

Faber Lab Safety Procedures

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Safety Officer

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Purpose

The purpose of this procedure is to support work practices for protecting laboratory personnel from potential health hazards in the laboratory.

1. Laboratory Safety Guidelines

1.1 GENERAL LABORATORY SAFETY

- Do not eat, drink, or apply cosmetics in the lab.
- Store food and drink in food-designated refrigerators only. Don't mix chemical and food storage.
- Tie back medium length and long hair when working near flames or entangling equipment.
- All accidents, no matter how minor, should be reported to the faculty/staff member supervising the laboratory.
- Know the location of all safety equipment (e.g. eyewash, fire extinguisher, safety showers, spill kit) if available.
- Keep aisles clear.
- Maintain unobstructed access to all exits, fire extinguishers, electrical panels, emergency showers, and eyewashes.
- Do not use corridors for storage or work areas.
- Do not store heavy items above 6 feet high.
- Work in the lab during times when campus EHS staff are not on campus (eg; after business hours or on weekends or holidays) should be limited. If unavoidable, use the buddy system: If working after hours and:
 - Experiment is minimally hazardous (eg; microscopy, mass measurements, polishing, etc.) ensure at least one other safety-trained lab member is aware (via text or call) of your presence in the lab during the experiment to arrive and assist in the event of an emergency after hours.
 - Experiment is moderately hazardous (eg; use of diamond saw, solvents, torches, etc.) ensure at least one other safety-trained lab member is in the lab or on campus during the experiment. That member should check in with you every 30 minutes. If your buddy doesn't hear from you, they should go to the lab to assist.
- **No hazardous experiments should be undertaken when working alone in the laboratory or when campus EHS staff are not on campus.** All work with hazardous materials or operations must be approved by the Principal Investigator or lab manager, and must be conducted using the "buddy" system. See sections 1.9.1 and 2.1 for more detail regarding specific hazardous experiments.

- In keeping with the buddy system, undergraduate researchers are not permitted to work in the lab during times when campus EHS staff are not on campus (eg; after business hours or on weekends or holidays)
- Keep area clean and uncluttered; clean up area upon completion of task or at end of the day.

1.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Review standard operating procedures, safety data sheets and other hazard information to determine appropriate PPE to wear based on chemical hazards encountered.
- Remove gloves and lab coats when leaving the laboratory, so as not to contaminate doorknobs, etc.
- Wear closed toed shoes and long pants when performing lab work.

1.3 ELECTRICAL SAFETY

- Don't use permanent extension cords.
- Don't daisy chain power strips.

1.4 FUME HOODS

- Ensure the fume hood is labeled with a certification date of less than one-year prior.
- Maintain hood sash at or below the maximum height indicated by an arrow on the side of the fume hood. Close the hood sash when not working in the hood.
- Equipment used in hoods should be placed securely on blocks to allow air to flow under and around the equipment.
- Keep chemical sources and equipment at least six inches away from the face or rear of the hood.
- Don't store equipment and chemicals in the hood to avoid dead air spaces and to prevent blocking back baffles.
- Visually inspect baffles (openings at the top and rear of the hood) to be sure slots are open and unobstructed.
- All electrical devices should be connected outside the hood to avoid sparks that may ignite a flammable or explosive chemical.
- Do not use a fume hood for any function which it is not intended. Certain chemicals or reactions require special constructed hoods. Examples are perchloric acid or high pressure reactions.
- If you are not sure if there is sufficient airflow in your fumehood due to extra equipment, please contact the EHS Office and we will perform a survey for you.

1.5 CHEMICAL SAFETY

- Know the hazards of the chemicals you're working with. Consult the material safety data sheet (MSDS) or other appropriate references prior to using a chemical with which you're unfamiliar.
 - MSDS forms for all chemicals should be added to the binders in the NE corner of Keck 336
- Make sure all chemicals are clearly and currently labeled with the substance name.
- Use volatile and flammable compounds only in a fume hood. Procedures that produce aerosols should be performed in a hood to prevent inhalation of hazardous material. Be sure the fan is on at all times when using a fume hood. Fume hoods should not be used for storage.
- Material Safety Data Sheets (MSDS) shall be provided for all hazardous chemicals before use.
- Keep proper records of time sensitive chemicals (oxidizers, THF, and organic peroxides), and dispose of all these chemicals before their expiration date.
- Perform proper housecleaning of your lab area once a year to discard of unused chemicals and materials. General chemicals that have been around for three years or more should be discarded.
- Provide a check in procedure for incoming researchers and visiting researchers. Review safety and operational procedures with them.
- If a researcher will be leaving Caltech, please go through a check out procedure with your researcher (visiting and otherwise) that all chemicals and related materials are also properly disposed of, prior to them leaving Caltech. This helps to avoid any unknowns in your lab area, which are difficult to manage by the Institute.
- Clean up of large spills should not be attempted. Call Environmental Health and Safety Office at 6727 for clean up.

1.5.1 FINE POWDERS AND NANOMATERIALS (NANO/MICRO-SIZED POWDERS)

- Treat nano- and micro-sized powders as inhalation hazards; minimize dust generation and avoid creating aerosols.
- Perform weighing, pouring, and transfers inside a functioning fume hood (sash as low as practical) or a ventilated/HEPA-filtered enclosure; keep containers closed when not in use.
- Use wet methods where feasible (e.g., wet wipe, dampened towels) to prevent resuspension; do NOT dry sweep or use compressed air. Use a HEPA vacuum only if approved for fine powders.
- Label containers clearly and store powders in sealed containers with secondary containment; transport powders in closed secondary containers.

- PPE baseline: safety glasses/goggles, lab coat, gloves; consider a face shield for splash/impact hazards. If airborne dust is possible, use a P100 respirator within the institute respiratory protection program (medical clearance + fit test + training required).
- Spills: isolate area, prevent foot traffic/air currents, wet-wipe/HEPA-vac cleanup as appropriate, and dispose cleanup materials as hazardous waste when applicable.

1.6 FLAMMABLE AND COMBUSTIBLE LIQUIDS

- Use fire-hazard chemicals in vented hoods and away from sources of ignition. Fire-hazard chemicals are chemicals with a flash point below 200° F (93.3° C).
- Store flammable liquids in excess of 10 gallons in approved flammable liquid storage cabinets.
- Follow proper storage procedures for flammable and combustible liquids. This includes not storing corrosives and flammables in the same cabinet.

1.7 CORROSIVE AND CONTACT-HAZARD MATERIALS

- Corrosive, allergenic, and sensitizer information is given in MSDS and on chemical container labels.
- Handling processes should be designed to minimize the potential for splash, splatter, or other likely scenarios for accidental contact. Handle corrosive chemicals and contact-hazard chemicals with all proper safety precautions according to the way they will be used. This may include wearing both safety goggles and face shield, gloves tested for absence of pinholes and known to be resistant to permeation or penetration, and a laboratory apron or laboratory coat. Additional protective clothing (i.e., apron, oversleeves) is appropriate where chemical contact with body and/or skin is foreseeable.
 - Do not pour water into acid. Slowly add the acid to the water and stir.
 - Open bottles or carboys slowly and carefully and wear protective equipment to guard hands, face, and body from splashes, vapors, gases and fumes.
 - Use a mechanical aid or a pipette bulb for pipetting.
 - Wipe drips from containers and bench tops. Be especially careful to wipe up visible residues of sodium hydroxide and potassium hydroxide from all surfaces. Skin contact with dry residue will result in burns.
 - Acids/bases are to be handled in a fume hood. A fume hood in the Northwest corner of lab, behind the containment berm, is designated for acid/base use.
 - Corrosives should always be stored with secondary containment and never above eye level.

- The following items should be stored separately:
 - Segregate acids from bases.
 - Segregate inorganic acids from organic acids and flammables.
 - Segregate all acids from reactive metals (e.g. sodium, potassium, magnesium).
 - Segregate acids from azides and cyanides to prevent adverse reactions.

1.8 PEROXIDE FORMING CHEMICALS

Peroxide forming chemicals (PFCs) are organic compounds that may form potentially explosive organic peroxides through exposure to air over time. Many of these chemicals are common solvents and care must be taken in managing these chemicals to prevent the formation of peroxides.

- All solvents should be checked to see if they belong to peroxide forming chemicals. Common peroxide forming materials include ethers, amides, alkynes and 1, 4-dioxane. Please see the attached tables for examples of peroxide forming materials.
- In this lab, we have only used 1, 4-dioxane (class-2 peroxide-forming chemicals). The following guidelines are for class 2. If other classes of PFCs are used, please contact the safety officer.
- All peroxide forming chemicals **must** be marked with the **receiving date** and **opening date**.
- Class-2 PFCs should be disposed of within 12 months of opening, and tested monthly for peroxides starting 3 months from opening if uninhibited by stabilizers (e.g. hydroquinone and BHT).
- Use in a well-ventilated area or in a fume hood.
- Proper PPE (gloves, lab coat, eyewear, long pants and closed-toed shoes) should be used when handling PFCs. Wash hands thoroughly after handling PFCs.
- Keep containers closed when not in use.
- Peroxide forming chemicals should be stored in airtight containers in a dark, cool, and dry place.
- Most PFCs are flammable organic liquids so the precautions for handling flammables applies to PFCs as well.
- If old containers of peroxide formers are found in the lab (greater than 2 years old, or if the date is unknown) do not handle the container. If there is any sign of peroxide formation, such as discoloration, cloudiness, crystal formation anywhere in or on the bottle, do not handle the container and contact EH&S immediately at x6727. Please see the Chemical Hygiene Plan for spill and accident procedures.

Class 1 PFCs		
Isopropyl ether	Potassium amide	Vinylidene chloride
Divinyl acetylene	Potassium metal	

Divinyl ether	Sodium amide	
Class 2 PFCs		
Acetaldehyde	Diethyl ether	4-Methyl-2-pentanone
Cumene	1,4-Dioxane	Tetrahydrofuran
Cyclohexene	Dimethoxyethane (glyme)	Tetrahydronaphthalene
Cyclopentene	Furan	Vinyl ethers
Diacetylene	Propyne	
Dicyclopentadiene	Methylcyclopentane	
Class 3 PFCs		
Acrylic acid	Chlorotrifluoroethylene	Vinyl acetate
Acrylonitrile	Methyl methacrylate	Vinylacetylene
Butadiene	Styrene	2-Vinylpyridine
Chlorobutadiene	Tetrafluoroethylene	
Vinyl chloride (chloroethene)	1,1-Dichloroethene	

1.9 COMPRESSED GAS CYLINDERS

- **For all lab personnel:**
 - Should be familiar with the gas container content and the potential hazards. They should have access to the appropriate Material Safety Data Sheet.
 - Secure cylinders at the top and bottom. Keep the cylinder capped when not in use.
 - All gas cylinders, including lecture and empty bottles, should be in an upright manner and chained.
- **For lab personnel responsible for changing out compressed gas cylinders:**
 - Wear safety glasses when handling compressed gases.
 - Do not lubricate, modify, force, or tamper with cylinder valves.
 - Always make sure that the regulator appears sound before attaching it to a cylinder.
 - Make sure that the correct regulator and CGA connector is being used. (See 4.1: CGA Connection Chart.) If the connections do not fit together readily, the wrong regulator or a defective regulator is probably being used.
 - Use only the correct fittings and connections to ensure compatibility. Make sure that the threads on the cylinder and the connection mate, and are of a type intended for gas service.

- Attach the regulator securely with the secondary valve closed and preferably with the regulator flow backed off (counterclockwise) before opening the cylinder valve wide.
- When cylinders are no longer in use, shut the valves, relieve the pressure in the gas regulators, remove the regulators and cap the cylinders.
- Before returning empty gas containers, a check should be carried out to ensure that the container valve is closed (and not leaking) and that the valve outlet plug (or cap nut) has been securely refitted.
- Leave a small amount of contents in the cylinder to avoid contamination.
- Segregate gas cylinder storage from chemical storage.
- Keep incompatible classes of gases stored separately. Keep flammables from reactives which include oxidizers and corrosives. For example, keep cylinders containing oxygen or oxidizing gases away from flammable solvents, combustible materials, unprotected electrical connections, gas flames or other sources of ignition.
- Always label cylinders so you know their contents; do not depend on the manufacturers color code. Gas cabinets should have a clear label on the outside.
- Note the name and phone number of the supplier of the cylinder. Cylinders are generally “loaned” when they are distributed, and the empty cylinders are to be returned to the supplier once you are finished with the gas.
- If a cylinder of material has been here for more than three years, please contact the EHS Office and mark it for return to the supplier.

1.9.1 Flammable gases

- Flammable gases must be separated from oxidizing gases. A distance of 20 ft. or a noncombustible barrier at least 5 ft. high is a minimum requirement.
- Flammable gases, except for protected fuel gases, must not be used near ignition sources. Ignition sources include open flames and sparks, sources of heat, oxidizing agents and ungrounded or non-intrinsically safe electrical or electronic equipment.
- **Do not** use flames for detecting leaks. A compatible leak detection solution must be used for leak detection.
- Use spark-proof tools when working with or on a compressed gas cylinder system containing flammable gases.
- Post “No Open Flames” signage on access doors to areas that use or store flammable gases.

- Flammable gases must vent into a fume hood. Before use, minimize or eliminate flammable items in the fume hood.
- When using flammable gases as the environment during a furnace run:
 - Use the hierarchy of controls (see Appendix A) to minimize risk to yourself and others
 - Thoroughly inspect the furnace, cylinder, and off-gassing setup for leaks before starting a furnace run
 - When possible, use a furnace that fits inside the fume hood and keep the sash closed throughout the duration of the experiment
 - When possible, restrict experiments to business hours (ie; not on weekends or holidays)
 - Alert lab members to the active experiment with signage
 - Use the buddy system: ensure at least one other safety-trained lab member is in the lab or on campus during the experiment to assist in the event of an emergency after hours, use the buddy system to check in with someone every 30 minutes. If your buddy doesn't hear from you, they should go to the lab to assist.

1.10 HAZARDOUS WASTE MANAGEMENT

- Hazardous waste containers must be completely labeled and dated when the first drop of hazardous waste goes in Use only authorized Institute Hazardous Waste Identification Tags for container labeling. See the Environment, Health, & Safety website for more information: www.safety.caltech.edu
- Waste containers must be kept closed except when adding hazardous waste
- Do not fill a waste container completely to the top. Provide room for air space
- Do not place incompatible chemicals in a waste container
- EHS must receive all hazardous waste containers within 9 months from the date of initial accumulation
- Dispose of your waste at the completion of a project. Do not abandon the waste, so that someone else must deal with it
- Call EH&S for waste pick-up

1.11 OLD, DAMAGED, OR NO LONGER USEFUL EQUIPMENT

- Review the equipment asset list for your lab at least once a year to see if you have old, damaged, or outdated equipment that require disposal.
- For proper disposal, notify the Safety Office if you believe that the equipment has been used for radiological, biological, or chemical work. The types of equipment should be decontaminated and certified prior to disposal, and the Safety Office is able to assist you with this process.

- Contact your Building Administrator if you have a large amount of e-waste for disposal, as they work with you to get this matter taken care of, or you may take it over to the Recycling Center on the first Wednesday of each month between 9:00am and 12:00pm for proper disposal.
- Try not to leave old equipment in the hallways, as these are potential fire hazards.

1.12 SHARPS WASTE MANAGEMENT

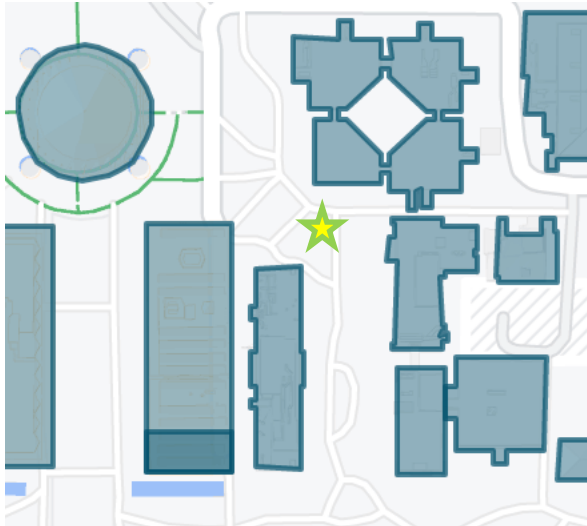
- Must be appropriate for the size of the items being placed in the sharps container
- All sharps are to be disposed in appropriate sharps containers
- Must be sealable (taped closed or tightly lidded)
- Should be no more than 2/3rds full
- Are available at the Biology Division and VWR stockrooms
- Close the sharps container according to the manufacturer's instructions when it is 2/3rd full and call the Environment, Health and Safety Office to request a pickup at x6727
- Never place sharps in regular or solid biohazardous waste bags as they can puncture the bag and cause injury

1.13 EMERGENCY RESPONSE PROCEDURES

Emergencies on campus (ex: police, fire, paramedics, chemical, etc.) **CALL 5000.**

1.13.1 Fire

- Remain calm
- Alert others
- Close doors
- Evacuate to EAP:



1.13.2 Earthquake

- Remain calm
- Drop, cover, and hold
- Evacuate when shaking stops if building damage present

1.13.3 Shelter in Place when

- A chemical or biological spill
- Severe weather
- Or an armed individual on campus
 - For Keck individuals, when safe, take cover in the roof-top labs. Roof keys are located in the bottom center drawer in Keck 340 (Imaging room) and in Keck 309. If not possible to reach the roof, shelter behind as many (solid wood) doors as possible.

1.13.4 Biological, Chemical, and Radiological Incidents

- Attend to injured persons
- Confine the area
- Get help-notify Safety or Security
- Evacuate if necessary

1.13.5 Personal Injury

- Check the area for additional hazards
- Call **5000** and notify the supervisor
- Care:
 - Remove the injured/exposed individual from the area, unless it is unsafe to do so because of the medical condition of the victim or the potential hazard to rescuers.
 - Report the exposure to EH&S.
 - Flush contamination from eyes/skin using the nearest emergency eyewash/shower for a minimum of 15 minutes. Remove any contaminated clothing.
 - Bring to the hospital copies of MSDSs for all chemicals the victim was exposed to.

2. Keck 336

2.1 MERCURY POROSIMETER

Mercury and mercury vapor are harmful materials – use of the porosimeter requires hands-on training for material testing, cleanup procedures, and waste disposal. Such training will occur on an individual, as-needed basis – the following list of precautions is important for all lab users but does not substitute for user familiarization with equipment and safe handling procedures

- The porosimeter, porosimeter computer, and adjacent fume hood should be treated as mercury-containing areas and avoided for all non-porosimeter related work.
- The lab phone next to the porosimeter computer is designed for emergency calls only.
- Proper PPE (gloves, lab coat, eyewear) should be used when interacting with the porosimeter, computer, or fume hood.
- A buddy is required in lab when transitioning a sample from low to high pressure chambers and when removing a sample from the high pressure chamber for disposal
- Mercury waste containers should be sealed when not in use
- Any mercury spilled on the counter tray should be wiped into the drain hole in the tray, from which it will fall into a collector and be covered by a layer of oil.
- The instrument must be unplugged before any panel is removed to avoid the hazards of high voltages which are present.
- When performing a low-pressure operation, make sure all retaining knobs are securely tightened. It is recommended that capacitance detectors be installed on all ports, used and unused. This is to prevent the possibility of the penetrometer being expelled when the system pressure is raised to as high as 50 psi.
- Should a penetrometer be broken and mercury spilled in the high pressure chamber, the glass and mercury should be removed immediately.
- The mercury supply reservoir located adjacent to the high pressure chamber is sealed by a stopper cap. The cap must always be securely in place during a test.
- Should a large mercury spill happen, the operator should follow the instruction in the mercury emergency spill kit to clean up the spill. An incident report (on the Caltech EHS website) should be filed to the EHS office afterward. The EHS office can conduct a mercury residue test if needed.

2.2 1600°C TUBE FURNACE & 1700°C BOX FURNACE

- To avoid electrical shock, this furnace must:
 - Be installed by a competent, qualified electrician who insures compatibility among furnace specifications, electrical source and grounding code requirements.

- Always be disconnected from the electrical supply prior to maintenance and servicing.
- To avoid personal injury:
 - Do not stand directly in front of the open, heated chamber without wearing a heat resistant face shield, gloves, and apron. If quenching a sample is necessary, consult faculty or lab manager, use appropriate equipment such as tongs and insulation, and wear necessary PPE. Work with a buddy if quenching using water or oil.
 - Do not use in the presence of flammable or combustible materials; fire or explosion may result. This device contains components which may ignite such materials.
 - Refer servicing to qualified personnel.
 - CAUTION: Hot Surface. Avoid Contact.
 - To AVOID EYE DAMAGE in servicing or cleaning furnace, proper eye protection must be worn.
 - To AVOID BURNS, do not stand directly in front of the chamber without wearing a heat resistant faceshield, gloves and apron.
 - To AVOID FIRE, do not place combustible materials where exposed to heat from open door.
 - Always assume a furnace is hot!
 - Take care when quenching materials directly out of a furnace. Always ensure there is adequate cooling and wear eye protection in case of shattering

2.2.1 LEAD-TIN-OXIDE PIGMENT EXPERIMENTS (Pb-Sn-O; UP TO 1600°C)

- Lead-containing compounds are toxic by inhalation/ingestion. Handle pigments as fine powders: weigh/transfer only in a fume hood or ventilated enclosure (see **Section 1.5.1**).
- Thermal processing can generate lead-containing fumes/particulates and can contaminate furnaces. Use the best available engineering controls (vented furnace / local exhaust) and keep crucibles covered when possible.
- PPE: safety glasses/goggles, lab coat, appropriate gloves; use P100 respiratory protection when there is potential for airborne pigment dust or when loading/unloading potentially contaminated furnace hardware (per institute respiratory protection program).
- Keep lead work areas clearly labeled; prevent cross-contamination (dedicated tools/crucibles where feasible). Wash hands after handling and before leaving lab; avoid food/drink contact.

Waste: treat pigment residues, wipes, and contaminated disposables as hazardous heavy-metal waste. Label waste containers appropriately and coordinate disposal through EH&S.

2.3 JULABO CHILLER

- Avoid skin contact to chill plate or plumbing when chiller system is active. The system is capable of reaching temperatures as low as -50°C; skin contact can result in injuries or burns.
- Polydimethylsiloxane, PDMS, a silicone oil, is used for circulation – care should be taken to avoid leaks or spills as impacted surfaces can become slippery. Address leaks and clean spills as soon as they are detected by turning off chiller and alerting safety officer and/or equipment manager.

2.4 DRILL PRESS

- Everything must be clamped. Always remove key from the chuck before turning on the press. Let press stop on its own after turning power off; don't attempt to stop it with your hand.
- Before starting a machine, always check it for correct setup.
- Wear proper clothing while working on the press:
 - No loose clothing
 - No open-toed shoes must not be worn in machine/maintenance shops. c)
 - No jewelry must not be worn.
 - Tie back long hair.
 - Wear goggles
- Do not work in the shop if tired, in hurry, or any medication which might cause drowsiness.
- Report any damage to machine or hand tools immediately to safety officer.
- While the drill is running, keep your head and hands away from spinning bit.
- Machines must be shut off when cleaning, repairing, or oiling.
- Clean up your machine after use.
- Keep the floor around machines clean, dry, and free from trip hazards. Do not allow chips to accumulate.

2.5 LIQUID NITROGEN (CRYOGENIC LIQUIDS)

Cryogenic liquids are characterized by having a boiling point of less than -90 °C (-130 °F). Cryogenic liquids can pose both physical and health hazards. This guideline is for liquid nitrogen only. For other cryogenic liquids, read 'Cryogenic liquids' safety document in the Faber group cloud.

- Use in a well-ventilated area.
- Do not plug, remove, or tamper with any pressure relief device.

- Ensure the hose fitting is appropriate for the dispensing valve (proper CGA number).
- DO NOT use tools on cylinder valves.
- Use tongs to immerse or remove items from cryogenic liquids. Never immerse hands, even if PPE is worn.
- Proper PPE (gloves, lab coat, eyewear, face shield) should be used when dispensing or handling liquid nitrogen.
- Loose fitting cryogenic gloves should be worn when handling and dispensing cryogenics.
- Never allow any unprotected part of the body to come in contact with un-insulated pipes or equipment that contains cryogenic product.
- Dewar flasks used to collect cryogenics for use in the lab should have a cap that allows built-up pressure to escape and keep air and moisture out.

3. Keck 326

3.1 FURNACE

- Always assume a furnace is hot.
- Leave a note if any material near a furnace, or the furnace itself, is hot.
- Wear close-toed shoes, long pants, and non-synthetic fabrics when using furnaces.
- Take care when quenching materials directly out of a furnace. Always ensure there is adequate cooling and wear eye protection in case of shattering

3.2 1600°C BOX FURNACE

- **The area beyond the yellow tape is to be generally avoided unless the user is thoroughly trained by Zachary A. Chase and has been granted access by him to operate in the area.**

3.2.1 Box Furnace

- To avoid electrical shock, this furnace must:

- Be installed by a competent, qualified electrician who insures compatibility among furnace specifications, electrical source and grounding code requirements.
- Always be disconnected from the electrical supply prior to maintenance and servicing.
- To avoid personal injury:
 - Do not stand directly in front of the open, heated chamber without wearing a heat resistant face shield, gloves, and apron. If quenching a sample is necessary, consult faculty or lab manager, use appropriate equipment such as tongs and insulation, and wear necessary PPE. Work with a buddy if quenching using water or oil.
 - Do not use in the presence of flammable or combustible materials; fire or explosion may result. This device contains components which may ignite such materials.
 - Refer servicing to qualified personnel.
 - CAUTION: Hot Surface. Avoid Contact.
 - To AVOID EYE DAMAGE in servicing or cleaning furnace, proper eye protection must be worn.
 - To AVOID BURNS, do not stand directly in front of the chamber without wearing a heat resistant faceshield, gloves and apron.
 - To AVOID FIRE, do not place combustible materials where exposed to heat from open door.
 - Always assume a furnace is hot!
 - Take care when quenching materials directly out of a furnace. Always ensure there is adequate cooling and wear eye protection in case of shattering.

3.3 COMPRESSED GAS CYLINDERS

- Cylinders for the Faber Group are delivered to and primarily stored in Keck 326A. All cylinders should have two restraining chains, and should be stored in the designated cylinder mounts. Cylinders should NEVER be left unrestrained or outside of the designated areas.
- Before returning empty gas containers, a check should be carried out to ensure that the container valve is closed (and not leaking) and that the valve outlet plug (or cap nut) has been securely refitted.
- Leave a small amount of contents in the cylinder to avoid contamination.
- Segregate gas cylinder storage from chemical storage.

- Keep incompatible classes of gases stored separately. Keep flammables from reactives which include oxidizers and corrosives. For example, keep cylinders containing oxygen or oxidizing gases away from flammable solvents, combustible materials, unprotected electrical connections, gas flames or other sources of ignition.
- Always label cylinders so you know their contents; do not depend on the manufacturers color code. Gas cabinets should have a clear label on the outside.
- Note the name and phone number of the supplier of the cylinder. Cylinders are generally “loaned” when they are distributed, and the empty cylinders are to be returned to the supplier once you are finished with the gas.
- If a cylinder of material has been here for more than three years, please contact the EHS Office and mark it for return to the supplier.

3.4 INSTRON

- Before using the Instron, operators must receive room-specific and instrument-specific safety training.
- Be aware of all moving and operating components that are potentially hazardous.
- Read all relevant manuals and observe all Warnings and Cautions.
- Press the Emergency Stop button whenever you consider that an unsafe condition exists.
- When possible, use the height-based stop triggers to prevent the machine from reaching unsafe conditions.
- Set software limits to stop the program at designated forces and displacements to ensure safety.
- Make sure that test specimens are installed correctly in grips or fixtures in order to eliminate stresses that can cause breakage of grip jaws or fixture components.
- Wear protective clothing when handling equipment at extremes of temperature.
- When using the furnace with the Instron, be sure to wear safety goggles.
- Take care when installing or removing a specimen, assembly, structure, or load string component.
- Ensure safety shields are in place anytime the machine is in operation.

- Do not place a testing system off-line from computer control without first ensuring that no actuator or crosshead movement will occur upon transfer to manual control.
- Keep clear of the operating envelope of a robotic device unless the device is de-activated.
- Disconnect the electrical power supply before removing the covers to electrical equipment.
- Disconnect power supplies before removing the covers to rotating machinery.
- Shut down the hydraulic power supply and discharge hydraulic pressure before disconnection of any hydraulic fluid coupling.

3.5 RDF

- Never bypass safety mechanisms.
- Never leave the machine on while unattended.
- Take extreme caution when working underneath the piston.
- Never pull electrical leads outside of the safety enclosure.

3.6 SHOP SAFETY

- Eye protection is essential. Always wear safety glasses when using machinery.
- Always wear closed-toe shoes in the shop.
- Remove or secure anything that might get caught in moving machinery. Rings, necklaces, long hair, loose clothes, and headphones.
- Keep your hands away from sharp tools, and your fingers clear of running machines. Use special tools such as, clamps, vises, pliers, etc.
- A hammer should not be used to strike a hardened tool or any machine part.
- If a tool is damaged, dispose of it properly or leave it with a note. Don't put it back.
- Chuck keys are to be removed before starting lathes, drills, mills.
- Don't operate the machines without the appropriate guards in place.
- Remove chips with a brush or compressed air, never by hand or by blowing. Be careful of sharp edges.
- Clean machine and surrounding when finished or at the end of the day.

3.6.1 Ball Mill

- Always wear safety glasses when using the rolling mill.
- Decrease the rolling thickness slowly. Making too large of steps can damage the rollers.
- Insert any small samples with a pushing stick. Do not use wood or metal as they can splinter or damage the roller. A piece of paper folded on itself a bunch of times or a very thin piece of plastic is a good choice.
- Do not stand directly behind or in front of the rollers as samples can shoot out either way forcefully.
- Rolled materials can get very hot after severe deformation. Take caution when dealing with them.

4. Appendices

4.1 GCA Connections



Gases CGA Selection Chart

PURE GASES CGA SELECTION CHART FOR FITTINGS

CGA Fittings Required	Pure Gases
510/300	Acetylene
590/346/347/702	Air
240/660/705	Ammonia
580/680/677	Argon
350	Arsine*
320	Carbon Dioxide
350	Carbon Monoxide
660	Chlorine
510	Cyclopropane
350	Deuterium
350	Ethane
350	Ethylene
510	Ethylene Oxide
580/680/677	Helium
350/695/703	Hydrogen
330	Hydrogen Chloride
330	Hydrogen Sulfide
580	Krypton
350/695/703	Methane
510	Methyl Chloride
580/680/677	Neon
580/680/677	Nitrogen
326	Nitrous Oxide
540/577/701	Oxygen*
350	Phosphine
510	Propane
350	Silane*
668/660	Sulfur Dioxide
590	Sulfur Hexafluoride
580/680/677	Xenon

MIXED GASES CGA SELECTION CHART FOR FITTINGS

CGA Fittings Required	Mixed Gases	
	Minor Component	in Major Component
240/660/705	Ammonia	Nitrogen
350	Butane	Nitrogen
296	Carbon Dioxide	Oxygen
580	Carbon Dioxide	Helium or Nitrogen
580	Carbon Dioxide and/or Nitrogen	Helium
590	Carbon Monoxide	Air
330	Chlorine	Nitrogen
350	Diborane	Argon, Helium, Hydrogen, Nitrogen
580	Freon-12	Nitrogen
296	Helium	Oxygen
350	Hexane	Nitrogen
350	Isobutane	Nitrogen
580	Krypton	Argon
590	Methane	Air
580	Moisture	Argon, Helium or Nitrogen
660	Nitric Oxide	Nitrogen
660	Nitrogen Dioxide	Air or Nitrogen
590	Nitrous Oxide	Nitrogen
590	Oxygen	Nitrogen or Helium
350	Propane	Nitrogen or Helium
590	Propane	Air
660	Sulfur Dioxide	Air or Nitrogen
590	Sulfur Hexafluoride	Argon, Helium or Nitrogen
350	Sulfur Hexafluoride	Hydrogen

It is recommended that the user thoroughly familiarize himself with the specific properties of these gases.

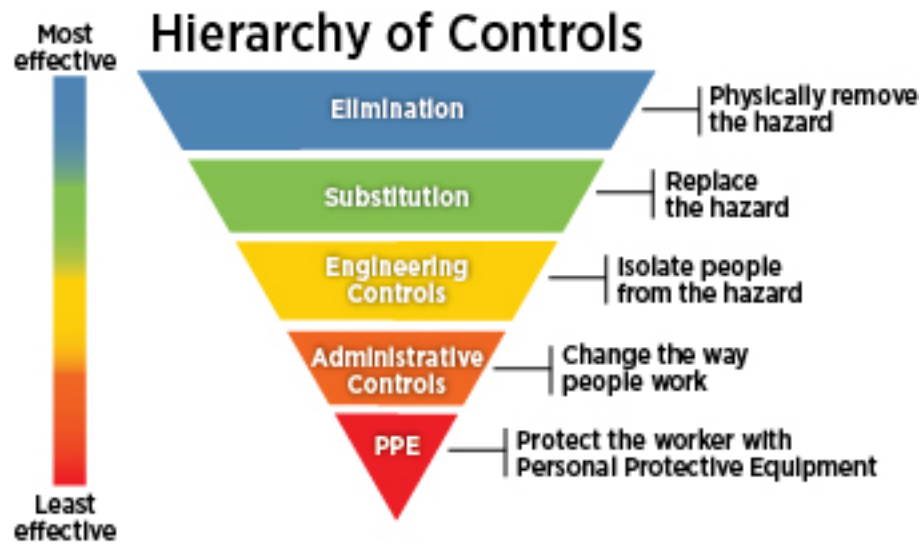
The Compressed Gas Association (CGA) has selected and standardized the valve outlet to be used on each gas cylinder. These standards, contained in the document "CGA STANDARD V-1, Compressed Gas Cylinder Valve Outlet Connections", have been adopted to prevent the inadvertent mixing of gases which could be reactive and to avoid other possible misuse hazards.

The above chart may be used for guide purposes only. Consult your gas supplier to determine the actual CGA connection required when ordering a regulator.

Since the combined characteristics of a mixture of gases often differ from the properties of the separate components, different CGA connections are often required. The CGA has selected and standardized the valve outlets to be used with mixed gases. These standards are described in CGA publication V-7 - "Standard Method for Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures".

Mixtures which use the same CGA connection as if the minor component were in its pure gas form have not been included for the sake of brevity. The proper fitting for these mixtures can be determined by looking up the minor component on the chart for pure gases.

4.2 OSHA Hierarchy of Controls



Source: NIOSH

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