UNIVERSITY of VIRGINIA | ENGINEERING
Department of Materials Science and Engineering

S A F E T Y M A N U A L

EMERGENCY PHONE NUMBERS

ALL EMERGENCIES ……	**911**
UNIVERSITY POLICE ……	**4-7166**
ENVIRONMENTAL HEALTH & SAFETY ... **http://www.ehs.virginia.edu/**	**2-4911**
SAFERIDE SERVICE ……	**2-1122**
BLUE RIDGE POISON CENTER ……	**800-222-1222**

(REVISED: January 2024)

IN CASE OF EMERGENCY

In the event of a chemical exposure or any injury, the injured person must seek medical attention in one of the following places (depending on the severity of the exposure/injury and your physical location):

If You Are:	**UVA Academic**	**UVA Medical Center**
Faculty, staff, students paid through University Payroll	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013
All other students	Student Health and Wellness 550 Brandon Ave. (434) 924-5362 (434) 297-4261 after hours	Student Health and Wellness 550 Brandon Ave. (434) 924-5362 (434) 297-4261 after hours
Visiting scientists and scholars, interns, volunteers	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013

If after hours or high degree of injury

- UVA or closest Emergency Room, or Urgent Care facility
- UVA Health System Emergency Room (434) 924-2231 Lee Street, Charlottesville
- Martha Jefferson Emergency Room (434) 654-7150 500 Martha Jefferson Drive, Charlottesville
- 911 (if injured person cannot move or be moved)

Reporting of Incidents, Injuries, Chemical Exposures and Near Misses

To achieve a safe workplace both within our laboratories and office space takes everyone's involvement. The motto, **'If you see something, say something'**, is important to help identify and resolve potential safety situations before they get worse. When in doubt, it is better to stop, re-assess, and ask someone.

All injuries, chemical exposures, and incidents (no matter how small) and near misses with the potential to cause harm or damage, should be promptly reported to the faculty or supervisor in charge of the lab / area, followed up with notification via email or phone call to the Safety Committee or the Department Chair, which are listed below**.** EHS should also be notified through their online reporting tool.

In case of potential or actual chemical exposure, EHS **must** also be notified.

The Materials Science and Engineering (MSE) Safety Committee has recently updated the MSE Safety Handbook, created a Department Safety Policy that defines roles and responsibilities in our laboratory environments, and conducted a safety culture survey. In the safety culture survey, one of the write-in comments that showed up repeatedly was that safety information was not centrally located and easy to access. In response to this input, the MSE Safety Committee has created a web page, linked to the top-level MSE homepage that aggregates all relevant safety information for the department. Please take a moment to familiarize yourself with the content:

https://engineering.virginia.edu/departments/materials-science-and-engineering/mse-safety#accordion500710

Please note that there is a **quick link for reporting an accident** to EHS. We aspire to be a learning organization when it comes to safety, and reporting of near misses can help the entire department to identify risks and put smart layers of protection in place to mitigate these hazards. Near miss information can help us by reminding us about things we already "know" and help us learn about unforeseen issues.

Thank you for your curiosity and diligence in determining hazards and mitigating all our risks associated with the leading-edge research activities that we conduct. Any questions or concerns, please feel free to contact any safety committee member. Let's keep each other safe.

FOREWORD

- This manual provides a summary of the Materials Science and Engineering Department safety policies and standards. Take time to read it carefully and direct your unanswered safety questions to your advisor or any of the safety committee members listed below.

- **You are responsible for compliance with all safety regulations and for elimination of hazards in your own lab.** It is your responsibility to make your lab a safe place to work for you, your lab partners, and visitors to your lab. Safe work habits which you develop now will prepare you for work in industry and may save you from injury or save your life.

- **The safety regulations in this safety manual apply to all faculty, students, post-docs, and research staff who are part of the Materials Science and Engineering program,** regardless of their assigned laboratory or location.

- After reading this safety manual, **complete, sign, and date the Certification Form found on APPENDIX H of this manual**. Give the completed form to the Department Secretary. You are not allowed to use any of the Materials Science and Engineering laboratories prior to turning in this form.

- You must also carefully read the University of Virginia **Chemical Hygiene Plan** and complete the **mandatory e-learning safety training** PRIOR to starting work in your laboratory. Even though you are Materials Science and Engineering you share space with Chemical Engineering and should be familiar with proper handling, safety and PPE needed to be around any chemicals you may encounter.

    - Chemical Hygiene Plan **http://ehs.virginia.edu/Chemical-Safety-Plans.html**
    - Mandatory Training **http://ehs.virginia.edu/Chemical-Safety-Training.html**

- **In the case of new equipment setup**, the Hazard Review Checklist provides a practical guide to safety considerations in designing new experimental equipment. See SECTION VIII / APPENDIX F for a copy of this checklist.

- **Where to get advice on safety problems**- Day-to-day problems should be directed to your advisor or lab/area supervisor. For other safety issues, beyond your advisor or lab/area supervisor, seek advice and information from the MSE Safety Committee and Environmental Health & Safety (EHS) personnel.

- UVA Environmental Health and Safety's fundamental mission is to support the research, education and patient care activities of the University through promotion of a safe and healthy environment. This is achieved by providing high quality programs, training, evaluation and consultation designed to minimize safety, health, environmental and regulatory risks to the University community. Phone: 434-982-4911, **http://www.ehs.virginia.edu/)**

Material Science and Engineering Safety Committee

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WDF - Wilsdorf Hall
JH - Jesser Hall
TH - Thornton Hall

ACKNOWLEDGEMENT -This manual is based in large part on the CHE Department safety manual originally developed and written by ***Prof. Giorgio Carta***. It was revised extensively in April 2021 to better align with UVA's Chemical Hygiene Plan, and, to update and expand guidance through the adoption of additional good laboratory practices developed since the first revision of this manual. It has been adapted to also serve Materials Science and Engineering. A special thanks to CHE for their generous contribution of time and effort in the formulation of this manual.

TABLE OF CONTENTS

SECTION I
ROLES & RESPONSIBILITIES

To maintain a safe, healthy, and compliant laboratory setting requires the ongoing effort and commitment of everyone in the Materials Science and Engineering Department.

Department Chair

The Department Chair has overall responsibility for the effectiveness of the safety program within the Materials Science and Engineering Department to enable a strong safety culture to flourish in the laboratories. In addition, the Chair is responsible for,

- Establishing a safety committee and appoints safety committee members,
- Ensuring the development and implementation of safe practices, safety protocols, and safety rules for undergraduate and graduate laboratories and other affiliated shops,
- Reinforcing safety responsibilities for faculty, staff, and students,
- Ensuring faculty, staff, laboratory supervisors, and teaching assistants involved in teaching and overseeing laboratory operations have received an appropriate level of safety training,

Principal Investigators and Lab Directors

Principal Investigators need to:

- Be familiar with UVA safety and health requirements that may impact their laboratory, including waste management practices, and ensure that activities in their lab follow them,
- Ensure the EHS Hazard Communication Sign is posted on the lab entrance door / up to date,
- Ensure that lab occupants have received specialized training on specific hazards and chemicals used in their laboratory such as biosafety, laser safety, and radiation safety,
- Ensure new members of the laboratory, visitors, service providers receive safety orientation before working or visiting their laboratory,
- Ensure appropriate PPE is provided and used properly,
- Ensure monthly emergency eyewash station checks are conducted,
- Investigate all incidents resulting in injury or property damage or near misses with such potential and report them to the Department Chair or the MSE Safety Committee,
- Ensure that any deviations noted during lab inspection by EHS, by the Fire Marshal, and/or by the MSE Safety Committee are corrected in a timely manner,
- Conduct or provide guidance for hazard assessments to identify hazardous conditions or operations in the lab and establish standard operating procedures and safe work practices to effectively control or reduce hazards.
- As needed, review new materials, equipment, and instrumentation with EHS to ensure that they can be safely accommodated and determine if supplemental controls will be needed.
- Contact EHS when expanding lab space, moving to a different lab space, or if leaving the University to safely and compliantly move and/or dispose of regulated materials and equipment.

Research Staff, Post-docs, and Students

Students in a UVA laboratory are responsible for their own safety and those around them. In addition, students are responsible for

- Completing required safety training before beginning work in the lab,
- Developing good personal safety habits such as keeping work areas clean and uncluttered,
- Wearing appropriate clothing, and required PPE (refer to PPE section),
- Utilizing appropriate measures to control hazards, such as Fume Hoods and procedures,
- Asking for advice/ approval before undertaking new or unfamiliar procedures, using highly hazardous materials, or "scaling up" an experiment,
- Stopping work if any unusual or unexpected conditions arise, or if unsure it's safe to continue,
- Removing damaged equipment from use, and report the problem,
- Reporting accidents, over-exposures, symptoms of potential over-exposure, any unsafe conditions and near misses as soon as possible.

Teaching Assistants (TA's)

Teaching assistants (TA's) have responsibilities for operating equipment, supervising undergraduate students, maintaining laboratories, and serving as positive role models in demonstrating safe laboratory practices, including,

- Knowing the location of the SDS information for their assigned laboratories,
- Knowing the underlying chemistry for each experiment being taught,
- Demonstrating proper laboratory techniques for each experiment to the students, and procedures for operation of common laboratory equipment, such as burners and hot plates,
- Providing appropriate laboratory safety instruction to students, including explaining the health hazards and risks associated with each experiment,
- Managing the setup and cleanup of laboratory experiments,
- Enforcing appropriate safety and PPE protocols during laboratory preparation activities, such as making solutions and preparing samples,
- Be familiar with University requirements during the generation/ disposal of hazardous waste,
- Maintaining good housekeeping in assigned laboratories,
- Addressing any observed safety concerns or expressed by a student including stopping work and correcting unsafe conditions or activities,
- Reporting any injuries, incidents, spills or near misses that have the potential to cause harm or damage.

New Faculty

- New UVA faculty who will work in a laboratory should contact EHS prior to or upon arrival for guidance and assistance on safety requirements and considerations for setting up the laboratory.

MSE Safety Committee

Safety Committee is responsible to,

- Maintain the MSE Department Safety Manual ensuring that it is current and consistent with University policies,
- Serve as a resource for members of the department and help enforce safety requirements, including initial safety orientation for new faculty members,
- Work with the faculty, department chair and EHS to ensure an effective program,

- Support faculty in accident investigations and hazard reviews, as needed,
- Review and report, as appropriate, incident and injury reports,
- Report to the MSE Department community on the outcome of the lab inspections and conduct follow-on inspection to verify that safety violations have been addressed.

SECTION II
TRAINING AND DOCUMENTATION

This section outlines training, laboratory signage and other documentation requirements and resources.

Training

- **Required Training-** University faculty, staff, and students who are required to complete Chemical Safety Training must complete at least one of the following training modules (or have properly documented completion of analogous training) to be considered in compliance with University policy. Laboratories, Departments, or other groups may schedule an in-person "live" Chemical Safety and Waste Training session by calling EHS at 434-982-4911.
    - Chemical Safety and Waste Training for Research Personnel & Students -Required training for Research Personnel & Students who work in a laboratory/area where chemicals are used, or who generate Hazardous (Chemical) Waste.
    - Chemical Safety and Waste Training for Non-Research Personnel-Required training for Non-Research Personnel who work in a laboratory/area where chemicals are used, or who generate Hazardous (Chemical) Waste.
    - Chemical Safety Training for Support Staff -Required training for persons who do NOT handle chemicals, but who may be accidentally exposed to chemicals.

- **Site-specific hazard training** shall also be given by Principal Investigators or lab/space managers on site-specific chemical hazards, i.e., personnel are given an understanding of the specific hazards they may be exposed to, how to safely handle, protect themselves to minimize risk of exposure, and proper disposal of the specific chemicals. Lab occupants should complete applicable training prior to working in the lab.

- **Other training** will depend upon other work protocols (Radioactive material, etc.), or specialized needs (shipping dry ice). EHS has also developed a wide range of recommended trainings that faculty and lab managers will find helpful for further safety awareness in the lab.

- **Online safety training modules** are also available for other laboratory subjects, including Chemical Storage, Compressed Gas Cylinder and Regulator Safety. Available training can be found at **http://ehs.virginia.edu/Training.html**

- The Safety, Training, and Recordkeeping (STAR) system on the EHS website can be used to document training provided locally in laboratories and other work units.

Signage and Other Documentation

- **Lab Occupant Information**- All laboratories must display updated lab occupant's information with

contact information to be used in case of emergencies. A sample information form can be found in **Appendix A.**

- **High Hazard Unattended Equipment –** Any equipment or experiment that is operated unattended for any length of time and requires either special shutdown procedures or warnings about unusual hazards must display an Emergency Notification form (**Appendix B)**.

- **Hazard Communication Sign** -As required by regulation and for the benefit of UVA personnel, outside contractors, emergency personnel, or other visitors to an area, UVA posts a Hazard Communication Sign on all laboratory, shop, studio, and makerspace doors, and other select room doors where hazardous materials may be present. Laboratories should periodically review this signage and work with EHS to make necessary updates. Posting and maintaining the Hazard Communication sign is a responsibility of UVA EHS.

  

  The Hazard Communication Sign will display through symbols, icons, and text which types of hazards (e.g., biological, radiological, chemical, or non-ionizing radiation) are potentially present beyond the door. The sign will also list PI(s) and emergency contact information. The potential hazards in the space may provide direction on personal protective equipment (PPE) or other safety precautions that are required for entry.

- **Safety Data Sheets (SDS)** The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (HCS) requires that employees be provided information about the physical and health hazards of the chemicals they use or are potentially exposed to in their work area.

  Safety Data Sheets (SDS) are the primary communication tool that provides the most basic, essential information about a hazardous substance or mixture. Federal law requires that an SDS for all the hazardous chemicals used at a location must be readily accessible to employees. These sheets provide detailed information and precautionary measures for the handling of chemicals and solvents.

  SDS can be found on a searchable database on the EHS website, **http://ehs.virginia.edu/Chemical-Safety-SDS.html**

SECTION III
SAFETY INSPECTIONS

Safety inspections may be conducted by members of the safety committee to help maintain a safe, healthy, and compliant lab environment across the department. Lab PIs and directors should be notified prior, consistent with EHS inspections. Significant safety non-conformances should be addressed immediately, or in cases where they cannot, interim risk reduction measures must be agreed upon with the committee. Results of the inspection are summarized in a report directed to the Department Chair.

In addition, faculty advisors or their designated group supervisor are responsible for routine monitoring of their assigned laboratory space and of students, research staff, and visitors occupying that space. EHS has developed a Laboratory Safety Self-Assessment Guide to aid you in your self-assessment and can be found in the following link.

http://ehs.virginia.edu/ehs/ehs.chemicalsafety/chemicalsafety.documents/Self-Assessment-Guidance-UVA-EHS.pdf

The laboratory safety checklist can be found in **Appendix C.**

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SECTION IV
GENERAL & SAFE WORK PRACTICES

This section provides general guidance on work practices and procedures in the laboratory. Additional information is provided during chemical safety and waste training, and from laboratory supervisory personnel.

Be Prepared

- Be alert to unsafe conditions and actions and call attention to them so that corrections can be made as soon as possible. Someone else's accident can be as dangerous to you as a potential accident of your own.

- Think, act, and encourage safety until it becomes a habit. Avoid distracting or startling any other worker. Horseplay and practical jokes have no place in the laboratory.

- Determine the potential hazards (e.g., physical, chemical biological) and appropriate safety precautions before beginning any new operation. Know the safety procedures that apply to the work being done. Review in advance Safety Data Sheets and equipment operating manuals.

- Know where the closest emergency equipment is located, including emergency eyewash stations and showers, fire extinguishers, fire alarms, landline phone, and first aid and spill supplies. For work with pyrophoric chemicals and other air/water reactive materials, keep an appropriate portable fire extinguisher ready for use nearby.

- Follow standard operating procedures, posted instructions, supplier or manufacturer guidelines, and document experiments in a laboratory notebook.

General Laboratory Procedures

- Use equipment and reagents only for their intended purpose and seek advice for new procedures. Combine reagents in appropriate order and avoid adding solids to hot liquids.

- Stop, re-assess, and seek assistance anytime that something in the lab is not going as expected (especially if the procedure is being attempted for the first time). The use of makeshift tools and shortcut methods leads to equipment damage and injuries.

- Use mechanical devices when aspirating chemicals - never pipette by mouth. Never purposefully smell, taste, or touch chemicals.

- When diluting concentrated acids, always add acid to water – not the other way around. Work behind the sash of a chemical fume hood or a portable splash shield, consider the need for an ice bath, and proceed slowly. Upgrade personal protective equipment to include a face-shield and arm protection using disposal coated "sleeves."
- Labelling- Original labels must remain on chemical containers. In addition, the date of opening and

initials of the person first opening a chemical should be marked on the label. However, glassware and other vessels used for handling, transferring, or mixing chemicals need not be labeled if they will remain in full control of the same person and are used only temporarily and immediately (i.e., not left unattended).

- All other secondary containers (e.g., squeeze bottles, laboratory-prepared stock solutions) must be labeled with their name or commonly recognized acronym or abbreviation, e.g., 70% EtOH, 1 M NaCl, Luria Broth.

- Promptly notify laboratory supervisory personnel of any maintenance problems or equipment malfunctions. Until repaired, tag equipment as "out of service" and advise maintenance/service personnel of any hazards they may encounter.

- No unaccompanied unauthorized visitors are allowed in laboratory areas at any time. Please, make sure that your visitors follow all safety rules listed in this manual. It is your responsibility to provide them with proper personal safety equipment.

Working Alone and Unattended Operations

- To the extent possible, avoid working alone in a laboratory. Under ordinary circumstances, someone else should be present in your designated laboratory area to render emergency help should this be required. At a minimum, someone else should be on the same floor within hearing distance. When working at night or on weekends, make sure that someone else is notified of your presence.

- If solo work is necessary, review in advance with laboratory supervisory personnel. For work with high hazard materials, put additional safeguards in place, including pre- and post-work notifications to supervisory personnel and colleagues. Consult EHS for additional information and advice.

- Unattended operations that are high hazard. Review high hazard procedures in advance with laboratory supervisory personnel. Any equipment or experiment that is operated unattended for any length of time and requires either special shutdown procedures and/or has a warning about an unusual hazard must display an Emergency Notification form (see Appendix B).

Consumption/Storage of Food/Drink in Labs

- Eating, drinking, smoking, vaping, chewing gum, and applying cosmetics is prohibited in the laboratory and all other areas where chemicals are stored or used.

- Glassware or utensils that have been used for laboratory operations should never be used to prepare or consume food or beverages.

- Laboratory refrigerators, ice machines, ice chests and such must not be used for food storage. Laboratory ice is not for human consumption. Lab refrigerators, freezers should be clearly labeled "Not for Storage of Food for Human Consumption". Refrigerators used for food storage should be located outside of laboratory areas. Should the location of such refrigerators create confusion, they should be

labeled “Food storage only”

Housekeeping

- Keep work-space uncluttered. Keep floors, benchtops, and chemical fume hoods clear, uncluttered, and clean. Only the required materials, instructions, notebook, tablet/laptop, and pen should be present.

- Crates and solvent bottles should be removed from laboratory areas within 24 hours after receipt to reduce fire hazards and general clutter Dispose of empty cardboard boxes.

- Ensure that aisles always remain unobstructed with at least 36 in. width and that lighting is adequate (e.g., no burned- out lightbulbs)

- Ensure that surplus supplies, equipment, containers are stored appropriately (e.g., not on floor, work areas, student desks), and that storage clearance below ceiling is appropriate (18” for sprinklered, 24” for non-sprinklered)

Glassware

- Never use glassware that is chipped, cracked, etched, or flawed in any way. Carefully handle and store glassware to avoid injury. Inspect before use and discard damaged pieces.

- Shield or tape-wrap Dewar flasks and other glass apparatus that is either under vacuum or elevated pressure. Avoid chromic acid for glassware cleaning.

- A common injury sustained in the laboratory occurs from the improper insertion of glass tubing into a rubber stopper. To avoid injuries while cutting glass tubing, hold the tubing against a firm notched support, make one quick firm stroke with a sharp file, rocking the file to extend the deep nick one-third around the circumference. Hold the tubing in both hands, away from the body, with the nick turned directly opposite the body. Place the thumbs on the tubing opposite the nick about an inch apart. With hand protection, push out on the tubing with the thumbs. All glass tubing and rods should be fire polished before use. When inserting glass tubing into a stopper, use a glove or towel for protection and be certain that the tubing is lubricated lightly, and that excess pressure is not applied to the tubing.

- Place non-contaminated broken glassware and other glass items in a bag-lined cardboard box and label it with an EHS “Waste Laboratory Glassware” sticker. Once full, close the bag and tape the box shut. These materials are managed as regular trash and can be removed by Housekeeping or taken directly to a trash dumpster. Make sure that you do not overfill these containers leaving enough room to be able to tape the containment bag taped and the box shut.

- Glass Ampules- ampules are often opened by hand by applying a torque to the top of the ampule vial. The ampule glass is scored to facilitate a controlled break upon application of a reasonable amount of torque. To prevent injury, use cut-resistant gloves, or disposable ampule openers. Additional information on the proper technique to open an ampule can be found at: https://www.tcichemicals.com/BE/en/product/container/ampule.

Security

- All laboratory and graduate student office entry doors must be locked when not occupied.

- Report immediately any person whom you believe is an intruder to the University Police. Do not confront such individuals, but retreat to your office or lab, lock the door, and call 911 if you feel it is an emergency or 4-7166 otherwise.

- Report any missing or stolen item whether they are lab or personal belongings.

Sharps

- Hypodermic needles require special attention. Safe lab practice requires that sharp objects, especially needles and syringes, be protected to avoid accidental injection into the skin. A GC septum or a plastic syringe cap will protect these points adequately.

- If a needle does not need to be re-used and can be disposed at the location of use (there should be no walking or turning around with uncapped needles), it should be discarded in appropriate needle waste box without attempting to recap it them.

- If a needle is to be re-used or cannot be disposed at the point of use, it should not be left unprotected to avoid injury and accidental injection. To safely re-cap the needles, one should leave the cap lying on bench surface or in rubber septum or clamp (rather than in one's hand), insert the needle into the cap, and only pick up the capped syringe after a successful insertion.

- All sharps (razor blades, scalpels, needles, other objects that pose a puncture or laceration hazard), whether they are contaminated with trace chemicals or uncontaminated, must be placed in a sharps container. Always use the sharps container with the top in place and only fill no more than two-thirds full. Sharps containers are available from EHS. Do NOT add extra labels to sharps containers or deface labels on sharps containers. If you have questions about managing sharps waste, contact EHS.

Reporting of incidents, injuries and near misses

- To achieve a safe workplace both within our laboratories and office space takes everyone's involvement. The motto, 'If you see something, say something', is important to help identify and resolve potential safety situations before they get worse. When in doubt, it is better to stop, re-assess, and ask someone.

- All chemical exposures, injuries, and incidents (no matter how small) and near misses with the potential to cause harm or damage, should be promptly reported to the faculty or supervisor in charge of the lab / area, followed up with notification via email or phone call to the MSE Safety Committee or to the Department Chair. EHS should also be notified through their online reporting tool.

- In case of potential or actual chemical exposure, EHS **must** also be notified.

Miscellaneous

- Headphones/ear buds are discouraged in the laboratories since they can prevent recognizing hazards and hearing safety communications. Should you choose to wear them, they are permitted if only one ear is covered, if the volume is kept low, and if there are no loose cords.

- Do not cover windows of laboratory doors except for special experimental requirements, as passers-by should have an unobstructed view to notice if someone needs help.

- Pets of any kind are not allowed in the laboratories.

- Bicycles may be kept inside office rooms and in laboratories if they do not block emergency equipment (e.g., safety showers), aisles or corridors.

- All departing graduate and undergraduate students, staff, post-docs, visitors, and faculty, who have worked in an MSE research laboratory must complete and sign a form available from the department office attesting that all chemical wastes generated have been properly disposed of and that the laboratory areas used are being left in proper order. The form must be approved and signed by a designated senior lab member and by the faculty advisor. Completion / approval of the form is required prior to receiving a degree.

Machine Shop

Graduate students and undergraduate researchers may request permission from the shop supervisor to use the departmental machine shop for research-related projects. The shop supervisor will need to approve the use of any shop equipment and will assist you in starting-up equipment fabrication and modifications of existing equipment.

- Safety glasses are required when using equipment in the shop area. Full face shields, welding goggles, welding masks and fixed safety shields on shop equipment are also available in the shop and must be used as the job at hand requires.

- Remove rings, watches, bracelets, pendants, and neckties which may be caught in moving machinery. Roll-up your long sleeves and secure long hair for the same reason.

- Do not operate <u>any</u> shop equipment unless you are authorized to do so by the shop supervisor. If you are uncertain of any shop procedure, ask the shop personnel for assistance.

- Always clean up the work before you leave.

SECTION V
PERSONAL PROTECTIVE EQUIPMENT AND ATTIRE

Personal protective equipment (PPE) refers to garments and devices worn to protect the human body from exposure to hazardous materials. Since no single article of PPE is protective against all hazardous materials or conditions, the proper selection, use, and maintenance of PPE is critical.

Laboratory PPE should be selected based on anticipated hazards. EHS provides guidance through a Hazard Assessment Survey and guidance in the attached table (see Appendix D). PPE must meet or exceed the certifications and requirements established from applicable regulatory or advisory agencies,

As important as PPE is for laboratory safety, it is the last line of defense. If a more effective method of exposure control is available, it should be used instead, e.g., handling volatile chemicals inside a chemical fume hood rather than wearing a respirator and working with them at the open bench. Consult EHS for any questions about PPE.

PPE for Basic Entry and Exit into / from Laboratories

- SAFETY GLASSES ARE THE MINIMUM EYE PROTECTION REQUIRED AND MUST BE WORN AT ALL TIMES IN ALL AREAS THAT ARE DESIGNATED AS EYE-PROTECTION REQUIRED. This includes all laboratory spaces where hazardous materials are stored or used.
- Closed-toe, slip-resistant footwear and clothing that covers the legs are required in all laboratories. Open-toe shoes are not permitted.
- Confine or restrain long hanging hair and beards, loose clothing or scarves, neck ties, and any dangling jewelry.
- Remove personal protective equipment and wash hands with soap and water before leaving the laboratory. Avoid the use of solvents for washing the skin. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, washing with a solvent may facilitate absorption of a toxic chemical.
- Never use gloves in public spaces, unless you are handling something that requires the use of gloves. To prevent contamination of public areas, glove use outside of the lab should be strictly avoided. Never touch anything while wearing gloves outside of the lab. If you must transport material in the halls use secondary containment or a cart. If you must transport materials and require PPE, get a helper to open doors and push buttons for you. If you can safely and securely hold the container with one hand, do so with a glove on just one hand. That way you can open doors, press elevator buttons and so on with your un-gloved hand.
- Never touch doorknobs, elevator buttons, pens, or other surfaces with a gloved hand. Unintentional spread of contamination should be considered unacceptable, as it puts both yourself and others at risk

Additional PPE When Handling Hazardous Chemicals

This includes “Basic Entry’ PPE, plus,

- Gloves where chemical contact may occur. Disposable nitrile exam gloves for incidental contact, and forearm length utility gloves worn over nitrile gloves for potential long- term exposure. Additional information on glove selection can be found later in this section.
- Long sleeves or laboratory coat. Rubber Splash apron for handling amounts of corrosives larger than what can be handled on a benchtop.
- Safety goggles, or face-shield for high-risk splash potential.

Eye Protection Requirements[1]

- Eye Protection Areas include all active areas of laboratories and are designated by BLUE SIGNS at the entrance doors. YELLOW FLOOR TAPE may be used to designate specific areas where safety glasses must be worn all the time.

- Minimum eye protection, for most laboratories, this means safety-rated glasses with side shields. Side shields offer some protection from objects that approach from the side but may not provide adequate protection from splashes. Safety eyewear and face protection must meet the ANSI Standard Z87.1, Occupational and Educational Personal Eye and Face Protection Devices. Safety glasses can be worn over prescription glasses.

- Eye protection should be upgraded to safety goggles or by adding a face-shield when handling concentrated acids and bases or when handling larger quantities of chemicals or performing procedures with elevated risk of splashing or flying particles.

- Regular glasses with corrective lenses are not a substitute for safety glasses, although they may be worn under safety glasses or goggles designed to cover prescription glasses, or under a face shield. Contact lenses are permitted in these areas if safety glasses are also worn.

Special Eye Protection is required when activities take place involving the following activities. Contact EHS for additional guidance on protective measures:

- Larger quantities of corrosive or other chemically hazardous materials.
- Hot molten metals.
- Heat treatment.
- Gas or electric arc welding.
- Lasers or Infrared or microwave radiation

Body Protection

In addition to safety glasses, closed-toe shoes, and clothing that covers the legs, gloves and long sleeves should be used when handling hazardous chemicals. In higher risk activities, laboratory coats should be worn for additional protection:

- High cotton content laboratory coats offer protection against common laboratory substances and are less susceptible to burning than many synthetics.
- Disposable Tyvek or coated Tyvek laboratory coats offer better chemical resistance; they are recommended for certain activities with Particularly Hazardous Substances and can be discarded as hazardous waste upon completion of work.
- Special flame resistant (“FR”) laboratory coats or smocks should be worn where sparks or open flames larger than Bunsen burner scale are present, and for all operations involving pyrophoric materials or water / air reactive substances.
- Rubberized splash aprons may also be worn for handling larger quantities of corrosives, while fully encapsulating suits or coveralls may be required in some areas (e.g., cleanroom).

[1] Approximately 60% of workers who suffered eye injuries were not wearing eye protection.

Hand Protection

Dermal contact is among the most common route for exposure to chemicals in the laboratory. As for PPE in general, no single glove provides protection against all chemicals or physical agents. General recommendations for glove selection are provided below; more detailed chemical-specific information is available by contacting EHS directly.

Style and Membrane	Typical Uses
Disposable Exam - Nitrile	Incidental chemical contact or to protect specimens from enzymes on skin. Excellent dexterity, comfortable to wear, and inexpensive.
Nitrile	Contact or short duration immersion with most solvents, oils, and some corrosives
Butyl	Contact or short duration immersion with most aliphatic, halogenated solvents, aromatic hydrocarbons, mineral acids, ketones (best material for acetone – see note 1)
Neoprene	Contact or short duration immersion with oils, most acids and bases, alcohols
Latex	Good for biohazard protection, inorganic chemicals. Highly dexterous. Avoid: oils, grease, hydrocarbon derivatives. Difficult to detect holes. Can trigger latex allergies.
PVA (Poly- vinyl-alcohol)	Contact or short duration immersion with aromatics and chlorinated solvents
Teflon	Contact or extended duration immersion with nearly all chemicals. Very poor dexterity – may need to be worn under other gloves.
Kevlar	Handling sharp objects
Heavy Leather or Insulated	Extremely hot or cold objects, cryogen handling, sparks

Note (1) – for handling acetone, butyl gloves are best, latex is acceptable. Nitrile should be avoided.

Single Use/Specialty Gloves-For incidental contact with low hazard substances or to protect specimens from possible skin / hand contamination, single use / specialty gloves are commonly worn in the laboratory. Exam gloves are thin, disposable gloves meant for single use.

- They should not be worn where direct chemical contact or immersion is expected. Double gloving can provide some additional protection, but it is generally preferable to wear a pair of heavier, longer "utility grade" gloves over exam gloves for direct contact or immersion.
- Utility grade gloves are available in a range of thicknesses and membranes, with nitrile, neoprene, and butyl rubber among the more useful, along with Teflon gloves.
- Other specialty gloves include Kevlar puncture- and cut-resistant gloves, Nomex and other non-combustible fibers for high heat and open flame work, and insulated gloves for work with hot objects and cryogenic liquids.

Respiratory Protection

Respirators are generally not needed in laboratories due to the small quantities of chemicals handled and the use of chemical fume hoods and other local exhaust ventilation devices. Since improper selection or use of a respirator can place individuals at significant health risk, their use is regulated by OSHA and UVA.

- Respirators are not all the same nor do they provide universal protection against all inhalation hazards. Where needed, only NIOSH-certified respirators may be used.
- Individuals considering the use of a respirator must contact EHS to review the intended application and assist in the proper selection, training, fit testing, and maintenance of respirators.
- Those individuals will also need medical clearance in advance from their UVA healthcare provider.

PPE Selection Guidelines

Laboratory PPE should be selected based on anticipated hazards.

- General guidance can be found in Appendix D (PPE Selection).
- EHS also provides guidance through a Hazard Assessment Survey and online training modules for PPE selection. Refer to **https://ehs.virginia.edu/Chemical-Safety-PPE.html**

SECTION VI
CHEMICAL HAZARDS

This section introduces the hazards of chemicals and routes of exposure to them in the laboratory. Additional information can be found on the EHS website in the Chemical Hygiene Plan.

Hazard Classifications

Hazards are the inherent harmful characteristics or properties of a substance, operation, or activity, regardless of the quantity involved or method of use. Chemicals can pose a variety of hazards to human health and physical injury, including:

Health Hazards	**Physical Hazards**
Toxic	Combustible
Carcinogenic	Flammable
Mutagenic	Explosive
Reproductive toxins	Reactive or pyrophoric
Sensitizers	Oxidizers
Irritants and Corrosives	Corrosive
Asphyxiants	Compressed gases and liquids
	Cryogenic liquids

Some chemicals pose both health and physical hazards. For example, inhalation of benzene vapors can result in central nervous system narcosis, direct skin contact can defatten skin, and long-term exposure has been demonstrated to increase the rate of leukemia. As a flammable liquid, benzene can also result in serious burns or cause a structural fire if it is accidentally ignited.

Hazard classifications of substances, chemicals and mixtures can be found in Safety Data Sheets (SDS). They follow a globally harmonized system (GHS) to ensure consistency in the presentation of important safety information about a chemical. The GHS classifies chemicals into nine major hazard groups shown in this table,

Group Pictograms

Health Hazard 	Flammability 	Compressed Gas 
Corrosive 	Explosive 	Oxidizers 
Environmental 	Acute Toxicity 	Other Hazards 

While the hazards of a particular chemical reflect inherent properties of the chemical, the actual risk of

injury or illness is a **function of both hazard and exposure**. Regardless of the route, the exposure may consist of a brief or even one-time (**acute)** exposure, or it may repeatedly occur over longer (**chronic**) periods of time. Efforts that minimize exposure will limit risk of harm.

Routes of Exposure

Chemicals exert harmful effects on the body through exposure by one or more of the following routes: Ingestion, Inhalation, Dermal (skin) contact, and Percutaneous (puncture).

- Ingestion refers to eating or drinking a substance and can also include, to a lesser extent, swallowing mucous containing a substance that was inhaled into the upper respiratory system. Ingestion is the most common route of poisoning in homes with small children but is rare in laboratory settings due to restrictions on smoking, eating, or drinking. Individuals handling hazardous materials must nevertheless still take precautions against inadvertent ingestion by carefully controlling contamination, especially on the hands.

- Inhalation and dermal (skin) contact are the more common routes of chemical exposure in most laboratories. Inhalation can generally be controlled effectively using a local exhaust ventilation device such as a chemical fume hood or exhaust snorkel when handling volatile substances or performing operations likely to splash or aerosolize. Dermal contact can be limited through careful work practices that minimize contamination such as the use of tongs or forceps, good housekeeping, and the proper selection and consistent use of gloves.

- Puncture exposures occur when intact skin is punctured by a sharp or pointed object and contamination on the object is introduced into the body. These so-called "Sharps" injuries not only physically damage tissue but are also responsible for a large proportion of laboratory- and clinically acquired infections. Within chemical laboratories, puncture wounds and percutaneous exposures can be minimized by:
    - Replacing sharp needle syringes with blunt cannula devices,
    - Eliminating Pasteur pipettes,
    - Substituting safety blades and scalpels for straight-edge razors,
    - Using forceps for collecting broken glass or dropped needles and syringes,
    - Adopting one-handed techniques and not recapping needles.

Signs and Symptoms of Over-Exposure

Information about the hazardous properties of chemicals, including typical medical signs and symptoms of over-exposure, is available from container labels, Safety Data Sheets, and other references and resources.

The signs and symptoms of over-exposure vary widely by the chemical, concentration, route of exposure, and individual health and medical conditions. In addition, over-exposure to many chemicals may not result in immediately recognizable signs or symptoms.

However, should any of the following symptoms develop, individuals should stop work immediately,

remove PPE, wash their hands, and contact their Healthcare provider:

- Unusual taste or odor,
- Respiratory irritation, coughing, choking, or shortness of breath,
- Sudden headache, dizziness, blurred vision, or loss of consciousness,
- Burning or painful sensation,
- Swelling, reddening, or itching skin.

Particularly Hazardous Substances (PHS)

OSHA's Laboratory Standard identifies Particularly Hazardous Substances as several categories of chemicals that pose serious and potentially irreversible health hazards. They include select carcinogens, reproductive toxins, and acutely toxic chemicals. Due to their significant potential for harm, work with these substances requires adoption of additional safe working practices to further control exposure. Please contact EHS for help in identifying Particularly Hazardous Substances or for assistance in evaluating the hazards from these or any other chemicals.

- Select Carcinogens are the subset of chemicals known or reasonably anticipated to cause cancer in humans based upon epidemiological research or animal testing. They include chemicals identified by the International Agency for Research on Cancer and the National Toxicology Program, and those specifically regulated as carcinogens by OSHA.

- Reproductive Toxins are those chemicals that can negatively affect human reproduction or reproductive capabilities. They include chemicals that can damage reproductive organs or their function, cause mutations to inheritable genetic material (mutations in sperm or egg), or cause malformations to a developing embryo or fetus (teratogenesis).

- Acutely or Highly Toxic chemicals are chemicals that cause serious illness or death after exposure to small quantities or at low concentrations.

Other Regulated or High Hazard Chemicals

In addition to the Particularly Hazardous Substances specifically addressed by OSHA's Laboratory Standard, many other chemicals pose serious hazards or carry special regulatory requirements.

- Toxins are widely used in biological research. Due to their high toxicity, many are regulated by the Federal Select Agent Program. Select agent toxins include toxic materials and toxic products from biological organisms and recombinant or synthesized molecules and can pose a severe threat to public health, animal or plant health, or animal or plant products. Laboratories interested in working with these or any other highly active toxins must first consult EHS and UVA's Institutional Biosafety Committee.

- Hydrogen Fluoride and Hydrofluoric Acid can cause severe, penetrating burns to the skin, eyes, and lungs. Although concentrated forms of these compounds are readily perceived by a burning sensation, more dilute forms may be imperceptible for hours, potentially leading to insidious and difficult-to-treat deep burns. Seek medical treatment for any exposure to HF and use Calgonate® gel for topical first aid treatment as soon as you have an exposure. Be mindful that the product has a roughly 1-yr shelf life.

Laboratories interested in or already working with HF should consult with EHS (and for supplies of Calgonate® gel).

- Heavy Metals are toxic in most forms and some, in their organic form, are extremely toxic and highly permeable to most gloves and other personal protective equipment. Laboratories interested in or already working with heavy metals (arsenic, beryllium, cadmium, hexavalent chromium, lead, and mercury) should contact EHS for a hazard assessment. In many cases, and especially when handling powders, EHS will recommend the laboratory have an Industrial Hygienist (EHS) conduct periodic sampling to determine potential for exposure. Based on sampling results, EHS can provide additional recommendations.

Highly Reactive and Explosive Compounds

Highly reactive compounds include chemicals that are unstable and capable of self-decomposition or that react violently when exposed to water, humid air, oxygen, light, heat or friction, physical shock, or other chemicals. These reactions are highly exothermic and may also evolve toxic or flammable gases. They include water / air reactive and pyrophoric chemicals, azo compounds, peroxides, and peroxide-forming chemicals. Some highly reactive compounds are shipped and stored under mineral oil, solvent, or an inert atmosphere to minimize the potential for contact with air or water.

- Alkali metals (e.g., sodium, potassium), some metal hydrides (e.g., lithium aluminum hydride, calcium hydride), and pyrophoric chemicals (e.g., organo-lithium compounds) react violently when exposed to water, humid air, or oxygen.

- Pyrophoric materials often react so rapidly that actual ignition occurs. Depending upon the location of work and the other chemicals in use, unexpected ignition can result in serious fires and life-threatening burns. Note that EHS provides an on-line training module specifically on Handling Organolithiums and Related Agents, available through the STAR training portal.

- Explosives are a broad category of chemicals with the potential to release such large amounts of gas that they generate a high-pressure shock wave capable of causing serious physical damages. Explosives can be initiated by mechanical impact, heat, light, or chemical reaction. In the laboratory, explosives may be under purposeful study but are more commonly encountered as accidental by-products, residues, or decomposition products.

- Azo compounds and peroxides are highly sensitive to physical shock, heat or friction, and sparks. Many require storage below room temperature. Some common laboratory chemicals can also form potentially explosive peroxides over time, even when stored in sealed containers. Manufacturers sometimes add inhibitors to these compounds to retard peroxide formation.

- Chloroform can form very toxic phosgene over time when exposed to oxygen and amounts of UV light (or if contaminants are present). Unstabilized chloroform should be discarded 6 months after opening and stabilized chloroform discarded after 12 months.

- Peroxide-forming chemicals should be purchased in amber bottles and stored under dark conditions. In general, the preferred method for safe management of these chemicals is to purchase them in the

smallest quantity needed, date label their containers, and discard them as hazardous waste before the manufacturer's expiration date.

- Class A compounds should be disposed of within 3 months of receipt.
- Class B compounds should be disposed of within 6 months of receipt.
- Class C compounds (and Class B with stabilizers) can generally be stored for longer periods of time but should be visually inspected at least every 6 months.

- The table below describes the three generally recognized classes of peroxide-forming chemicals and provides some common laboratory examples of each. Additional information on peroxide-forming chemicals is available from Safety Data Sheets, technical references and EHS.

Class A	Class B	Class C
Chemicals that form explosive levels of peroxides without concentration	Chemicals that form explosive levels of peroxides upon distillation or evaporation	Unsaturated monomers that can auto-polymerize if inhibitors have been removed or depleted
Butadiene	Cumene	Acrylic acid
Chloroprene	Cyclohexene	Butadiene
Isopropyl ether	Diethyl ether	Ethyl acrylate
Potassium amide	Dioxane	Methyl methacrylate
Sodium amide	Furan	Styrene
	Tetrahydrofuran	Vinyl acetate

- Perchloric acid, picric acid, and sodium azide are three additional chemicals that can pose serious explosion hazards. These three chemicals pose little risk of explosive reaction when kept wet by solution in water. When dried, however, their residues (as perchlorates, picrate, and azides) can become shock, friction, and heat sensitive, and frequently accumulate under bottle caps over time.

- Controlled Substances are drugs, drug-like substances, and certain precursor materials that are regulated by the U.S. Drug Enforcement Administration (DEA) and by the Virginia Board of Pharmacy (VBP). Researchers planning work with controlled substances must first obtain Practitioner registrations from both the DEA and VBP, and meet specific laboratory security, inventory control, and user authorization requirements. Current lists of controlled substances and registration requirements are available from the DEA and VBP websites.

- Several hundred chemicals were previously regulated under the U.S. Department of Homeland Security's (DHS) Chemical Facility Anti-Terrorism Standards (6 Code of Federal Regulations Part 27). Commonly referred to by its acronym, CFATS, this regulation addressed specific "chemicals of interest" to help protect against purposeful or accidental release, theft, diversion, or sabotage. While Congress allowed the statutory authority for CFATS to expire in July 2023, it remains important to safeguard chemical inventories from unauthorized access especially those that are highly hazardous to health such as highly toxics, carcinogens, and reproductive toxins.

SECTION VII
HANDLING AND STORAGE OF CHEMICALS AND SOLVENTS

This section provides general guidance for safely managing hazardous chemicals in the laboratory. Additional information is provided during laboratory chemical safety training.

Chemical Ordering

- Cyanide and Nitrile compounds are among the most toxic substances encountered in the Chemical laboratory. The compounds are toxic if inhaled, ingested, or absorbed through the skin. HCN readily occupies the oxygen binding site on the hemoglobin molecules in red blood cells, causing death by oxygen deprivation. You must obtain lab certification from the Department Chair before using Cyanide or Nitrile.

- UVA limits individual chemical containers to a maximum capacity of 4 liters or 1 gallon. The Virginia State Fire Marshal does not permit the storage and use of flammable liquids in 5 -gallon cans or larger.

- Where a choice is available, order chemicals in safety-coated or shatter-resistant containers, especially corrosive and reactive materials.

- Ensure your laboratory has an appropriate place to store and use new chemicals. For example, using toxic volatile liquids requires a chemical fume hood, while compressed toxic or corrosive gases generally require a dedicated ventilated gas cabinet. Consult EHS if you have questions about the safety infrastructure needed for a new chemical.

- Ensure all chemicals, especially flammables, are purchased in the smallest quantities needed and inventories are maintained at levels reasonably needed to perform work.

Chemical Transport

- When transporting chemical containers outside of the laboratory or between work areas, use a secondary container such as a chemical bottle tote, covered bucket, or a tray. Be sure to secure the load or use a cart with raised edges. Wheels should be large enough to roll over uneven floor surfaces and elevator door gaps.

- Use extra care when transporting chemicals in elevators since these locations have limited ventilation and are difficult to exit quickly in the event of a spill. Avoid transporting cryogen tanks and liquid nitrogen tanks in passenger elevators. Use service elevators when available, and do not ride with the tank in the elevator. Use a “buddy system” to intercept passengers if you must transport up or down several floors.

- Contact EHS for assistance if you need to: Transport large quantities of chemicals elsewhere indoors, move or transport chemicals outdoors, or ship any chemicals or research specimens off-Grounds.

Chemical Storage & Handling

- Segregate and store chemicals by their hazards using a classification system.
    - See Appendix E for guidelines.

- Keep flammable liquids in storage devices listed or approved by the National Fire Protection Association. Flammable storage cabinets must have self-closing doors and be prominently posted. Cabinet vents must be capped closed or, if connected to building exhaust, provided with a flame arrestor.

- Refrigerators and freezers used to store flammable liquids below room temperature must also be listed or approved for such use – never store flammable materials in an ordinary refrigerator or freezer.

- Date-labeling is recommended for all chemicals, but especially for unstable materials and those that can form reactive / explosive secondary products over time such as peroxides and shock-sensitive salts, e.g., ethers, other peroxide-forming chemicals, picric acid, perchloric acid.

- Periodically inspect chemical storage areas for expired materials and for any containers with damages such as bulging or deformation exteriors, broken caps or lids, discoloration, or unexpected precipitates or crusts. Consult EHS for assistance before repackaging.

- A fume hood or other approved ventilation/exhaust system should be utilized whenever flammable solvents or toxic gases are used. Do not operate the fume hood with the sash above the indicated level.

- The best ventilating efficiency is attained with the hood sash closed. Keeping all items at least 6 inches behind the sash line and minimizing the quantity of equipment within the hood area will greatly improve its exhaust effect.

- The operating condition of a hood should be determined before the hood is used. Fume hoods are inspected and certified annually by EHS. They will affix a label on the fume hood indicating the operability of the system and the maximum acceptable elevation of the hood sash. If your fume hood has not been inspected in more than one year, please call EH&S.

- Perchloric Acid - The use of perchloric acid can result in the accumulation of explosive perchlorate crystals on chemical fume hood surfaces and inside ductwork. Work that involves heating or evaporating concentrated perchloric acid must be performed in a special Perchloric Acid Fume Hood. These devices have self-contained water rinsing and wash-down features to minimize the formation and accumulation of reactive crystals. These are available in select labs in Jesser and Wilsdorf Halls.

- All chemicals must be correctly and clearly labeled and kept in capped containers. Parafilm and aluminum foil are not acceptable for long-term storage of chemicals. Screw caps should be used whenever possible Post warning signs when unusual hazards, such as radiation, flammable materials, biological hazards, or other special problems exist. It is recommended that you place your initials and date on the label of any chemical container.

- Chemical splash goggles (or face shields) and rubber gloves should be worn when concentrated acids are poured. Such equipment must also be worn when any highly reactive or toxic chemicals are handled,

such as elemental sodium or cyanide.

- All chemicals must be organized and stored on shelves or in cabinets where they will not be knocked over. One way to organize chemicals is to store organics by number of Carbon atoms and keep them separate from inorganics, which should be stored in alphabetical order. Upon receipt, date and initial the label so that the age of the stock can be determined.

- All chemicals in the laboratory must be labeled with permanent labels. The label should indicate the full chemical name and the primary hazard associated with the substance (e.g., flammable, toxic). Do not use abbreviations. Include your initials and date.

- Discarding containers- UNBROKEN chemical reagent, salt, and solvent bottles can be discarded in trash bins once they are THOROUGHLY RINSED. If a chemical label is present, it should be removed or defaced.
- **NEVER** put hazardous waste down the sink or in the trash. If you are not sure if a chemical is hazardous, contact EHS. Generally, we advise collecting and submitting any chemical waste to EHS for disposal. All disposal costs are covered through research overhead, so laboratories will never be charged directly.
- Dichromate in Sulfuric acid and other strong acid or oxidizer cleaning solutions should not be used for general cleaning purposes. Due to liberation of extremely toxic chromyl chlorides, Dichromate/Sulfuric acid is approved for use only in fume hoods.
- Concentrated acids and bases should be stored in containment trays, separated from all other chemicals. They should not be stored on high shelves. ACIDS AND BASES SHOULD BE STORED IN SEPARATE CABINETS.
- Peroxides, hydroperoxides, and peroxyesters - these compounds are all active oxygen-containing materials which can decompose generating oxygen or oxidizing agents. These materials are chemically unstable to varying degrees. Many organic compounds, including the following types, are known to form extremely dangerous peroxides.
    - Aldehydes and Ketones, Ethers, especially cyclic ethers such as THF.
    - Compounds containing benzylic hydrogen atoms, e.g., cumene.
    - Compounds containing the allylene ($CH_2=CHCH_2R$ structure).
    - Vinyl and vinylidene compounds, e.g., vinyl acetate and vinylidene chloride.
    - Examples of common materials which form dangerous peroxides upon long exposure to air are: Cyclohexene, Cyclooctene, Decalin, p-Dioxane, Ethyl ether, Isopropyl ether, Tetrahydrofuran (THF) and Tetralin.
- Disposal of Peroxides - Do not mix with other chemicals for disposal – keep in a separate contained properly labeled for disposal by EHS.

- **Special precautions are needed for other especially hazardous chemicals**:
    - Picric acid, which is highly shock sensitive,
    - Ethers, can form highly unstable peroxides, should be discarded after 6 months,
    - Triethyl aluminum, which is highly pyrophoric,
    - Lithium aluminum hydride, which is highly water reactive,
    - Piranha solution, which is a strong corrosive and oxidizer.

- **Flammable solvents-**Properties of flammable liquids:
    - **Flash Point**: Temperature at which the vapor pressure is sufficient to form an ignitable mixture

with the air.
    - **Ignition Temperature**: Minimum temperature required to cause self-sustained combustion.

- **Classification of flammable liquids**:
  Class IA Liquids: flash point below 73°F (23 C) and boiling point below 100°F (38 C).
  Class IB Liquids: flash point below 73°F (23 C) and boiling point at or above 100°F (38 C).
  Class IC Liquids: flash point between 73°F (23 C) and 100 °F (38 C).
  Class II Liquids: flash point between 100°F (38 C) and 140 °F (60 C).
  Class IIIA Liquids: flash point between 140°F (60 C) and 200 °F (93 C).
  Class IIIB Liquids: flash point above 200°F (93 C).

- The **maximum allowable size of containers for flammable liquids** is one gallon. or less.
- The **toxicity of common solvents** should be recognized. It is best to consider every chemical toxic and to protect yourself accordingly. Examples include:
    - Certain aromatic hydrocarbons
    - Esters of organic acids
    - Ethylene glycol, glycol esters and glycol ethers
    - Halogenated hydrocarbons
    - Lower alcohols - methanol, ethanol, etc.
    - Nitrogenous compounds such as amine

- **A list of some common solvents** is given in the following table.

Name	Flash pt. F (C)	Boiling Pt. F (C)	Class
Acetone	0 (-18)	133 (56)	IB
Acetonitrile	42 (6)	179 (82)	IB
Benzene	12 (-11)	176 (80)	IB
Butanol	84 (29)	243 (117)	IC
Carbon disulfide	-22 (-30)	115 (46)	IB
Cyclohexane	0 (-18)	179 (82)	IB
p-Dioxane	55 (13)	214 (101)	IB
Ethanol	55 (13)	173 (78)	IB
Diethyl ether	-49 (-45)	95 (35)	IA
Heptane	25 (-4)	209 (98)	IB
Hexane	-7 (-22)	156 (69)	IB
Methanol	53 (11)	147 (64)	IB
M.E.K.	16 (-9)	176 (80)	IB
Octane	56 (13)	258 (126)	IB
n-Pentane	-57 (-49)	97 (36)	IA
2-Propanol	53 (12)	181 (83)	IB
THF	6 (-14)	151 (66)	IB
Toluene	40 (4)	231 (111)	IB
p-Xylene	81 (27)	281 (138)	IC

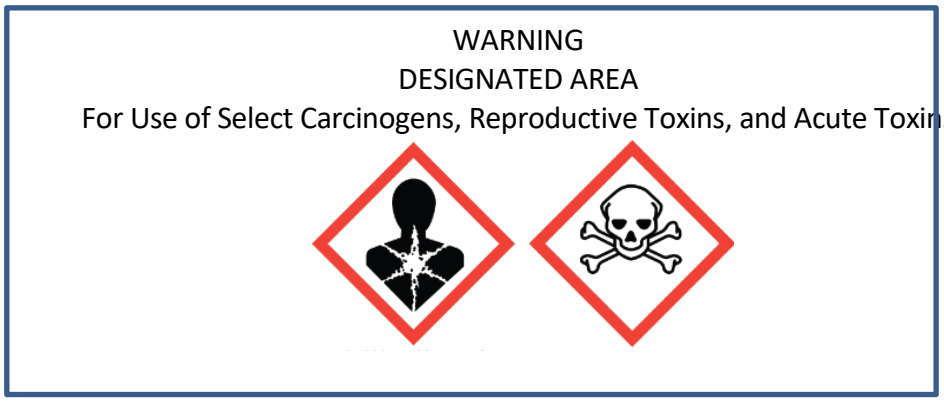
Additional Requirements for Particularly Hazardous Substances

The OSHA Lab Safety Standard specifically mandates that labs maintain an inventory and develop additional precautions for handling “Particularly Hazardous Substances”, which they define as Select Carcinogens, Reproductive Toxins and Acute Toxins. If you are unsure if a chemical fall into one of these categories, check the SDS, or contact EHS.

When working with Particularly Hazardous Substances or other high hazard or regulated chemicals, laboratories are advised to:

- Maintain an inventory of these chemicals and restrict access to authorized persons.
- Seek formal review and approval from laboratory supervisory personnel for new work or scale-ups. Conduct a “dry run” as appropriate and revise procedures accordingly.

- Establish one or more Designated Areas for the handling and use of these chemicals. The Designated Area may be as small as a portion of a laboratory bench, the interior of a chemical fume hood, or as large as the entire laboratory.
- Post Designated Areas with labels or signage as follows:



- Provide containment appropriate to the chemical and task such as an absorbent bench coating or covering, non-absorbent tray, or a device with inherent spill containment such as the interior of a chemical fume hood.

- Weigh dry powders in a HEPA filtered weigh station enclosure or inside a chemical fume hood with a shield to minimize air currents. Preparing concentrated stock solutions is preferred to repeat dry powder handling if the resulting solution is stable and has good storage characteristics. Alternatively, where possible, purchase highly toxic dry powder reagents in pre-weighed vials with rubber septa to eliminate open air powder handling.

- Perform any inactivation, neutralization, or other step(s) designed to render a hazardous chemical into a less or non-hazardous state before completing the experimental procedure. Review these protocols in advance with EHS.

Shipping Hazardous Materials (Dangerous Goods)

- There are critical safety and regulatory considerations for shipping materials, such as chemical and biochemical samples, from UVA. These shipments are highly regulated by the U.S. Department of Transportation (USDOT) and/or international agencies (IATA, ICAO). And requirements vary depending upon the material, the mode of transportation, the commercial carrier, and the destination.

- Hazardous materials (HazMat) may include items as: laboratory chemicals, radioactive materials, compressed gases, biological agents, human (or non-human primate) derived materials (cell lines, blood, tissues, patient samples, etc.), equipment or instruments that contain hazardous materials (e.g., mercury), lithium batteries, and dry ice.

- To comply with shipping regulations, these materials must be properly classified, packaged, documented, and handled by trained employees. Anyone who ships HazMat can be subject to

inspection by federal enforcement officers (e.g., FAA or PHMSA/DOT). Failure to meet regulatory requirements may result in citations, fines, and/or imprisonment. Fines can range from $250 to $250,000 per violation.

- All shipments of hazardous chemicals, gases and radiological materials MUST be shipped by EHS personnel. Contact EHS for the proper shipping of these materials, refer to https://ehs.virginia.edu/Shipping.html. Certain chemicals that are non-toxic in nature may be shipped without training, but must be cleared for EHS approval. When in doubt, check with EHS.

- Infectious substances or other biological materials must be shipped by trained personnel in the lab, or department. Contact EHS Biosafety with specific questions and Refer to http://ehs.virginia.edu/Biosafety-Shipping.html

- Shipments containing Dry Ice - any shipment containing dry ice must be shipped by trained personnel in the lab, or department. EHS can ship upon special request. Dry ice is classified as a "miscellaneous" hazard, Class 9, by the U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA), and is characterized as a (1) explosion hazard, (2) suffocation hazard, and (3) contacthazard. The FAA requires training prior to shipping hazardous materials, including dry ice.

- Consider using freeze packs (blue ice packs), which are normally not considered hazardous in lieu of dry ice.

- EHS provides online training for shipping of dry ice, and infectious substances. Refer to. http://ehs.virginia.edu/Chemical-Safety-Shipping.html

- Contact EHS if there is any question if an item is regulated for shipping.

SECTION VIII
ASSEMBLY AND USE OF APPARATUS

This section provides general guidance for the safe design and operation of laboratory apparatus.

Introduction

"Hazard" and "Risk" are not the same. A "hazard" is an inherent chemical or physical characteristic that has the potential for causing damage to people, property, or the environment. A hazard can be eliminated, but not reduced. A hazard causes harm. "Risk" is the probability that a hazard will cause harm. It is a is a measure of human injury, environmental damage, or economic loss in terms of both of the "likelihood" and the "magnitude" of the loss or injury. Risk associated with a hazard can be reduced.

There are many ways to identify and evaluate safety hazards in a laboratory. No matter what method or combination of methods you choose, they all help you achieve hazard identification, which will inform your risk assessment and selection of control measures. To conduct a hazard assessment, you should:

1. IDENTIFY HAZARDS – a review of the materials, equipment, facility, and work habits and practices will reveal potential hazards. The question to ask is "What exactly is the hazard?"
2. ANALYZE THE RISKS -Rank hazards by how likely they are to happen and how severe the outcomes would be. Questions to ask are "What can go wrong and how?", "How bad can it be?", and "How often can it happen? "
3. SELECT CONTROLS -Choose the best possible response to eliminate a hazard or lower its risk of occurring. The question to ask is "How do we control and manage this given the risk?"

Safe Design and Assembly of Apparatus

- Prior to new equipment set-up, a Hazard Review Checklist (Appendix F) should be completed to determine if adequate safety plans were considered in your equipment design. The completed checklist is to be reviewed and approved by your faculty advisor prior to the initiation of an experiment.

- You may choose to use more than one method beyond the Hazard Review Checklist for your lab's hazard identification and evaluation assessment. The American Chemical Society has developed a full suite of hazard identification tools. Other examples can be found in SECTION XIII under key references.

Safe Operation of Apparatus

- Procedures that may release toxic vapors, fumes, mists, or aerosols should be performed in a chemical fume hood or other local exhaust ventilation device.

- The apparatus should be set up in a clean and dry area. Be certain that the equipment is firmly clamped and is kept well back from the edge of the laboratory bench. Many accidents occur when someone walks by a bench and brushes against the glassware or other equipment.

- Make sure that you use the proper size equipment for the experiment, allowing at least 20% free space. Flasks that contain solutions to be refluxed should have 50% free space.

- Bunsen burners are allowed in laboratories provided the immediate areas around them are kept clear of combustible and flammable materials. A good rule of thumb is a ~1-foot radius clearance with an additional ~2-foot radius work zone that is clear of flammable/combustible materials that are not immediately needed for the work being done. It is especially important for labs to maintain clear access to designated exits and know where fire extinguishers are. Beware of the quiet and nearly invisible nature of a Bunsen burner flame. Open flame work beyond the scale of a Bunsen burner must be reviewed and approved in advance by EHS. EHS encourages fire extinguisher training for all open flame users. Contact the EHS Fire Safety group to arrange an in-person training.

- Distillation and other hot operations should be performed with a heating mantle or hot plate only. For routine purification needs, cold solvent filtration systems are greatly preferred over hot distillation; contact EHS for advice.

- To the extent possible, place laboratory balances or scales in low pedestrian traffic areas of the laboratory, away from doors and overhead supply air grilles to minimize air disturbances.

- Position and clamp reaction apparatus thoughtfully to permit manipulation without the need to move the apparatus until the entire reaction is completed.

- Ground glass joints or stopcocks should be sleeved with Teflon or freshly lubricated unless a lubricant will contaminate the system. Retainer rings should be used on stopcock plugs.

- Condensers must be properly supported with securely positioned clamps. Any attached water hoses should be clamped with clamps of an adequate material. Condensers running unattended overnight should preferably be attached to a water pressure regulator in order that surges in the water pressure do not cause the hoses to rupture.

- Stirrer motors should be secured to retain proper alignment. An air driven stirrer or magnetic stirrer should be used whenever possible. Only non-sparking motors ought to be used in hazardous areas, where significant amounts of flammable gases and solvents are present.

- Vacuum pumps and other belt-driven equipment must always have a belt guard. Refer to this for more information. http://ehs.virginia.edu/Chemical-Safety-Vacuum.html

- If a cooling bath is required and ice water is not cold enough, dry ice in an organic liquid should be used instead of liquid nitrogen whenever possible. The ideal cooling liquid for a dry ice bath should be relatively non-toxic, non-viscous, non-flammable, non-volatile, insoluble in water and should float dry ice. Ethylene glycol thinned with 2/3 water or isopropanol makes a useful cooling mixture.

- Electrical equipment including variacs, stirrers, vacuum pumps, etc., must be carefully checked for faulty or frayed line cords. Grounded electrical plugs should be used: existing ungrounded plugs should be changed immediately.

- Electrical cords should be in good condition, out of travel paths, and free of any breaks in insulation. Extension cords are for temporary use only and must be disconnected at the end of every working period. Power strips with integrated overcurrent protection (breakers) are a preferred alternative. They should be UL approved, and cannot be 'daisy-chained' to increase length.

- In the event of an electrical short, and only if it is safe to do so, unplug the appliance or trip the circuit breaker. The area in front of building electrical panels must be kept unobstructed.

- Equipment and appliances that operate at higher currents (1,000 watts) must be plugged directly into the building's wall receptacles and never into a power strip. Some examples: Refrigerators, freezers, large centrifuges, sterilizers, vacuum pumps, water stills, hot plates, heat guns and microwaves.

- Ovens- direct- heated ovens should only be used to dry glassware (and not flammables). Ovens that dry materials that off-gas noxious vapors should be contained in a hood or preferably connected to the fume exhaust system. EHS can advise on connecting equipment to building exhaust systems.

- Utility failure / Power Blips- Power blips are common during the summer thunderstorm season. Careful re-inspection of lab experiments and equipment should be conducted following a power blip or power failure. Verify that key systems, such as the HVAC, fume ventilation, and electrical circuits are still working properly.

- An unintentional cross connection between the University water supply and wastewater may occur from a submerged inlet in your laboratory unless vacuum breakers are present on the faucet. "Draw down" occurs when city water pressure drops from low reservoir conditions, opening of fire hydrants, unbalanced demand on water circuits or from other causes. If your lab faucets have an attached Tygon or rubber hose to prevent splashing or to facilitate washing, it may siphon sink wastes and possibly raw sewage into the water lines. You must cut off each faucet hose at least 2 inches (5 cm) above the sink rim elevation. This gap will assure you that no back-siphonage of laboratory sewage will pollute our potable water supply.

- Another common problem is that of "dry traps". A plumbing trap which has lost water seal through evaporation is likely to release sewer gases into your laboratory. Dry traps in adjacent rooms may also duct lab odors from remote labs into yours; this may account for unlocatable mystery odors that may be noticed. Pouring water or mineral oil into seldom used drains and cup sinks (check lab benches and fume hoods) as needed will restore the water seal and assure you that no sewer gases will escape into your work environment. Floor drains as well as unused sinks are common sources. Consult with UVA Facilities Maintenance for recurring issues.

SECTION IX
LOAD FRAME

This section outlines safety reminders for the safe use of load frames.

- Always wear safety glasses and other appropriate safety equipment when operating the instrument. Depending on the material under test, fragments have been known to fly out from the sample and can present a projectile hazard. Please do not operate this instrument until you have been properly trained.

- Install the appropriate fixtures for your test. If you are using the tensile grips, please remember to install the adapter first. (see below) Install the grips and be sure to tighten them up.

- Make sure the correct pins are installed. Never install a pin that is too small or force in one that is too large.

- Put down the protective shield and put on your safety glasses.

- When you are finished, please remember to remove your broken samples. Place them in a trash receptacle. If your material is hazardous, place in a plastic bag, apply a hazardous waste label (filled out) and place with other hazardous waste materials waiting for EHS.

- Please clean up any mess – leave the lab better than you found it!

SECTION X
HYDRAULICS

This section outlines safety reminders for working with hydraulics.

Always use the Right Gear

- The first thing you should do when arriving at the lab is make sure you are dressed for the job. Whether you operate a hydraulic press or some other machine, everyone should have a specific list of safety gear.
- Everyone should wear eye protection, gloves, and sturdy non-slip shoes at a minimum. You may also want to require a full-face mask or mouth and nose protection if the work area often has contaminants in the air.
- Create a culture where every employee holds each other responsible for wearing the right safety gear. If anyone sees someone operating a machine without the right equipment, they should be called out immediately.

Use a Checklist to Inspect Your Pump or Press

- Before any hydraulic machine begins operation, you should conduct an inspection to ensure a safe working environment. To make sure nothing gets overlooked, create an inspection checklist that every employee must use.
- Start the list by including the donning of the safety gear we just talked about. But then the actual machinery and surrounding area needs to be closely inspected. Make sure the work area is clear of debris and that the floor does not have any slippery substances.
- The hydraulic press or machinery itself should be closely inspected to make sure all guards are in place and working properly. If your machinery has a safety shut off, you should try and intentionally trigger it at least once a week to make sure it is still working.

Use Caution When Moving Dangerous Materials

- If you will be moving sharp or otherwise dangerous materials into the press or machinery, make sure they follow proper protocol. The previously mentioned work gloves should protect their hands, but you also will want to make sure that the area is clear of distractions and trip hazards. Other persons should know not to go near a hydraulic operator while they are on the job.

Use Common Sense When the Press or Pump is Moving

- When the time comes to place the materials into the press or pump-operated machine, keep your wits about you. Keep your body and limbs as clear of the area as you can. If you accidentally drop something near a moving press, shut the machine off before you move closer to put it back into position.

- Release Hydraulic systems or hydraulic power pack high pressure first before you make any hydraulic trouble shooting or replace any hydraulic component from system.

- High pressure oil can cause severe eye injury, blindness and could result in a fatality.

- Pressurized fluid can penetrate the skin, requiring prompt emergency medical attention. If not properly cared for, gangrene may result. Penetration injuries may not appear serious, but the injected body part is usually lost if medical attention in not promptly sought.

- If troubleshooting or replacing hydraulic components cannot be done safely, it is not worth doing at all!

MOST IMPORTANT: If you are not sure, ASK!

SECTION XI
COMPRESSED GASES AND CRYOGENIC LIQUIDS

This section outlines the safe handling of compressed gases and cryogenic liquids.

Compressed Gases

Compressed gases refer to gases and some liquids contained within a vessel at pressures significantly higher than the surrounding atmosphere. Most laboratory compressed gases have internal cylinder pressures on the order of thousands of pounds per square inch (PSI), making them a potentially catastrophic physical hazard in the event of cylinder rupture, valve failure, or another event that results in rapid loss of contents. The large quantities of material that can be stored compressed in a cylinder and their ability to rapidly diffuse in air can also make them significant health hazards. Compressed gases can present any of the health or physical hazards associated with chemicals. The table below outlines some basic properties of compressed gases commonly used in the laboratory.

Gas	UN Number	Density (air = 1)	LEL (%)	Primary hazard(s)	Regulator
Acetylene	1001	0.91	2.5	Flammable, simple asphyxiant	510
Ammonia, anhydrous	1005	0.60	15	Corrosive, toxic	705
Argon	1006	1.38	None	Simple asphyxiant	580

Carbon dioxide	2187	1.53	None	Simple asphyxiant	320
Carbon monoxide	1016	0.97	12.5	Flammable, toxic	350
Helium	1046	0.14	None	Simple asphyxiant	580
Hydrogen	1049	0.07	4.0	Flammable, simple asphyxiant	350
Hydrogen chloride	1050	1.27	None	Highly corrosive, toxic	330
Methane	1971	0.56	5.0	Flammable, simple asphyxiant	350
Neon	1065	0.70	None	Simple asphyxiant	580
Nitrogen (3500 / 6000 PSI)	1066	0.97	None	Simple asphyxiant	580 (680/677)
Oxygen	1072	1.12	Oxy	Oxidizer	540

- *Density refers to the relative density of the gas once released into room air. Those greater than 1 are heavier than air and will tend to accumulate at low levels while those below 1 are lighter than air and will rise.*
- *LEL is the lower explosive limit, the lowest concentration at which the gas can form a flammable/ explosive mixture in air.*
- *Primary hazards are briefly listed – consult Safety Data Sheets for more specific hazard information.*
- *Regulator refers to the specific threading and construction type of the regulator that must be used for each given gas; ultra-high purity gases often require a different regulator. Regulators are specified by Compressed Gas Association (CGA).*

- **Additional information** about compressed gases is covered in the sections *Safe Management of Chemicals* and *Good Work Practices*, UVA's chemical safety and waste training, and from the EHS on-line module, *Compressed Gas Cylinder and Regulator Safety.*

Safe Handling of Compressed Gases

- Know the contents of a cylinder and be familiar with the properties of that gas. Never use a cylinder which cannot be positively identified; cylinder color coding varies among gas vendors and is an unreliable identifier of cylinder contents.

- All cylinders in operation or not, must be firmly always secured by an adequate bench- or wall-mounted cylinder clamp or chain. Keep in mind that breakage of the valve body on a compressed gas cylinder can easily transform the cylinder into a "torpedo" capable of going through concrete walls! Cylinders need to be restrained by the mid-point of the unit to something sturdy by a chain or strap the is substantial enough to support the weight of the cylinder or group of cylinders. We do not require more than one strap or chain.

- Cylinders of compressed gases must be handled as high energy sources and therefore as potential explosives. Cylinder valves should be opened slowly. Never tamper with any part of a valve such as the safety relief or packing nuts.

- Upon receipt of a new cylinder from the vendor immediately check the cylinder valve for leaks with a soap solution. Leaks in cylinders should promptly be reported to the shop personnel and corrected.

- When installing a new cylinder, write your name on the cylinder information tag and attach it to the valve stem. Ensure that cylinders are prominently posted / labeled as to their contents, and tagged as "Full", "In Use", or "Empty" as appropriate.

- Use cylinders only with matched connectors and proper Compressed Gas Association (CGA) regulator. Never install cylinder adapters on a regulator. Teflon tape must never be used on any CGA cylinder valve fitting.

- Oxygen regulators should be used only on oxygen tanks. Contamination of oxygen regulators with the oil present in other gases can result in a serious explosion hazard when the regulator is again used for oxygen. Oxygen, or oxygen-rich gas mixes, can explode in high pressure or shock situations where any organic materials (e.g., plastic gaskets) are present. Open valves slowly and wear appropriate PPE.

- Leak- test all connections to a cylinder with a soap solution. CAUTION! Any gas, regardless of its health hazard may cause asphyxiation by displacing oxygen.

- Lubricants and greases should never be used on regulators or gas cylinder fittings. Refer to supplier technical bulletins for when to use Teflon tape, washers, or special consumable seals.

- Pressure-relief devices protecting equipment attached to cylinders of flammable, toxic, or otherwise hazardous gases should be vented to an exhaust duct or fume hood.

- When not in use, the regulators on cylinders should be depressurized. If the cylinder is not to be used for a long time, the regulator must be removed. Never leave partly assembled apparatus attached to gas cylinders. Never attempt to refill a cylinder.

- When storing or moving a cylinder, always attach the safety cap securely to protect the valve stem, and transport gas cylinders of size 2 or larger on a specifically designed wheeled cart.

- Cylinders should be in the lab so that the cylinder valve is always accessible. The main cylinder valve should be closed as soon as it is no longer necessary that it be open (i.e., it should never be left open when the equipment is unattended or not operating.) When storing or moving a cylinder, have the cap in place to protect the valve stem and never expose cylinders to temperatures higher than 50 ^{o}C.

- A cylinder should never be emptied to a pressure lower than 172kPa (25 psig): leave a slight pressure to keep contaminants out and notify the vendor with a note if draw- down occurs. Empty cylinders should not be refilled by anyone except the gas supplier. Remove the empty cylinder regulator and replace the valve cap. Keep the empty cylinder chained until pickup by the gas vendor. Be sure that a cylinder tag is attached and indicates the proper status of the cylinder (full, partially full, empty).

- Cylinder discharge lines should be equipped with approved check valves to prevent inadvertent contamination of cylinders that are connected to a closed system where the possibility of flow reversal exists. Sucking back is particularly troublesome in the case of gases used as reactants in a closed system. If there is a possibility that a cylinder has been contaminated, it should be so labeled and returned to the supplier.

- When ordering toxic or flammable gases, whenever possible request a Flow Restrictor cylinder Valve. The FRV orifice considerably reduces the full-open leak rate in event of a major leak (e.g., regulator diaphragm failure).

- When not in use, store cylinders by gas type, separating oxidizing gases from flammable ones. Hydrogen and oxygen cylinders should be kept 20 ft apart when not in use, and using a 30-minute fire rated barrier between the gases when they are in use.

- Hydrogen is lighter than air and highly flammable, with a very wide range of explosive concentrations. The Virginia fire code greatly limits the quantity of flammable compressed gases that can be stored on elevated floors or the basement. If hydrogen is needed regularly consider a hydrogen generator instead of compressed gas cylinders. The same kind of technology can be used to produce high purity oxygen. Contact EHS for information.

- Most inert gases are permitted in UVA laboratories without special ventilation, but compressed toxic, reactive, and most flammable gases require storage inside a chemical fume hood or a dedicated exhausted gas cabinet. Certain gas storage and delivery systems also require active leak detection and alarms.

Cryogenic Liquids

Cryogenic liquids are extremely cold liquids that pose a risk of serious tissue damage from immersion or splash contact. Their very high liquid-to-gas expansion ratios can also pose an asphyxiation hazard from oxygen displacement, cause explosion-like events when sealed containers are rapidly warmed up or result in fires and explosions from the uncontrolled release of a flammable cryogenic liquid. The table below summarizes the properties for some of the more common cryogenic liquids used in laboratories.

Properties of Common Cryogenic Liquids				
Liquid Cryogen	**UN Number**	**bp (°F)**	**bp (°C)**	**Liquid : Gas Expansion Ratio**
Argon	1066	-309	-185	1 : 860
Helium	1963	-452	-268	755
Hydrogen	1966	-423	-253	860
Neon	1913	-411	-246	1,445
Nitrogen	1977	-321	-196	696
Oxygen	1073	-297	-183	860

Safe Handling of Cryogenic Liquids and Dry Ice

- Cryogenic liquids are supplied in special insulated (“Dewar”) vessels with pressure relief fittings. To the extent possible, avoid damp areas since moisture can result in excess ice formation around the relief valve. Periodically inspect cryogenic liquid vessels.

- Store cryogens and dry ice in well-ventilated areas since they are continuously "boiling off" or sublimating to a gaseous state. Do not store cryogenic liquid or dry ice in cold rooms, as they are not ventilated spaces.

- Cryogenic liquids and dry ice can easily damage laboratory countertops and sinks, and floor tiles; avoid prolonged contact with any material not designed for extreme low temperatures. Never dispose of dry ice in lab sinks; instead, allow dry ice to sublimate in a loose- fitting cooler in a well-ventilated space.

- Avoid transporting cryogen tanks and liquid nitrogen tanks in passenger elevators. Use service elevators when available, and do not ride with the tank in the elevator. Use a "buddy system" to intercept passengers if you must transport up or down several floors.

- Upgrade personal protective equipment with a face-shield (over safety glasses) and heavy insulated forearm-length gloves when dispensing cryogenic liquids.

- Oxygen deficiency detection, alarms, and control systems may be needed in enclosed rooms where appreciable quantities of cryogenic liquid are stored and, in such places, where filling or dispensing operations occur. Contact EHS for additional information.

- In case of liquid nitrogen tank icing: Attempt to tighten the liquid dispensing valve. Be sure to wear insulated gloves. If icing increases or stays steady, move the tank outside, and call Praxair to have them pick it up. When in doubt, call the vendor, or contact EHS.

- For laboratories that have Praxair tanks, the Praxair call number should be posted near the EHS number for quick reference. (contact numbers – Praxair Technician 434-531-7858, and the general service number 804-231-1191).

SECTION XII
WASTE MANAGEMENT /DISPOSAL

This section outlines the requirements and recommended guidelines for proper waste disposal.

Importance of Proper Waste Disposal

Hazardous chemical waste is regulated by the Virginia Department of Environmental Quality, following rules established by the U.S. Environmental Protection Agency. Everyone who generates hazardous waste at UVA shares responsibilities for its proper management and disposal. Often called *cradle to grave*, these responsibilities begin at the time a chemical is declared unwanted and becomes a waste, through multiple handling and transportation steps, and ultimately to final disposal.

EHS manages the overall UVA hazardous waste program, including performing periodic waste inspections and providing information, containers, special labels, and waste collection and disposal services. When in doubt, call EHS (982-4911).

Hazardous waste management rules are complex and carry significant penalties for violation. As a result, it is important that you properly dispose of laboratory waste and unwanted chemicals strictly following these procedures.

General Waste Disposal Procedures

- All HAZARDOUS WASTE DISPOSAL CONTAINERS MUST BE PROPERLY LABELED AND KEPT CAPPED AT ALL TIMES.
- All waste must reside in closed, non-leaking containers. Do Not use flasks or test tubes with stoppers, beakers with parafilm, or bottles with ground glass stoppers. The outside of the waste container must be reasonably clean. Do not put liquids (especially phenol) in bottles designed for solids.
- Hazardous waste must never be disposed of in non-hazardous waste trash cans.

- Do not put hazardous waste down the sink or in the trash. Sink drain disposal is limited to dilute, non-hazardous aqueous and water miscible materials, typically buffer solutions, disinfected tissue and cell culture media, and glassware and container rinse waters of non-toxic chemicals. Consult EHS if you have any questions.

- All empty bottles must be defaced, labeled empty, and must remain capped. Dispose of empty, defaced bottles as soon as possible. Bottles that have not been defaced and labeled empty, will be counted as full. Before discarding in a trash can, these containers must be THOROUGHLY RINSED.

- Original chemical reagent containers can make good waste collection containers, but they must be appropriate to the characteristics and properties of the waste.

- Glass bottles should be avoided to the extent possible unless they have a shatter-resistant coating, and metal containers should never be used for corrosive materials. Food and beverage containers are not suitable for chemicals and should never be used for waste.

- Limit waste containers to no larger than 5 gallons (~ 22 Liters) capacity. EHS provides 1 gallon and 5 gallon suitable waste collection containers.

- Do not put acidic or basic waste (pH <3 or >9) in metal cans. Metal cans corrode in a very short time. Keep acids and bases separated from hydrocarbons and ethers.

- Do not completely fill liquid waste containers - leave a gap of at least 2 inches (about 5 cm) below the cap.

- Keep waste containers closed except when adding waste. For operations that continuously generate chemical waste, high volume waste operations, or for wastes that may evolve significant amounts of gas, contact EHS for special container caps that can be used to accommodate continuous accumulations and prevent pressure build-up.

- Do not let **any** solid materials, such as pipette tips, rubber stoppers, Kim wipes, etc. enter a

liquid waste bottles / carboys! If contaminated, these items must go into the EHS provided buckets. Solid materials will damage our equipment used to transfer liquid waste from 1- and 5-gallon bottles to 55-gallon drums.

- Sharps Disposal- Needles (trace chemically contaminated and non-contaminated), razor blades, scalpels, and other objects that pose a puncture or laceration hazard must be collected in a Sharps container for disposal as regulated medical waste. Only fill containers to about two-thirds of their capacity. No additional waste label or ticket is necessary.

- Sharps containers are available from EHS; Environmental Services (EVS) supplies and picks up sharps containers at Medical Center laboratory locations. Collect other chemically contaminated items such as syringe barrels, capillary tubes, pipettes, and pipette tips in hazardous waste buckets.

- Store hazardous chemical wastes in your established laboratory satellite accumulation area, using secondary containment.

- Place non-contaminated glassware and other glass items in a bag-lined cardboard box and label it with an EHS "Waste Laboratory Glassware" sticker. Once full, close the bag and tape the box shut. These materials are managed as regular trash and can be removed by Housekeeping or taken directly to a trash dumpster. Make sure that you do not overfill these containers leaving enough room to be able to tape the containment bag taped and the box shut.

- Unknown wastes can be dangerous to handle. In addition, they are not accepted by disposal firms. Every effort must be made to identify. EHS will require a department charge code for identifying unknowns should their waste vendor itemize the characterization needed to properly ship and dispose. If a waste (or any other chemical) container has unknown contents, contact EHS as soon as possible for assistance.

- Do Not accumulate more than five 5-gallon cans or carboys, or more than ten gallons in bottles. Larger pickups will have to be scheduled separately.

- Acidic solutions containing METALS (arsenic, barium, cadmium, chromium, lead, silver) should NOT go in 5-gallon carboys.

- When waste containers are ready for pick up, notify EHS by using the on-line Waste Pick-Up Request Form or calling (434) 982-4911.

Special Waste Disposal Precautions

- Ethers tend to form extremely explosive compounds over time. Therefore, date all ether cans. Discard ethers after 6 months from receipt. If you have an old ether can, label as waste call EHS for pick up.

- Do not attempt to open bottles of DRY picric acid. This is an extreme explosion hazard! Any dry bottles of picric acid should be labeled as waste and picked up by EHS staff.

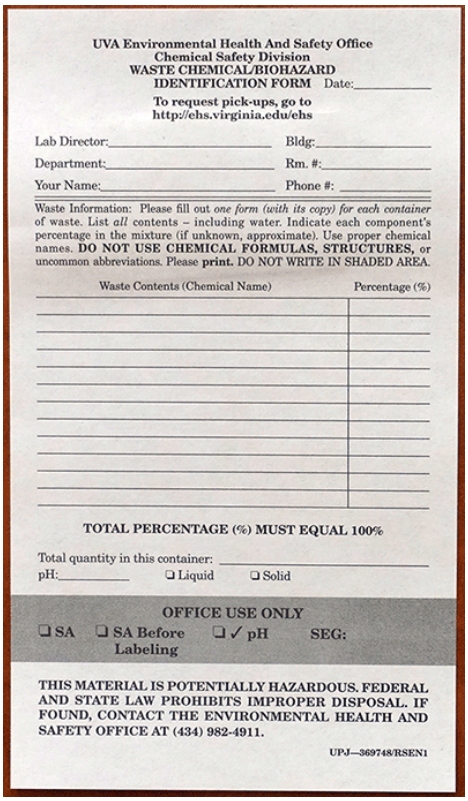
- Other chemicals requiring special precautions include triethyl aluminum (which is highly pyrophoric) and lithium aluminum hydride (which is highly water reactive)

Waste Containers and Labels

- Label every waste container with an approved EHS hazardous waste label, as shown. Waste labels are automatically provided on containers supplied by EHS; they are also available from EHS for reusing chemical reagent bottles. A hazard pictogram must be checked to indicate the hazard characteristic of the waste, along with details on the composition of the waste:

- EHS provides 1-gallon and DOT-approved 5-gallon carboys.

- In addition to waste stickers, all waste containers MUST contain a waste disposal ticket issued by EHS. This includes waste that consists of chemicals still in their original containers. Waste will not be picked up if it is not labeled properly.



- Both the label and its no-carbon-required copy should be affixed to the waste container by a single piece of tape across the top of the bottle or in such a way that it does not cover the waste label and can be removed when they pick up the waste.

- Information that is absolutely required on the chemical waste label includes:
  - The name of all possible contents, including stains, water, or any solvents.
  - The percentages of each component.
  - The total quantity.
  - The pH of the waste liquids if it is suspected to be below pH 3 or above pH 10.
  - Also include your name, date, department building and room number where the waste is located, phone number, and lab director.

- Important: Disposal companies will not accept unknown chemicals. You must make every

possible effort to accurately describe the contents of each container. This means tracking down and questioning previous lab occupants if necessary.

Waste Segregation

Waste segregation minimizes the chances of incompatible materials being mixed and to keeps disposal costs for the University as low as possible.

Avoid mixing different chemical waste streams together - instead, collect them by their hazardous properties. Contact EHS for additional guidance (see EHS's waste segregation guidelines) http://ehs.virginia.edu/Chemical-Safety-Waste.html

When combining different materials, always check the SDS to be sure they are compatible materials or call EHS for guidance.

Flammables

- Non-halogenated organic solvents, <5% water
- Non-halogenated organic solvents, >5% water

Toxic

- Halogenated solvents (% water unimportant)
- Cyanides
- Formaldehyde Solutions
- Solutions containing compounds of the following metals: arsenic, barium, cadmium, chromium, lead, silver, and selenium.
- Any solution containing mercury or its compounds. (Mercury and mercury compounds should be kept separate from any liquid whenever possible.)

Corrosive

- Acids, organic
- Acids, mineral
- Bases, organic
- Bases, mineral
- Photographic stop bath
- Note: Do not put acidic or basic waste (ph. <3 or >9) in metal cans. Metal cans corrode in a very short time. Keep acids and bases separate from hydrocarbons and ethers.

Oxidizers

- Inorganic oxidizers
- Organic peroxides

Aerosol Cans

- All aerosol cans.
- Note: A recent change in the Virginia Hazardous Waste Regulations requires that all unwanted aerosol cans be collected as Hazardous Waste.

Miscellaneous Waste Segregation

- Photographic fixer
- Photographic developer
- When possible, keep carcinogens, mutagens, and teratogens separate from other wastes.
- Keep aqueous wastes separate from organic solvents.
- Keep halogenated and non-halogenated wastes separate.
- Sulfides
- Pesticides
- Paints
- Oils
- Lamps/Bulbs - Fluorescent lamps and high intensity discharge bulbs contain mercury and must be recycled (building lighting- Facilities Management, lab equipment – EHS).
- Batteries - EHS will take lithium batteries, and damaged/defective batteries. UVA Recycling accepts lithium, lithium ion, lithium re-chargeable, lead acid, alkaline, nickel cadmium, nickel metal hydride, 9 volts, and button batteries.
- All sharps (Needles, razor blades, scalpel blades, etc.), whether they are contaminated with trace chemicals or uncontaminated, must be placed in a sharps container. Always use the sharps container with the top in place. Sharps container is available from EHS.

SECTION XIII
EMERGENCY / SPILL RESPONSE

This section provides a summary of the steps you should take to prepare for emergencies, and what to do in case of an emergency.

In the event of a serious or life threatening medical, fire, police, outdoor hazardous materials spill, or another emergency, dial 911 from any phone. Provide as much information as possible, the specific location of the emergency, and stay safely nearby to help direct emergency responders to the scene and answer any questions.

Emergency Preparedness

- Familiarize yourself with emergency procedures and learn how to obtain additional help in any emergency. Know how to use the emergency equipment in your work area.

- EVERYONE MUST BE FAMILIAR WITH THE LOCATION AND USE OF SAFETY SHOWERS, EYE WASH EQUIPMENT AND PERSONAL PROTECTIVE EQUIPMENT. Take a moment to familiarize yourself with the locations of these important items.

- Ensure a first aid kit is available and well stocked, and a fire extinguisher is available.

- Discharged fire extinguishers must be recharged by Facilities Management and returned to service immediately. Report any fire to EHS Fire Safety.

- Flush eye wash stations monthly. Eye wash stations in your laboratory area should be flushed monthly, preferably on weekly basis. Document each flush check on an eyewash tag, which

is available from EHS free-of-charge. EHS will verify labs are performing monthly flushes during inspections.

- Safety showers are inspected by UVA Facilities Management personnel with the inspection date recorded and attached to the shower. Make sure the inspections are conducted on a timely basis by checking the tag in the safety shower in your area. Should the date be more than 1 year old, call Facilities Management (924-1777) and request an inspection.

- Fire doors (which are typically labeled on the door jamb or frame) must not be normally propped open. Should this become necessary, make sure that the door is closed if you are not in the lab area for any length of time.

- Seek advice from EHS before doors between adjacent laboratories are blocked and avoid this if possible. These will provide alternate escape routes in case of an emergency and may be required egress routes per the building code.

- Keep aisles and exits clear, and maintain ready access to emergency eyewashes, showers, and fire extinguishers. Exits should always remain unobstructed.

- For work with hazardous materials:
    - Use the buddy system, and preferably work only during regular business hours.
    - For the small number of compounds with special first aid procedures or an antidote (e.g., hydrofluoric acid or hydrogen fluoride, cyanides), review in advance with EHS and your healthcare provider.

Emergency Response – Spills

- Promptly and completely neutralize, absorb, and bag spilled materials by the safest means possible. The Office of Environmental Health & Safety is equipped for a rapid response for toxic, flammable, or radioactive material spills, including after-hours and on weekends; if you are uncertain about the nature of the spill or on how to take care of it, call EHS at 434-982-4911. They may authorize you to perform a spill cleanup if the hazards are insignificant. Otherwise, EHS will undertake the cleanup operation. Note: If calling EHS after-hours/weekend, you will be prompted to press '0' for the University Operator. They will be able to take your report and contact the EHS person on-call for emergency spills.

- Tell others in the area and restrict access to the spill location. If anyone has already left the area, examine the potential for contamination to have spread.

- Identify the material(s) involved, quantity, and specific location. Review the Safety Data Sheet or contact EHS for additional information about the chemical. If anyone has already left the area, examine the potential for contamination to have spread.

- In general, minimize air disturbances and drafts for dry powder spills, but increase ventilation by opening nearby chemical fume hood(s) for most volatile liquids.

- In the event any property or equipment was damaged, contact the UVA Office of Property and Liability Risk Management.

- Promptly bag and dispose of oily or solvent-saturated cleanup materials following the instructions for waste disposal. The Environmental Health and Safety Office can determine if special containment and labeling is needed.

- Report any spill, however minor, to your supervisor and the MSE safety committee.

For Minor Chemical Spills (Low Hazard, < 1 Liter)

Trained laboratory personnel can clean-up most minor spills. But do not proceed if you have any concerns about your ability to safely clean the spill – contact EHS at (434) 982-4911.

- Confine liquid spills with absorbent materials to minimize spread.

- Use the appropriate spill kit to absorb or neutralize the material, and work from the perimeter inwards. Collect residue with a small non-reactive shovel, scoop, dustpan, or piece of cardboard, place in heavy plastic bag or other compatible container, label contents as waste, and arrange for pick-up by EHS.

Larger or More Hazardous Chemical Spills

- Summon emergency assistance by dialing 911 from any phone for situations that threaten life or property and give as much information as possible. Indicate that the incident involves a large or hazardous chemical spill. Activate a fire alarm pull station to evacuate the building if directed or appropriate for the situation. This may be your first action for life-threatening issues. For less serious spills, notify laboratory supervisory personnel and EHS at (434) 982-4911.

- Attend to any injured or contaminated persons and remove them from exposure. In case of personal contamination, remove affected clothing and rinse contaminated skin with water for at least 15 minutes.

- If safe to do so, turn off nearby electrical equipment, shut off any open flames, sources of gas, and turn off any other equipment that could pose a hazard if left unattended.

- Close room door(s) and safely wait nearby for emergency responders to arrive. Consider whether to evacuate a larger area.

Mercury Spills

Unless your laboratory has been provided with special training, equipment, and approval from EHS, do not attempt to clean-up a mercury spill. Instead:

- Tell others in the area and restrict access to the spill location. If anyone has already left the area, examine the potential for contamination to have spread.

- For spills involving more mercury than is contained in a typical laboratory thermometer, evacuate the room, and close the door.

- Notify laboratory supervisory personnel and EHS at (434) 982-4911. For mercury spills after hours, you may be asked to vacate and secure the area for response the following morning. Await safely nearby for EHS responders to arrive.

All instruments containing mercury are potential sources of poisonous mercury vapor and require special attention. Whenever possible, these devices should have a catch tray to contain spills. Mercury thermometers are not to be used in ovens. Whenever possible, mercury thermometers should be replaced with non-mercury ones. The Environmental Health and Safety Office has offered to provide replacement non-mercury thermometers at no charge.

Fire or Smoke

An uncontrolled fire in a building can spread rapidly and do a tremendous amount of damage in a short time. It is best to familiarize yourself with the building's fire extinguishers, fire alarm pull stations, breaker boxes, eyewash/shower stations and emergency exits.

- In general, safe egress from the emergency can be the best course of action when responding to a fire. Evacuate the building activating a pull station as you exit, notify anyone you come across as you exit and close but do not lock the doors on your way out. Follow-up with a phone call to 911 to report the fire.

- In case of a small fire and if you have been trained to use a fire extinguisher, then you may attempt to put out the fire. When in doubt, evacuate, notify others, and call for emergency response. Note: If attempting to put the fire out, shout out for someone else to call 911 to report the fire. Even if it appears you have successfully extinguished the fire, always call 911 for emergency response regardless.

- EHS offers an e-learning to familiarize users to the unique fire safety considerations in an academic setting. http://ehs.virginia.edu/Fire-Safety-Training.html EHS Fire Safety also conducts in-person fire extinguisher simulation training as requested by laboratories.

Chemical Exposures

The procedures below provide basic guidance for responding to most chemical exposures. Secure or save the container(s) involved to help ensure accurate chemical identification and provide a copy of the Safety Data Sheet as soon as possible to emergency responders or the hospital.

First Aid- Chemical Splash to the Eye(s)

- Flush the eyes(s) at the nearest emergency eyewash, forcibly holding the eyelids open to ensure effective rinsing. Continue rinsing for at least 15 minutes.
- Follow with prompt treatment or triage by medical personnel.
- If the situation requires emergency assistance, dial 911.

First Aid- Chemical Spills and Splashes to the Body

- Remove any contaminated clothing or personal protective equipment.
- Immediately rinse the affected body area(s) with water for at least 15 minutes, using the nearest emergency shower, retractable eyewash, or sink hose.
- Follow with prompt treatment or triage by medical personnel.
- If the situation requires emergency assistance, dial 911.

First Aid- Ingestion / Inhalation of Chemicals

- Summon emergency assistance by dialing 911.
- Ingestion - Do not induce vomiting or give water or other liquids unless instructed to do so by emergency responders.
- Inhalation- Remove the exposed person to clean air and treat for possible shock by having them sit or lie down.
- Do not return to the incident scene if you suspect that a dangerous condition persists.

Medical Information in the Event of a Chemical Exposure

When working with hazardous chemicals, appropriate engineering and administrative controls, and personal protective equipment shall always be utilized to prevent injury.

In the event of a chemical exposure, the injured person must seek medical attention in one of the following places (depending on the severity of the exposure and your physical location):

If You Are:	**UVA Academic**	**UVA Medical Center**
Faculty, staff, students paid through University Payroll	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013
All other students	Student Health and Wellness 550 Brandon Ave. (434) 924-5362 (434) 297-4261 after hours	Student Health and Wellness 550 Brandon Ave. (434) 924-5362 (434) 297-4261 after hours
Visiting scientists and scholars, interns, volunteers	UVA-WorkMed 1910 Arlington Blvd. (434) 243-0075	UVA Employee Health 1222 Jefferson Park Ave. (434) 924-2013

If after hours or high degree of injury

- UVA or closest Emergency Room, or Urgent Care facility
- UVA Health System Emergency Room (434) 924-2231 Lee Street, Charlottesville
- Martha Jefferson Emergency Room (434) 654-7150 500 Martha Jefferson Drive,

Charlottesville
- 911 (if injured person cannot move or be moved)

Individuals using hazardous chemicals should also obtain medical consultation if they:
- Develop any signs or symptoms associated with hazardous chemical exposure,
- Are exposed to a hazardous chemical above the OSHA action level or permissible exposure limit, or
- Experience an event such as a spill, leak, explosion, or other occurrence with a potential for exposure to a hazardous chemical.

Regardless, all chemical exposure incidents must be reported to the faculty or supervisor in charge of the lab/area, followed up with a notification to EHS. The PI or laboratory supervisor shall provide the following information to the UVA healthcare provider and the EHS Occupational Health Group (434-982-4911):
- Identity of the hazardous chemical(s) to which the individual may have been exposed, preferably along with copies of Safety Data Sheets,
- Description of the conditions and activities that may have resulted in potential exposure, including any quantitative monitoring data, and
- Description of the signs / symptoms experienced, if any.

Workers' Compensation

Injured Academic Division employees who have filed for Workers' Compensation benefits must choose one physician for treatment of claimed, work-related injuries.

Failure to choose one of the physicians listed below may bar compensation benefits, including the cost of medical care. Employees' Primary Care Physicians are not authorized as attending physicians on UVA's Panel. Panel physicians will make appropriate referrals to specialists. Further Guidance can be found in **Appendix G.**

Panel of physicians
- Dr. Daniel Chan (434) 978-3998 MedExpress 1149 Seminole Trail Charlottesville https://www.medexpress.com/
- Dr. Daniel Chan (434) 244-3027 MedExpress 260 Pantops Center Charlottesville https://www.medexpress.com/
- Dr. Denee J. Moore (434) 227-5624 Neighborhood Family Health Center 901 Preston Ave., Ste 301 Charlottesville http://www.cvhsinc.org/locations/nfhc
- Dr. David Rubendall (434) 243-0075 UVA-Work Med 1910 Arlington Blvd., Charlottesville https://UVAhealth.com/locations/profile/UVA-workmed-clinic?locationnamekey=UVAworkmed-clinic

Emergency Facilities for Initial Emergency Visit Only
- UVA University Hospital Emergency Room (434) 924-2231

1215 Lee Street, Charlottesville, VA 22903
- Martha Jefferson Emergency Room (434) 654-7150

500 Martha Jefferson Drive, Charlottesville, VA 22911

SECTION XIV
OTHER UNIQUE HAZARDS (BIOHAZARDS, RADIATION, LASERS)

This section briefly summarizes other unique hazards related to biosafety and safe use of radiation.

Biosafety

The Institutional Biosafety Committee (IBC) and EHS have formed a partnership to minimize risks to the University community from activities involving biological agents. The primary mission of the biosafety program is to aid the University community in assuring that research involving biological agents is conducted in a safe and responsible manner, and that these activities follow external regulations and applicable University policies. University Biosafety requirements are extensive. For more information on biosafety, please refer to
https://ehs.virginia.edu/Biosafety.html

Radiation

The Radiation Safety Program includes implementation procedures to facilitate the safe and secure use of all licensed material at the University. The Radiation Safety Program addresses the requirement that licensed material will be used in such a way to keep radiation doses to workers and members of the public ALARA (As Low as Reasonably Achievable).[2] The University is required to maintain a Radiation Safety Committee (RSC), which works with the Radiation Safety Officer (RSO) in implementing the radiation safety program. The RSC is authorized to approve all acquisition, use, location, and storage of radioactive materials. University Radiation Safety requirements are extensive. For more information on radiation, please refer to.

- EHS website **http://ehs.virginia.edu/Radiation-Safety.html**
- Radiation Safety Manual
  https://ehs.virginia.edu/ehs/ehs.rs/rs.documents/UVA-Radiation-Safety-Program-Manual.pdf

Lasers Class 3b or 4

The versatility and power of lasers has produced new frontiers in research and medical treatment. Along with these advances is the recognition that there is potential for significant injury from lasers. The privilege to use lasers at the University of Virginia requires each individual user to follow and adhere to the UVA Laser Safety Program.
University Laser Safety requirements are extensive. For more information on laser safety, please refer to.

- EHS website, **http://ehs.virginia.edu/Laser-Safety.html**
- Laser Safety Program, **http://ehs.virginia.edu/Laser-Safety-Program.html**
- Core Laser Safety Practices, **http://ehs.virginia.edu/Laser-Safety-Core.html**

[2] which is specified as the total effective dose equivalent (TEDE) to members of the public will not exceed more than 1 mSv (100 mrem) in one year, and the dose in any unrestricted area will not exceed 0.02 mSv (2 mrem) in any one hour.

SECTION XV
KEY REFERENCES AND OTHER RESOURCES

- Bretherick, L., Handbook of Reactive Chemical Hazards, 8th ed., Elsevier, 2017. Bretherick's Handbook of Reactive Chemical Hazards is a well-established source of information on chemical safety, often known by its author's name, and often cited in the chemical and chemical engineering literature.

- Compressed Gas Association, Inc., Handbook of Compressed Gases, 3rd edition, 1990, 507 pp., VanNostrand Co., N.Y. The focus of this book concerns the properties and the accepted means of transportation, storage, and handling of compressed gases.

- Lewis, RJ. Sax's Dangerous Properties of Industrial Materials. Wiley Interscience, Hoboken, NJ. (latest edition) Since its inception in the early 1950's, Sax's Dangerous Properties of Industrial Materials has become the primary source for those who need to evaluate the hazardous potential of substances used in commerce. Sax's is the only reference that combines data on toxicology, flammability, reactivity, explosive potential, and regularity information for over 28,000 substances.

- National Research Council's "*Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*." One of the more comprehensive references on chemical and laboratory safety. It has since been updated and expanded since 1981.

- Cameo Chemicals- CAMEO Chemicals is a database of hazardous chemical datasheets that emergency responders and planners can use to get response recommendations and predict hazards—such as explosions or toxic fumes. https://cameochemicals.noaa.gov/

- The NIOSH Pocket Guide to Chemical Hazards (NPG) The NPG gives general industrial hygiene information for hundreds of chemicals/classes. The NPG helps users recognize and control workplace chemical hazards. https://www.cdc.gov/niosh/npg/

- Dow Lab Safety Academy-The Dow Lab Safety Academy was developed to enhance the awareness of safe practices in academic research laboratories and to promote a safety-first mindset in the future workforce of the chemical industry.
  https://corporate.dow.com/en-us/science-and-sustainability/innovation/safety-at-dow.html

- Royal Society of Chemistry. The Merck Index Online. Merck & Co., Inc., Whitehouse Station, NJ. For over 120 years The Merck Index has been regarded as the most authoritative and reliable source of information on chemicals, drugs and biologicals. The Merck Index Online is a convenient and easily searchable full text database containing over 11,500 monographs. Accessible at: https://www.rsc.org/merck-index

- AICHE SACHE e-learning course - Laboratory safety. This module presents an introduction to laboratory safety and provides the content necessary to identify laboratory hazards, including chemical, equipment, and procedural hazards.
  https://www.aiche.org/academy/courses/ela954/sacher-certificate-program-lab-safety

- AICHE CCPS Chemical Reactivity Worksheet, The Chemical Reactivity Worksheet (CRW) is a free software program you can use to find out about the chemical reactivity of thousands of common hazardous chemicals, compatibility of absorbents, and suitability of materials of construction in chemical processes. https://www.aiche.org/ccps/resources/chemical-reactivity-worksheet

- AICHE Project Risk Analysis- The "Project Risk Analysis (PRA)" protocol provides an approach for analyzing and documenting laboratory hazards and risks. The PRA protocol is a step-by-step process that uses check sheets to help document the team's hazards and risk analyses. https://www.aiche.org/ccps/community/technological-communities/safety-and-chemical-engineering-education-sache/sache-products

- American Chemical Society (ACS) -Laboratory Safety for Colleges and Universities - This collection of guidelines supports institutions to help undergraduate and graduate students recognize hazards, assess risks, minimize risks, and prepare for proper execution of potentially hazardous processes. Downloadable and printable versions of laboratory safety guides for college labs are available. https://www.acs.org/content/acs/en/chemical-safety.html
  - Identifying and Evaluating Hazards in Research Laboratories [PDF]
  - Safety in Academic Chemistry Laboratories, Eighth Edition [PDF]
  - Creating Safety Cultures in Academic Institutions [PDF]
  - Guidelines for Chemical Laboratory Safety in Academic Institutions [PDF]

- U.S. Chemical Safety Board (CSB), *Experimenting with Danger (video), 2011.* The U.S. (CSB) released a safety video on the potential hazards associated with conducting research at chemical laboratories in academic institutions. The 14-minute video focuses on three serious laboratory accidents. https://www.csb.gov/videos/

- Occupational Safety and Health Administration (OSHA). *Occupational exposure to hazardous chemicals in laboratories*. Title 29 Code of Federal Regulations Part 1910.1450. Federal regulation that applies to all employers engaged in the laboratory use of hazardous chemicals. https://www.osha.gov/laws-regs/interlinking/standards/1910.1450(d)

- Hoffman, J. M., and D. C. Master, (ed), "Chemical Process Hazard Review", ACS Symposium Series 274, American Chemical Society, 1985. The phrase Chemical Process Hazard Review has widely varying meanings. To a researcher, it connotes a broadly based review of a chemical experiment which when conducted properly would provide assure an experiment is safe for the scientists in the laboratory. An appropriate Chemical Process Hazard Review can help identify the hazards associated with that process. https://pubs.acs.org/doi/10.1021/bk-1985-0274.ch001

APPENDICES

Appendix A – Contact Information Form

All laboratories must display updated lab occupant's information with contact information to be used in case of emergencies.

Materials Science and Engineering Laboratory

Name	Phone
Laboratory Name	xxx-xxxx
Advisor	
Advisor Name	xxx-xxxx (office) xxx-xxxx (cell)
Students	
Student Name	xxx-xxxx
Student Name	xxx-xxxx
Student Name	xxx-xxxx
Student Name	xxx-xxxx
Student Name	xxx-xxxx

Last updated:

APPENDIX B – Emergency Notification (for unattended equipment operation that requires special emergency procedures and/or unusual hazards)

EMERGENCY NOTIFICATION FORM

DATE:

TITLE OF EXPERIMENT:_____

RESEARCHER:_____
ADVISOR: _____

WARNINGS:

SPECIAL EMERGENCY PROCEDURES:

IN CASE OF EMERGENCY CALL:

1)_____ Ph. No.

2)_____ Ph. No.

3)_____ Ph. No.

POTENTIAL HAZARDS: (Toxic gases, Flammable solvents, Flammable gases, High pressure gas, Biological hazard, Radiation Hazard, etc.)

Appendix C – Lab Inspection Form

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MSE Department Safety Inspection Form

February 2021 rev 9 Final – for Lab occupant use

Lab PI:	Lab Room:
Lab Surveyor:	Assessment Date:

Training and Documentation	Yes	No	N/A
Hazard Communication Sign is up to date (NFPA rating, emergency phone #'s, etc.)			
A Hazard Review Checklist has been completed (See Checklist in Safety Manual)?			
Is an emergency notification form posted at/ near equipment that runs unattended?			

Personal Protective Clothing (PPE)	Yes	No	N/A
Are lab personnel are using appropriate PPE?			
Are lab personnel are using safety glasses or other appropriate eye wear?			
Are lab personnel are wearing closed-toe shoes, have confined long hair, not wearing loose articles (e.g., jewelry, neckties, lanyards)?			

Emergency / Spill Planning	Yes	No	N/A
Is a first aid kit readily available?			
Is a safety shower and eye wash accessible and unobstructed?			
Are eye wash stations tested, flushed, at least monthly?			
Are exits unobstructed?			
Is a fire extinguisher readily available, up to date, and unobstructed?			

General Safety / Housekeeping	Yes	No	N/A
No food/drink present, nobody was eating or drinking in lab?			
Is the Lab maintained secure; door locked when no one is in lab?			
Are aisles unobstructed and maintained at least 36 in. wide throughout?			
Are lab benches and work areas free of clutter?			
Are designated laboratory areas, including science refrigerators, freezers, and cold rooms, free from food and/or drink intended for human consumption?			
Are surplus supplies, equipment, containers stored appropriately (e.g., not on floor, desks)?			
Is storage clearance below ceiling appropriate (18" for sprinklered, 24" for non-sprinklered)			
Are refrigerators, freezers clearly labeled "Not for Storage of Food for Human Consumption"?			
Is lighting adequate (e.g., no burned- out lightbulbs)?			

Chemicals	Yes	No	N/A
Are chemicals in any container properly labeled, capped when not in use?			
Are chemicals properly segregated by hazard class (e.g., flammables away from oxidizers, acids separate from bases, incompatible acids separated)?			
Are chemical containers in good condition (i.e., are not cracked, no lids missing, etc.)?			
Are chemicals stored in a generally safe manner (not on the floor; secondary containment is used where appropriate, corrosives stored in appropriate cabinets)?			
Are flammable liquids stored in 5- gallon cans or smaller? (should be less than 5 gallons)			
Are chemicals, especially flammables, purchased in the smallest quantities needed?			
Are flammables liquids requiring refrigeration stored in either explosion proof or flammable resistant refrigerators and freezers (i.e., no regular refrigerators)?			
Are peroxide formers properly labeled? Expiration dates checked regularly?			

UNIVERSITY of VIRGINIA

Compressed Gas	Yes	No	N/A
Are cylinders stored upright, always secured, and in good condition?			
Are proper regulators used for type gas, pressure bled when not in use?			
Are gas monitoring devices used in areas with increased likelihood of risk (e.g., asphyxiation, explosion, etc.)			

Ventilation/Hoods	Yes	No	N/A
Are chemical hoods free of clutter, clean, and not used for excessive storage?			
Are perchloric acid operations conducted in specialized wash down chemical hoods?			
Are biological safety cabinet(s) certified within the last 12 months. (Report to Biosafety if overdue.)			

Glassware	Yes	No	N/A
Is glassware in good condition (i.e., not chipped, broken, or scratched)?			
Is glassware stored in designated areas?			
Is glass waste placed in a cardboard box with a 'waste laboratory glassware' sticker?			

Electrical	Yes	No	N/A
Are electrical cords in good condition, out of travel paths, free of any breaks in insulation?			
Are power strips UL approved, and not 'daisy-chained'?			
Are electrical panels are kept unobstructed?			
Are extension cords for temporary use only, disconnected at the end of every working period?			

Ovens	Yes	No	N/A
Are direct- heated ovens only used to dry glassware (and not flammables)?			
Are ovens used to dry materials that off-gas noxious vapors in a hood?			

Equipment	Yes	No	N/A
Are all guards and shields in place and secured and safety signs posted?			
Is equipment in good repair with evidence of proper maintenance?			

Waste	Yes	No	N/A
Are EHS provided, or otherwise appropriate, waste containers used and kept capped when not being filled. (Parafilm is not appropriate for capping waste containers)			
Do waste containers have an approved EHS hazardous waste label and contents label (see page 43-46 in the Chem. Hygiene Plan)			
Is waste not excessively accumulated (e.g., less than ten 5-gal carboys)			
Are waste containers storing liquid hazardous waste stored within secondary containment. Secondary containment in good condition?			
Are sharps disposal boxes less than full?			
Is the non-hazardous waste trash can free of hazardous waste?			
Are chemicals disposed of prior to expiration dates?			

Additional Comments /Actions Taken or Planned (by when)

UNIVERSITY of VIRGINIA

Supplemental- Lab Occupant Questionnaire

Training and Documentation	Yes	No	N/A
Have lab occupants received training on specific hazards/chemicals used in the laboratory?			
Do lab occupants know how to find Safety Data Sheets (SDS) and if applicable, chem. inventory?			

Emergency / Spill Planning	Yes	No	N/A
Are lab occupants familiar with the nearest fire exits, muster points*, fire alarm pull-stations? *(Muster point for the entire group of buildings along Engineering Way is T4-between Bryant and Rice Halls.)*			
Are lab personnel familiar with the use of the safety shower, eye wash, and fire extinguisher?			

General Safety / Housekeeping	Yes	No	N/A
Do lab occupants smoke, eat or drink in **only designated** laboratory areas?			
Do lab occupants lock the lab door when nobody is present?			
Do lab occupants wear appropriate PPE all the time?			

Chemicals	Yes	No	N/A
Do lab occupants use bottle carts when transporting hazardous chemicals between work areas?			
Do lab occupants purchase flammable liquids in 5- gallon cans or smaller?			
Do lab occupants maintain an inventory and incorporate additional safety practices for OSHA defined "Particularly Hazardous Substances" *(note 1)*			

[1] *The OSHA Lab Safety Standard specifically mandates that labs develop SOPs for handling "Particularly Hazardous Substances", which they define as Select Carcinogens, Reproductive Toxins and Acute Toxins. If you are unsure if a chemical fall into one of these categories, check the SDS, the UVA Chemical Hygiene Plan and/or contact Environmental Health & Safety.*

Compressed Gas/Ovens	Yes	No	N/A
Do lab occupants store cylinders of toxic gases (e.g., NFPA health hazard 3 or 4 and 2) in continuously ventilated enclosures?			
Do lab occupants store flammables separately from oxidizers, toxics in secure area, etc.?			
Do lab occupants transport cylinders with regulators removed and caps secured, use appropriate dolly cylinder cart, and avoid riding in elevators with gas cylinders?			
Do lab occupants only use direct- heated ovens to dry glassware (and not flammables)?			
Do lab occupants dry materials in ovens that off-gas noxious vapors in a hood?			

Waste	Yes	No	N/A
Do lab occupants immediately discard sharps into sharps disposal boxes provided by EH&S?			
Do lab occupants decontaminate biological waste liquids (if applicable) prior to drain disposal?			
Do lab occupants discard biological waste solids as regulated medical waste and autoclave or disinfect as appropriate?			

Laser Safety	Yes	No	N/A
Have all Class 3B and 4 lasers and modifications been registered with the University's Laser Safety Officer (LSO)?			
Are Class 3B, 4 laser labs posted to indicate that laser safe eyewear, by wavelength and optical density (O.D.) available?			
Are laser- controlled areas posted and equipment labeled with approved signs and labels?			

Biological Safety	Yes	No	N/A
Are biological materials stored in secured rooms?			
Are biohazard signs posted in labs handling infectious materials? (BSL1 or BSL2)			
Are adequate surface Disinfectants (EPA approved- bleach, Cavicide) available for disinfecting surfaces and treating spills.			
Ia biological waste always disposed appropriately in either a Contaminated Materials Container (CMC), or autoclaved following the IBC Autoclave policy.			

Appendix D – PPE Selection Guidelines

Material or Activity	Potential Exposures	Personal Protective Equipment
Basic entry into laboratories with hazardous materials or operations	• Chemical contamination • Splash or flying object to eyes	• Safety glasses with side-shields • Closed toe shoes • Long pants • Long-hair, beards, neck ties, and loose clothing and hanging jewelry secured. • Other PPE required by laboratory-specific policy
Handling hazardous chemicals < 1 Liter	• Chemical contamination • Splash or flying object to eyes	Basic entry PPE plus: • Long sleeves or lab coat • Gloves - disposable nitrile exam gloves for incidental contact. Consult EHS training *Glove Selection* for additional advice on high hazard materials
Handling hazardous chemicals > 1 Liter	• Chemical contamination • Chemical burns from corrosive materials • Splash or flying object to eyes and face	Handling hazardous chemicals < 1 Liter PPE plus: • Enclosing safety goggles, or face-shield for high-risk splash potential • Rubber splash apron for corrosives • Gloves, disposable nitrile, or forearm length utility gloves worn over nitrile exam gloves for potential long-term exposure or immersion. Consult EHS training *Glove Selection* for additional advice
Handling hot objects or working with open flames	• Thermal burns • Flying object to eyes and face	Basic entry PPE plus: • Laboratory coat (flame resistant for open flame work > than Bunsen burner scale) • Gloves – heat resistant
Working with pyrophoric or water-reactive compounds	• Chemical contamination • Splash, flames, and burns to body, face, and eyes	Basic entry PPE plus: • Safety Goggles (glove box) • Face shield (fume hood work) • Flame-resistant laboratory coat • Gloves – flame resistant worn over disposable nitrile exam gloves. Consult EHS training *Glove Selection* for advice • Perform work in chemical fume hood or glove box as appropriate. • Prior to use: o Complete EHS training *Handling Organolithium and Related Agents* o Obtain hands-on training from supervisory personnel
Working with highly reactive or explosive compounds	• Chemical contamination • Physical injuries from flying objects and fragments	Basic entry PPE plus: • Face shield • Flame resistant laboratory coat • Gloves – forearm length utility gloves worn over nitrile exam gloves. Consult EHS training *Glove Selection* for additional advice. • Perform work in chemical fume hood, glove box, or behind shield, as appropriate

Material or Activity	Potential Exposures	Personal Protective Equipment
Working with extremely deep vacuum or extremely high-pressure equipment	• Chemical contamination • Physical injuries from flying objects and fragments	Basic entry PPE plus: • Perform work behind shield as appropriate
Working with cryogenic liquids	• Frozen tissues • Splashes to body, face, and eyes • Potential asphyxiation hazards if working in small, enclosed space without ventilation. Consult with EHS if you have questions about appropriate ventilation.	Basic entry PPE plus: • Long sleeves or lab coat • Gloves – insulated, forearm length or longer.
Performing small volume chemical spill clean-up	• Chemical contamination	Basic entry PPE plus: • Long sleeves or lab coat • Gloves – double nitrile exam gloves or utility grade forearm length gloves over single use gloves. Consult EHS.
Working with or near high noise sources	• Hearing damage	Basic entry PPE plus: • Hearing protection devices – earmuffs or plugs. Consult EHS for assistance in monitoring the noise source(s) and selecting PPE.
Working with intense sources of visible or non-visible light, lasers, high electric or magnetic field equipment, ionizing radiation sources	• Physical injuries	• Consult EHS

APPENDIX E – Hazard Classification Chemical Storage Guidelines

Chemical Groups	Storage Guidelines
General, Non-Hazardous Chemicals Acetates, borates, carbonates, chlorides, glycols, halides, nitrides, phosphates, phosphides, polysulfides, silicates, sulfates, sulfides, sulfoxides, thiosulfates	Non-hazardous salts and buffers may be stored alphabetically.
Volatile Liquids: **Flammable:** Alcohols, alkanes, amides, amines, aromatic hydrocarbons, esters, ethers, ketones **Non-Flammable:** Halogenated hydrocarbons (e.g., Chloroform, carbon tetrachloride, methylene chloride	Store in cabinet or near fume hood for convenience. Separate flammable from non-flammable liquids and limit volumes to the smallest amounts needed. Flammable liquids must be stored in a rated cabinet or spark-proof refrigerator / freezer.
Water and Air Reactive Compounds: Calcium, sodium, potassium, lithium, phosphorus pentoxide, pyrophoric such as butyl-lithium.	These kinds of chemicals are usually shipped under mineral oil or an inert atmosphere. Store in original container unless supplier advises otherwise.
Corrosives: **Acids:** Mineral acids (e.g., hydrochloric), organic acids (e.g., acetic), per-acids **Bases:** Hydroxides, organic bases **Other:** Cresols, phenols, anhydrides	Store below eye-level in dedicated area (e.g., poly-ethylene trays under sink or fume hood) or corrosive cabinet. Store oxidizing acids (e.g., perchloric, nitric) separately. Note that concentrated acetic acid is flammable.
Oxidizers Amides, bromates, chlorates, chlorites, chromates, hypochlorites, hydroperoxides, manganates, nitrates, nitrites, perchlorates, permanganates, peroxydes	Store oxidizers separately. Store peroxidizable chemicals below room temperature but above freezing. Inspect caps for presence of potentially shock-sensitive crystals before opening.
Compressed Gases: Air, noble gases (e.g., argon, neon), chlorine, helium, hydrogen, nitrogen, oxygen	Secure cylinders. Keep valve caps on when not in active use. Consider gas generators as alternative to compressed H_2 or O_2. Toxic, corrosive, and flammable gases may require storage in a chemical fume hood or dedicated gas cabinet.
Cryogenic Liquids: Nitrogen, helium	Store vessels in dry, cool, well-ventilated locations. Consult EHS for information and options for oxygen monitoring.
Chemicals Requiring Refrigeration: Various	Non-flammable, non-oxidizing chemicals can be stored in ordinary refrigerators / freezers, but flammable and oxidizing chemicals must be stored in an explosion-proof refrigerator or freezer.
Select Carcinogens, Reproductive Toxins, and Highly Toxic Chemicals: Consult container labels, SDSs, or EHS.	Store these materials in a separate area or within a secondary container to facilitate tracking. Ensure that only authorized individuals can access them.
Controlled Substances: Schedule I – V drugs under the US DEA, plus VBP Schedule VI drugs	Keep an inventory and store under lock and key; Schedules I and II require additional security. Consult Center for Comparative Medicine and Office of Animal Welfare for more information.
DHS Chemicals of Interest: Specific chemicals with potential for harm upon accidental or purposeful release, theft, or sabotage.	Store according to hazardous properties and ensure only authorized individuals in the laboratory can access them. Consult EHS for more information.
Tax-Free Ethanol: 200 proof ethyl alcohol	Limit access to authorized laboratory personnel by keeping tax-free alcohol in a locked flammable storage cabinet or in an unlocked cabinet within a room that is locked when unattended.

Appendix F- Hazard Review Checklist

HAZARD REVIEW CHECKLIST
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
UNIVERSITY OF VIRGINIA

The health and safety of you and your colleagues in the Department is always your primary responsibility. The experiment itself is secondary to safe lab practices. This form is to be used prior to using equipment that you have assembled and to guide you in the safe design, construction, and assembly of laboratory equipment.

This review checklist has been developed at the University of Delaware and is adapted from industrial hazard review forms. The form is presented here with only minor modifications. Use it to review safety factors in your experimental equipment design and projected operating methods. The department safety manual and library safety references are good sources of design information. The completed form should be reviewed and approved by your advisor.

Review and approval to operate your equipment is not a blanket approval of safety status. The actual responsibility for safe operation is with the researcher.

Date:_____Lab Location: _____

Title of Experiment/Name of Equipment:
_____
_____
_____

Researcher:_____

Office Location: _____

Advisor: _____

EMERGENCY PREPAREDNESS

Label all experimental equipment with emergency shutdown information so that a non- operator can easily shutdown your equipment.

Is Sequence important? _____

Device Shutdown Location

_____

_____

_____

Special First Aid Procedures: _____
_____
_____

Where is the nearest:

- Evacuation Alarm Exit _____
- Fire Extinguisher _____
- Safety Shower _____
- Eyewash Station _____

Use the following checklist as a reminder to avoid unsafe practices and conditions in your equipment.

ELECTRICAL

Yes No N/A

__ __ __ 1) Are power cords of adequate design, inspected, and in safe condition?
__ __ __ 2) Are voltages guarded?
__ __ __ 3) Have you considered static electricity hazards?
__ __ __ 4) Are switches labeled and accessible, i.e., not in potentially hazardous areas?
__ __ __ 5) Should electrical plugs and switches be explosion proof?
__ __ __ 6) Is over-temperature shutdown of heaters necessary, and if so, provided?
__ __ __ 7) Is the test safe if electrical service is interrupted or fails?
__ __ __ 8) Are ground fault interrupters in place where needed?

MECHANICAL

__ __ __ 1) Are pinch points and exposed moving parts marked or guarded?
__ __ __ 2) Is the unit physically stable or mechanically anchored?
__ __ __ 3) Are cables, ropes, chain falls, and/or pulleys the right size and have they been inspected and judged in safe condition?
__ __ __ 4) Is protection against backlash from cables, pulleys, or ropes provided if they break?
__ __ __ 5) Are proper lifting devices being used?
__ __ __ 6) Are mechanical shutdown interlocks provided if needed?
__ __ __ 7) Have rotating parts been checked for balance?

PRESSURE - PNEUMATIC HYDRAULIC AND STEAM

__ __ __ 1) Do gauges have blow-out backs and safety fronts, or alternately, read by mirror?
__ __ __ 2) Are relief ports and gauge blow-outs directed so that discharge does not constitute a hazard if they blow?
__ __ __ 3) Are adequate relief devices installed in proper locations? (No valves between device and source.)
__ __ __ 4) Are pressure ratings adequate? (Piping, fittings, vessels, valves, gauges, etc.)
__ __ __ 5) Do cylinder regulators have required inspections?
__ __ __ 6) Are cylinders properly secured?
__ __ __ 7) Do pressure vessels have current inspections?
__ __ __ 8) Are valves accessible, i.e., not in potentially hazardous areas? (Are valve stems of high-pressure valves located above the operator's head or directed upwards?)
__ __ __ 9) Are flexible pressure lines secured to protect personnel in case of failure?
__ __ __ 10) Have safety relief valves been inspected and tested at set-point condition?
__ __ __ 11) Is nonmetallic tubing safe for this service? (Inert fluids, low pressure, temperature, static discharge.)

CHEMICAL

___ 1) Have you reviewed the Safety Data Sheets (SDS) to determine hazards and handling procedures for test materials?
___ 2) Is an appropriate hazard warning tag posted outside your lab?
___ 3) Are materials of construction proper considering their recommended service as well as pH, chlorides, chemical contaminants, temperature, pressure, stress, cycling, and test duration?
___ 4) Are experiments placed in chemically resistant trays that will keep reagents from spreading in case of breakage?
___ 5) Have you eliminated all ignition sources near flammable chemicals (e.g., stirring motors, hot plates, power stats, open flames, temp. baths, etc.)?
___ 6) Have you checked for hazardous reactions among chemicals in this test, chemicals potentially present in a common exhaust or drain system, or chemicals stored nearby?

GENERAL

___ 1) Is test area free from tripping hazards and sharp edges?
___ 2) Are automatic shutdown devices required to protect personnel and equipment?
___ 3) Is the test safe if air, electricity, steam, or vacuum is interrupted or fails?
___ 4) Is area fire extinguisher proper type ("A", paper, and wood; "B", oil solvent; "C", electrical) and are additional extinguisher needed?
___ 5) Is overhead clearance 7 feet? If not, is obstacle clearly marked?
___ 6) Are all containers labeled with contents, date, and person responsible?
___ 7) Are barricades and shields sufficient to prevent injury and protect equipment?
___ 8) Are signs and/or tags large enough and properly located to be easily seen?
___ 9) Does test require securing loose clothing and removing jewelry?
___ 10) Are inspection dates current on ladders, safety belts, or scaffolds required for overhead work?
___ 11) Have you planned an emergency escape route?
___ 12) Are good housekeeping practices being observed in the test area?
___ 13) Does noise level exceed 90 dB?
___ 14) Are personnel protected from hot/cold surfaces? (Steam lines, hot plates, etc.)
___ 15) Is special protective clothing, respirators, or first aid equipment provided and in good repair?
___ 16) Is dust level within allowable limits (10 mg/mL if nontoxic)?
___ 17) Will there be exposure of personnel to hazardous vapors?
___ 18) Is a special spill control procedure required?
___ 19) Is hood face air velocity adequate for the test being conducted?
___ 20) Is hood function impaired by air disturbances near the hood?

PERSONAL PROTECTIVE EQUIPMENT

FOR OPERATOR_____

FOR VISITORS: _____

SPECIAL STANDBY: _____
(Emergency use)

GENERAL QUESTIONS

1. What are the experimental equipment limitations? (Temp., press., electrical, rpm, other.)

2. What human or unusual material or equipment failures could lead to an accident? (Review test set-up carefully for hidden hazards.)

3. What unusual hazards will be involved in dismantling this experiment?

4. List the inventory of supplies (chemicals, reagents, solvents) you will maintain for this experiment. Where will you store these materials?

5. Explain your procedure to dispose of hazardous materials and used equipment?

6. What routine maintenance will you apply to your equipment to insure hazard-free service? Describe the records you will maintain.

7. What routine safety inspections will you apply to your equipment to insure hazard-free service? Describe the records you will maintain.

Appendix G- Worker's Compensation Guidelines

Workers' Compensation Attending Physician Panel For University Academic Division Employees

The University of Virginia is offering the following Attending Physician Panel in compliance with Section 65.2 of the Virginia Workers' Compensation Act. The below panel is to be used by employees in the University's Academic Division (Agency 207).

Injured Academic Division employees who have filed for Workers' Compensation benefits must choose one physician for treatment of claimed, work-related injuries. Failure to choose one of the physicians listed below may bar compensation benefits, including the cost of medical care.
Employees' Primary Care Physicians are not authorized as attending physicians on UVa's Panel.

Panel of physicians

Dr. Daniel Chan — (434) 978-3998
MedExpress
1149 Seminole Trail Charlottesville
https://www.medexpress.com/

Dr. Daniel Chan — (434) 244-3027
MedExpress
260 Pantops Center Charlottesville
https://www.medexpress.com/

Dr. Denee J. Moore — (434) 227-5624
Neighborhood Family Health Center
901 Preston Ave., Ste 301 Charlottesville
http://www.cvhsinc.org/locations/nfhc

Dr. David Rubendall — (434) 243-0075
UVA-WorkMed
1910 Arlington Blvd., Charlottesville
https://uvahealth.com/locations/profile/uva-workmed-clinic?locationnamekey=uvaworkmed-clinic

Panel physicians will make appropriate referrals to specialists

Emergency Facilities for Initial Emergency Visit Only

UVA Health System Emergency Room — (434) 924-2231
Lee Street, Charlottesville

Martha Jefferson Emergency Room — (434) 654-7150
500 Martha Jefferson Drive, Charlottesville

I have been offered a choice of attending physicians from UVa's Workers' Compensation Panel and have chosen the following physician:_____

Employee Signature: _____ Date: _____

Print employee Name: _____ Date of Accident: _____

Please initial _____ I understand that I am responsible for any costs incurred in the event that Workers' Compensation denies my claim. I understand that I am also responsible for obtaining prior authorization from MC Innovations for all referrals to specialists.

Return signed form to:
University Human Resources Benefits Division
914 Emmet Street
P.O. Box 400127
Charlottesville, VA 22904-4127 Fax 434-924-4042 askhr@virginia.edu (updated Sep 2018)

APPENDIX H - Safety Manual Certification Form

YOU MUST COMPLETE THIS FORM PRIOR TO USING LABORATORY FACILITIES IN THE DEPARTMENT. GIVE YOUR SIGNED FORM TO THE DEPARTMENT SECRETARY FOR INCLUSION IN YOUR FILE.

I CERTIFY BY MY SIGNATURE BELOW THAT I HAVE READ THE CHEMICAL ENGINEERING DEPARTMENT SAFETY MANUAL

I HAD A QUESTION ABOUT SAFETY PROCEDURES DESCRIBED IN THIS MANUAL.

YES	NO
_____	_____

MY QUESTIONS WERE ANSWERED BY THE SAFETY COMMITTEE OR BY MY ACADEMIC ADVISOR.

YES	NO
_____	_____

SIGNED _____

DATE _____