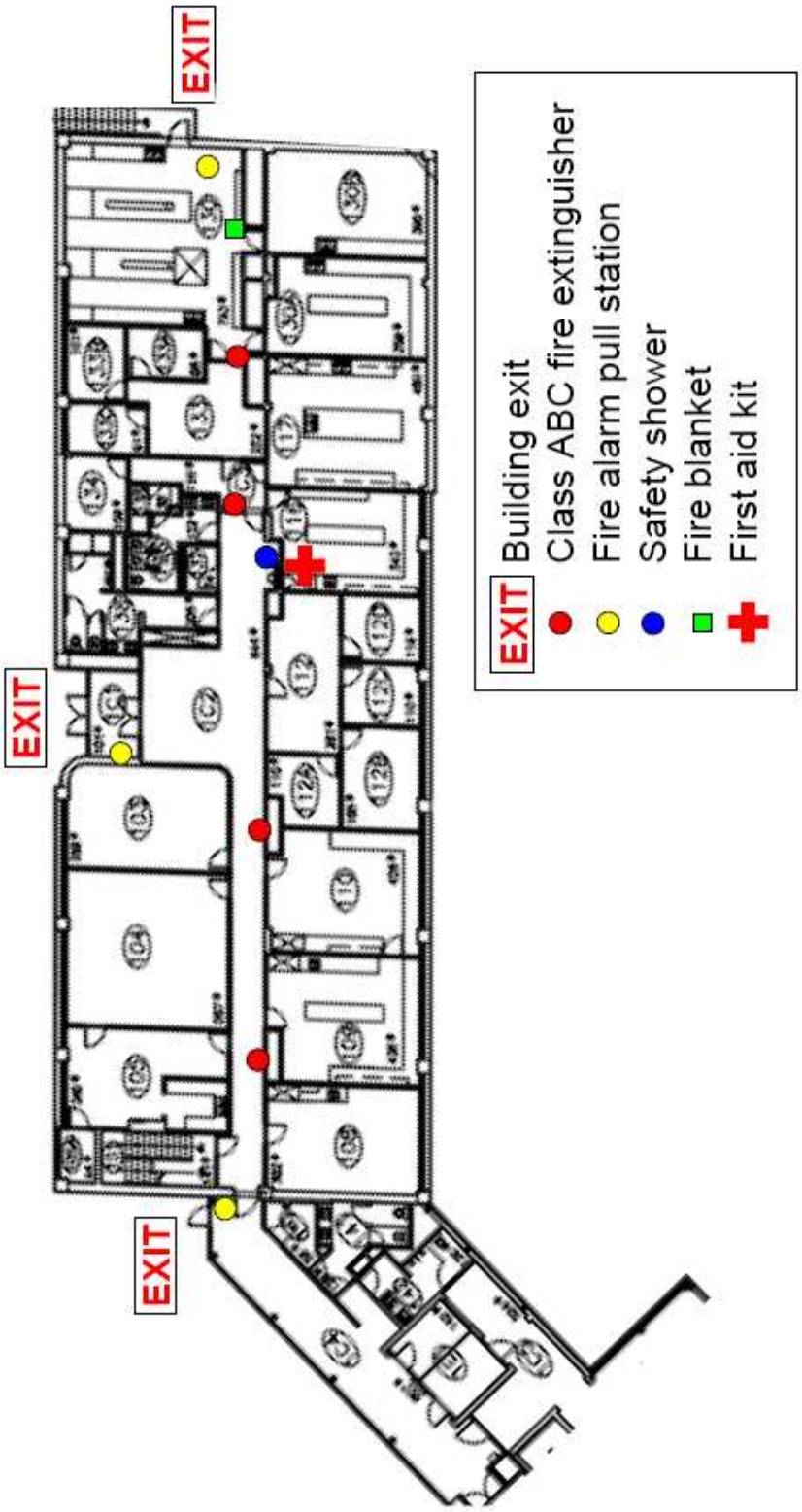
EXPERIMENT DESCRIPTION:

Appendix E. Building maps



CEBC Building B & C (basement)

Appendix E. Building maps (continued)



CEBC Building B & C (first floor)

Appendix F. Laboratory Inspection Report
Electronic version available at https://argon.cebc.ku.edu/resources/safety.shtml

Laboratory Inspection Report

Enter Lab # please select, Inspected by lyon, 7/21/2009

Inspection Item		Status		
Housekeeping		OK	Problem Corrected	Follow-up Needed
1	General tidiness: bench tops and hoods free of clutter	☑	☐	☐
2	Aisles and exits kept clear (32 inches of clearance) of obstructions	☑	☐	☐
3	Hazardous Waste: only EHS-issued waste containers used, properly labeled, only one waste container per type (halogenated, non-halogenated, aqueous) per lab (except 130); waste contents tracked	☑	☐	☐
4	Empty bottles or containers, broken equipment, and trash discarded	☑	☐	☐
5	Sharps, broken glass, needles disposed in proper container	☑	☐	☐
6	All chemicals and samples properly labeled, stored and grouped by hazard class (Flammable, Corrosive, etc.), with updated electronic chemical inventory available	☑	☐	☐
Equipment		OK	Problem Corrected	Follow-up Needed
7	Eyewash tested (flushed for 1 minute) and area kept clear	☑	☐	☐
8	Fire extinguisher charged and not obstructed	☑	☐	☐
9	Chemical spill kit available	☑	☐	☐
10	No electrical hazards (overloaded power outlets, damaged power cables, exposed connections etc.)	☑	☐	☐
11	Gas cylinders secured to bench or wall; closed when not in use	☑	☐	☐
12	Fume Hood /ventilation ports functioning	☑	☐	☐
13	Equipment logbooks available and up-to-date, equipment manuals/training materials available	☑	☐	☐

	Operation	OK	Problem Corrected	Follow-up Needed
14	Personal Protective Equipment (safety glasses, gloves, etc.) being used properly	☐	☐	☐
15	Lab users following faculty-approved standard operating procedures (SOPs)	☐	☐	☐
16	No food or drink in the lab	☐	☐	☐
17	"Unattended experiment" signs being used/updated	☐	☐	☐
18	Emergency contact list posted and up-to-date	☐	☐	☐
19	Hard-copy MSDS sheets available for 10 most hazardous chemicals in lab, web-access to other MSDS sheets	☐	☐	☐
20	Lab doors, drawers, and cabinets kept closed	☐	☐	☐

Comments:

Note: This inspection report will be available to all registered CEBC users. Do not name individuals in this form.

Submit Report

Appendix G. Lab Safety Evaluation Checklist

University of Kansas
Department of Environment, Health & Safety
Laboratory Safety Program

Lab Safety Evaluation Checklist

Auditor: _____ Date: _____
Building: _____ Room: _____
Department: _____
Faculty / PI: _____ Phone: _____
Authorized Lab Supervisor: _____ Phone: _____
Alternate Emergency Contact: _____ Phone: _____

General Safety Level: ○ 1 ○ 2 ○ 3 ○ 4

Lab Hazards: ☐ Radiation ☐ Biohazards ☐ Chemicals ☐ Physical ☐ Lasers
Lab Category: ☐ Research ☐ Support ☐ Academic/Teaching
Lab Scope of Work: _____

This checklist represents an evaluation of general safety and chemical hygiene/safety within the lab based on the KU Laboratory Safety Manual. Policies and procdures reflected in this checklist may be more stringent than minimum standards defined in regulatory compliance documentation. See Lab Safety Evaluation Study Guide for detailed explanation and training assistance.

Submit completed form for review and approval:
Department of Environment, Health & Safety
University of Kansas, 140 Burt Hall
Attention: Laboratory Safety Audit

LAB SAFETY EVALUATION CHECKLIST (Part I)

Lab Practices (A - Acceptable, N - Needs Improvement, NA - Not Applicable)	A	N	n/a
1. PPE available, in proper working condition, and used appropriately. (Eg: Gloves worn only in lab) -- _____	○	○	○
2. Safety Glasses worn at all times while in lab. Per Kansas Statute 72-5207.	○	○	○
3. Lab benches and fume hoods free of clutter and excess materials.	○	○	○
4. Aisles and exits free from obstructions.	○	○	○
5. Empty containers, boxes, broken equipment are properly discarded.	○	○	○
6. Lab door is kept closed for fire safety and proper lab ventilation.	○	○	○
7. No food or drink in lab.	○	○	○
8. Motor/Drive belts are covered on all equipment.	○	○	○
9. Power cords in good condition. (Power strips, extensions, flammable use areas, cord size, etc.)	○	○	○
10. Sharps, needles, broken glass, either sheathed or placed in approved waste containers.	○	○	○

For more information, please visit the EHS website, http://www.ehs.ku.edu/, or call 864-4089.

rev. 12/2007 Page 1 of 2

LAB SAFETY EVALUATION CHECKLIST (Part II)

Manuals and Training Records A - Acceptable, N - Needs Improvement, NA - Not Applicable	A	N	n/a
11. Lab Registration form on file with EHS.	○	○	○
12. Regular training conducted and documents on file.	○	○	○
13. Personnel familiar with Lab Safety Manuals and their locations.	○	○	○
14. Personnel familiar with Lab Specific Standard Operating Procedures and their locations.	○	○	○
15. Material Safety Data Sheets on file.	○	○	○
Signs			
16. Clean areas identified.	○	○	○
17. Emergency Contact list posted in lab and on entrance to lab.	○	○	○
18. Lab Entrance Posting at entrance to lab. (Contact EHS for assistance.)	○	○	○
19. Lab refrigerators, freezers, microwaves labeled "Not for Food & Flammable Liquids".	○	○	○
Safety Equipment			
20. Fire extinguisher in designated location, accessible, and inspected annually.	○	○	○
21. Approved eye wash available and accessible with documented weekly flushing.	○	○	○
22. Safety shower available and accessible with EHS documented annual flushing.	○	○	○
23. Adequate spill kit present.	○	○	○
24. Adequate first aid kit present.	○	○	○
25. Fume hood performance not impeded and has documented annual EHS inspection.	○	○	○

LAB SAFETY EVALUATION CHECKLIST (Part III)

Chemical Use and Storage A - Acceptable, N - Needs Improvement, NA - Not Applicable	A	N	n/a
26. Solvent stills are properly protected and/or enclosed.	○	○	○
27. Hazardous materials are separated by hazard class.	○	○	○
28. Hazardous materials are stored in appropriate cabinets.	○	○	○
29. Current Chemical Inventory List is readily available.	○	○	○
30. High pressure gas cylinders are capped, secured and transported safely.	○	○	○
31. Shelves storing chemicals have 1" leak-proof lips or secondary containment.	○	○	○
32. All chemicals and samples are labeled correctly and completely.	○	○	○
33. No flammable liquids stored in "regular" refrigerators.	○	○	○
34. Lab coordinates with EHS for shipping hazardous materials.	○	○	○
Chemical Waste			
35. One waste container per waste type per location.	○	○	○
36. EHS laminated label on waste solvent cans.	○	○	○
37. Waste containers marked "Hazardous Waste".	○	○	○
38. Full Waste cans have a correctly marked EHS Hazardous Materials Label.	○	○	○
39. Waste transfer containers marked, "Hazardous Waste, Transfer Container, Empty Daily".	○	○	○
40. Waste containers closed.	○	○	○

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Appendix H: SOP Template

CEBC Standard Operating Procedure

Section A: Summary Information

A1. Procedure ID[3]: 000-000
A2. Prepared By: Name
A3. Approved By (supervising PI): Name
A4. Approval Date: Date
A5. Replaces Procedure # (if applicable): N/A

A6. Title of Procedure/Experiment: Title.

A7. Location: Room.

A8. Special Training Requirements: Standard CEBC Training

A9. Summary of Safety Hazards (List)

- *i. Flammable Chemicals*: None
- *ii. Toxic/Carcinogenic Chemicals*: None
- *iii. Acids or Bases*: None
- *iv. Explosive/Pyrophoric Chemicals*: None
- *v. Extreme (High/Low) Temperature/Pressure*: None
- *vi. Moving Parts/Mechanical Hazards*: None
- *vii. Electrical Hazards*: None
- *viii. Lasers, Radiation, or Radioisotopes*: None
- *ix: Biological Hazards*: None
- *x. Other*: None

A10. Personal Protective Equipment Required: None

A11. Special Emergency Procedures (Spills, Exposure, First Aid, etc.): None

A12. Special Storage or Disposal Procedures: None

A13. Does the description of this procedure constitute potential intellectual property? No

[3] Each researcher should create a unique SOP number using his/her 3-digit ID number, followed by a dash, and then followed by a thee digit number given by the researcher. For example, researcher #30 will create SOPs 030-001, 030-002, etc. Contact Chris Lyon if you do not know your ID number.

Section B: Procedure Description

If this procedure contains potential intellectual property, this section will be held confidential, and only Section A will be placed in the CEBC SOP Library. The SOP should be written broadly enough that a new procedure is not *required for every experiment, but not so broadly that potential safety hazards go unidentified.*

B1. Brief description of the purpose of the procedure:

B2. Please list the step-by-step procedures in the table below[4]:

Step	*Description, hazards, and safety measures*
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

[4] Add as many rows as necessary. If any steps require special attention or involve specific hazards, please note these **in bold type**. Feel free to break the procedure into sections (preparation, start-up, shut-down, clean-up, etc.) to improve readability. If you wish to include drawings, photos, *etc.* to help illustrate the procedure, you may paste those at the end of this document, being sure to clearly number and cross-reference the figures.