UNIVERSITY of VIRGINIA | ENGINEERING
Department of Materials Science and Engineering

LAB SAFETY HANDBOOK

EMERGENCY PHONE NUMBERS:

To Report a Crime or immediate police or **EMERGENCY**: **Dial 911**

UNIVERSITY POLICE: **924-7166 (UVA non-emergency line)**

SafeRide Service: **242-1122 (Go to any Blue Light on grounds for assistance)**

Use the "red" safety phones located in hallways. These are direct contact with the police department.

Lab/Building Safety:

ENVIRONMENTAL HEALTH & SAFETY: 982-4911 http://ehs.virginia.edu/

Facilities Management Help Desk: 924-1777 or 982-5880

Systems Control (for Heat, Air, Electrical alarms): 982-4685

(REVISED: October 2020)

ACCIDENT/INJURYon the job?

Major: **CALL 911** and Follow Instructions

Minor: Go to your PI or Admin office and get treatment or help contacting one of the following:

UVA Student Health: **(434) 924-5362**

Daytime: **UVA-Work Med**: **243-0075**

UVA Employee Health: **924-2013**, located @ UVA Fontaine Research Park

Nights/Weekends: **UVA Emergency Room**: **924-2231**

Martha Jefferson Emergency Room :**982-7150**

The Blue Ridge Poison Center is a 24-hour, 7-days a week hotline for help with suspected poisonings.

Call 1-800-222-1222 right away if someone:

- Swallows something harmful.
- Touches or breathes something harmful.
- Overdoses on any substance.
- Is bitten or stung by a snake, spider, etc.

Don't wait for the person to look or feel sick. Call even if you are not sure a poisoning happened.

Please also contact your supervisor and department chair's office as soon as possible with details and treatment paperwork.

FOREWORD

1. This manual provides a summary of the Materials Science 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.

2. 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.

3. You must also read carefully and complete the mandatory safety online training session at the earliest offering. Once completed print of a copy of your training update and give it to the main office.

ACKNOWLEDGEMENT

This manual was developed by Prof. Giorgio Carta of the Department of Chemical Engineering at the University of Virginia. We are thankful for his permission to use and adapt this manual.

This manual has been developed based upon a laboratory safety manual in use at the University of Delaware.

We are very grateful to Mr. George Whitmyre of the Chemical Engineering Department at the University of Delaware for his permission to use, copy, and modify parts of their manual.

Material Science Safety Committee

Position	Name	Email	Phone No.	Room No.
Chair	Tao Sun	ts7qw@virginia.edu	243-6338	WDF-218
Co-Chair	Charles Philip Blankenship	cpb6r@virginia.edu	982-5661	WDF-312
Member	Kaitlin Detwiler	knk4dh@virginia.edu	982-5645	WDF-A024
Member	Zachary Harris	zdh8kt@virginia.edu	813-2768	JH353
Member	Helge Heinrich	hhh8n@virginia.edu	297-6391	WDF-B018
Member	Petra Reinke	pr6e@virginia.edu	924-7203	WDF-126
Member	Jerry Weaver	wjr4uu@virginia.edu	982-5661	WDF-A028
Member	Richard White	rrw3q@virginia.edu	982-5657	WDF-B018

*WDF= Wilsdorf Hall

Department Chairman: **Dr. John Scully, 982-5786**
Wilsdorf Hall, Room 109C and 330
Jrs8d@virginia.edu

Department Chair Assistant: **Jeannie Reese, 982-5643**
Wilsdorf Hall, Room 109D
jsv7u@virginia.edu

CHAPTER 1

GENERAL SAFETY PRINCIPLES AND REGULATIONS

Know the safety procedures that apply to the work being done. Determine the potential hazards (e.g., physical, chemical biological) and appropriate safety precautions before beginning any new operation. Every laboratory worker should observe the following rules:

1. Safety glasses must be worn at all times in designated areas (see Appendix 1 for details). Contact lenses are permitted in these areas provided that safety glasses are also worn.

2. Under ordinary circumstances, someone else should be present in your designated laboratory area in order to render emergency help should this be required. When working at night or on weekends, make sure that someone else is notified of your presence. Avoid carrying out experimental work alone in a laboratory building.

3. All injuries (and near misses), no matter how slight, should be reported to a member of the Safety Committee or the Department Chairman without delay.

4. Shoes with uppers of a solid material must be worn in the laboratories. This will prevent permeation by liquid chemical spills and other injuries. Open-toed shoes and bare feet, therefore, are not permitted.

5. 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. Please follow EH&S guidelines.

6. Properly dispose of laboratory waste and unwanted chemicals following strictly the procedures outlined in Appendix 2. All HAZARDOUS WASTE DISPOSAL CONTAINERS MUST BE PROPERLY LABELED AND KEPT CAPPED AT ALL TIMES ACCORDING TO THE PROCEDURES AND GUIDELINES SET BY ENVIRONMENTAL HEALTH AND SAFETY (EH&S). http://ehs.virginia.edu/

7. All departing graduate and undergraduate students, staff, post-docs, visitors, and faculty, who have worked in a MSE research laboratories must complete a decommission process prior to leaving or graduating. This process will either transfer chemicals to future work or dispose of according to EH&S guidelines. This process should be directed by the MSE safety committee and or senior lab members of MSE and EH&S when necessary.

8. Promptly and completely neutralize, absorb and bag spilled materials by the safest means possible. The Environmental Health & Safety Office is equipped for a rapid response for toxic, flammable or radioactive material spills; if you are uncertain about the nature of the spill or on how to take care of it, call the Environmental Office. They may authorize you to perform a spill cleanup if the hazards are insignificant. Otherwise, the Environmental Office will undertake the cleanup operation. Promptly bag and dispose of oily or solvent-saturated cleanup materials following the instructions for waste disposal given below. The Environmental Health and Safety Office can determine if special containment and labeling is needed.

9. Mercury spills should be cleaned using a mercury spill kit supplied by UVA environmental Health and safety.

-Follow waste chemical disposal guidelines outlined from your training on the UVA environmental Health and Safety Website.

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 thermometers at no charge.

10. Contamination of food, drink and smoking materials is a potential route for exposure to toxic substances. Consumption of food and beverages should be reserved to office rooms and desks removed from laboratory experiments. Smoking is not permitted.

11. 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 should not be used for food storage.

12. Wash your hands well before leaving the laboratory area. 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 adsorption of a toxic chemical.

13. All laboratories must display updated lab occupant's information with contact information to be used in case of emergencies. A sample form is given at the end of this Chapter.

14. Use equipment only for its designed purpose. The use of makeshift tools and shortcut methods leads to equipment damage and injuries. If you are in doubt, seek the help of your advisor or the Safety Committee. Label broken equipment and notify your advisor or lab coordinator promptly and provide for repairs and/or storage.

15. 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.

16. Flush eye wash stations periodically. Eye wash stations in your laboratory area should be flushed periodically, preferably on weekly basis. 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.

17. Discharged fire extinguishers must be recharged and returned to service immediately.

18. Do not cover windows of laboratory doors except for special experimental requirements, as passers-by should have an unobstructed view to notice if someone is in distress and needs help. The exception would be for Laser usage or some other experiment harmful to someone's eyes.

19. Pets of any kind are not to be brought into the laboratories. They are likely to upset equipment or be poisoned by ingesting or contacting toxic chemicals that may be present.

20. Hypodermic needles or GC/HPLC syringes 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.

-Needle disposal boxes labeled “bio-hazard” must be used for needles and syringes used with biological samples where biohazards can exist.

-Needle disposal boxes for “non-bio-hazard” needles should be used for other needles and are available from the Environmental Health and Safety Office.

21. To reduce fire hazards and general clutter, empty cardboard boxes, crates and solvent bottles must be removed from laboratory areas within 24 hours after receipt.

22. Compliance with the Virginia Occupational Safety and Health Hazard Communication Standard, requires that Material Safety Data Sheets (MSDS) be made available to all University employees. These sheets provide detailed information and precautionary measures for the handling of chemicals and solvents. The MSDS are available at various locations. The closest to the Engineering School are the Science and Engineering Library and the Chemistry Library. Note that an entire section of the Chemistry Library is dedicated to "safety". Check the references listed in Appendix 4.

Call Environmental health and Safety at 924-9111 if you have questions.

23. 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 un-locatable mystery odors that may be noticed. Pouring water into seldom-used drains biweekly will restore the water seal and assure you that no sewer gases will escape into your work environment. Consider floor drains as well.

24. 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 any you might have.

25. Avoid distracting or startling any other worker. Practical jokes or horseplay cannot be tolerated at any time.

26. Think, act and encourage safety until it becomes a habit.

Materials Science laboratory

Contact Information Contact Information

Professor (Advisor) Name: _____

Phone: (office)_____(Home)_____

Office room #: _____

Laboratory Name:

Students occupying this space:

Student Name: _____

Student Name: _____

Student Name: _____

Student Name: _____

Student Name: _____

Last updated: _____

This information is also provided by a contact sheet on the door of the lab provided by Environment Health and Safety. This is mainly to identify the NFPA chemical chart and emergency contacts for Fire and Safety.

WHERE TO GET ADVICE ON SAFETY PROBLEMS

When you become aware of a safety problem, your advisor, the Safety Committee, and the Office of Environmental Health and Safety (OEHS) personnel are the best source for information.

Day-to-day problems should be directed to your advisor or lab coordinator. In the case of equipment design problems and new equipment setups, the Hazard Review Checklist, available from the Department Office, provides a practical guide to safety considerations in designing new experimental equipment. See Appendix 3 for a copy of this checklist.

The Office of Environmental Health and Safety provides trained safety professionals for administration and implementation of safety at the University. They carry out waste disposal, fume hood tests, etc. In addition, they are responsible for radiation safety, fire safety, and other major hazard control areas.

SAFETY INSPECTIONS AND ENFORCEMENT

Periodic safety inspections will be conducted in the Department labs to check compliance with our safety regulations. The inspection team is composed of the Safety Committee and graduate student representatives. Results of the inspection are summarized in a report directed to the Department Chairman, with copies to everyone in the UVa Materials Science community.

Environmental Health and Safety also do periodic checks for proper storage of chemicals and general safety within the labs.

These periodic inspection reports will help you identify safety hazards in your lab and will remind you of our routine safety requirements. Your safety is your primary responsibility.

Equipment and procedures will be shut down if they are not in accordance with the established Departmental and University safety practices.

The safety know-how and training you acquire in your work will prepare you for work in industry or in other organizations. Safety training at the University will enhance your value to an employer. A poor safety record can be a serious impediment to employment.

Faculty advisors or their designated group supervisor are responsible for routine auditing of their assigned laboratory, undergraduates, graduate students and post-doctoral fellows.

CHAPTER 2

ASSEMBLY AND USE OF APPARATUS

Prior to equipment set-up, a Hazard Review Checklist (Appendix 3) should be completed to determine if adequate safety plans were considered in your equipment design. The Hazard Review Checklist is available in the Department office. The completed checklist is to be reviewed and approved by your faculty advisor prior to the initiation of an experiment.

The following guidelines should be observed:

1. Any equipment or experiment that is operated unattended for any length of time must have emergency information displayed on the form shown at the end of this chapter.

2. 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. Position and clamp reaction apparatus thoughtfully to permit manipulation without the need to move the apparatus until the entire reaction is completed. Combine reagents in appropriate order and avoid adding solids to hot liquids.

3. Never use glassware that is chipped, cracked, etched or flawed in any way.

4. Keep workspace uncluttered. Only the required materials, instructions, notebook and pen should be present. Keep the work area free from extraneous chemicals, scraps of paper and paper towels. Keep all other equipment far back where it will not be knocked over.

5. 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.

6. 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.

7. 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.

8. The most 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.

9. Broken glass, including broken reagent bottles should be disposed of promptly and in the appropriate disposal container. Unbroken chemical reagent, salt, and solvent bottles can be discarded in trash bins. Before discarding in a trash can, these containers must be THOROUGHLY RINSED. If a chemical label is present, it should be removed or defaced.

10. Vacuum pumps and other belt-driven equipment must always have a belt guard.

11. 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, and insoluble in water and should float dry ice. Ethylene glycol thinned with 2/3 water or isopropanol makes a useful cooling mixture.

12. Hardware, regulators, glassware, solvents, dry chemicals, acids, etc., stored in the laboratory must be isolated from each other in separate storage areas to prevent breakage and to avoid other undesirable effects.

13. Electrical equipment including variac’s, 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.

EMERGENCY NOTIFICATION FORM (example)

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.)

CHAPTER 3

HANDLING AND STORAGE OF CHEMICALS AND SOLVENTS

The following general guidelines apply to the handling and storage of chemicals and solvents.

1. 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.

2. A fume hood or other approved ventilation/exhaust system should be utilized whenever flammable solvents or toxic gases are to be used. It may be recalled that the best ventilating efficiency is attained with the hood sash closed. Keeping all items 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 put to use. Fume hoods must be approved and periodically inspected by the Office of Environmental Health & Safety. The Office personnel will affix a label on the fume hood indicating the operability of the system and the maximum acceptable elevation of the hood sash.

Do not operate the fume hood with the sash above the indicated level.

3. 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.

4. Flammable solvents:

A. Properties of flammable liquids:

1. Flash Point: Temperature at which the vapor pressure is sufficient to form an ignitable mixture with the air.

2. Ignition Temperature: Minimum temperature required to cause self-sustained combustion.

B. Classification of flammable liquids:

Class IA Liquids: flash point below 73°F and boiling point below 100°F.

Class IB Liquids: flash point below 73°F and boiling point at or above 100°F.

Class IC Liquids: flash point between 73°F and 100 F.

Class II Liquids: flash point between 100°F and 140°F.

Class IIIA Liquids: flash point between 140°F and 200°F**.**

Class IIIB Liquids: flash point above 200°F**.**

C. The maximum allowable size of containers for flammable liquids is as follows:

Container Class:	IA	IB	IC	II	III
Glass/plastic	1 pt	1gal	1gal	1gal	1gal
Tinplate can	1 gal	5 gal	5 gal	5 gal	5 gal
Safety cans	2 gal	5 gal	5 gal	5 gal	5 gal

A table of common solvents is given at the end of this chapter.

5. Oxidizing agents

A. Peroxides, hydro peroxides, 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. Organic peroxides are among the most hazardous chemicals handled in a laboratory. Many organic compounds, including the following types, are known to form extremely dangerous peroxides.

1. Aldehydes

2. Ethers, especially cyclic ethers such as THF.

3. Compounds containing benzylic hydrogen atoms, e.g. cumene.

4. Compounds containing the allylene (CH2=CHCH2R structure).

5. Ketones.

6. 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.

B. Disposal of Peroxides -Do not mix with other chemicals for disposal – keep in a separate contained properly labeled for disposal by the Environmental Office.

6. Concentrated acids and bases should preferably be stored in trays, separated from all other chemicals. They should not be stored on high shelves. ACIDS AND BASES SHOULD BE STORED IN SEPARATE CABINETS!

7. 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.

8. Only "non-hazardous materials", as defined in Appendix 2, may be poured into a sink. For all other materials follow the waste disposal guidelines in Appendix 2. Concentrated acids and bases can be removed by the Environmental Health and Safety Office. If you are unsure about any item, contact the EHS Office before putting anything in the sink.

9. UNBROKEN chemical reagent, salt, and solvent bottles can be discarded in trash bins. Before discarding in a trash can, these containers must be THOROUGHLY RINSED. If a chemical label is present, it should be removed or defaced.

10. 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.

11. Chemical toxins:

A. Cyanide and Nitrile -cyanide and nitrile 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.

IMPORTANT:

You must obtain lab certification from the Department Chairman and Environment Health and Safety before using Cyanide or Nitrile.

B. The toxicity of common solvents should be recognized. Solvents requiring special care

Include:

1. Certain aromatic hydrocarbons

2. Esters of organic acids

3. Glycol, glycol esters and glycol ethers

4. Halogenated hydrocarbons

5. Lower alcohols - methanol, ethanol, etc.

6. Nitrogenous compounds such as amine

7. Benzene should not be used unless absolutely necessary.

C. Do not overlook the toxicity of chemical compounds. It is best to consider every chemical toxic and to protect yourself accordingly.

Common Solvents

Name	Freezing pt. F (C)	Boiling Pt. F (C)	Class
Acetone	-4 (-20)	133 (56)	IB
Acetonitrile	46 (6)	179 (82)	IB
Benzene	12 (-11)	176 (80)	IB
Butanol	84 (29)	243 (117)	IC
Carbon disulfide	-22 (-30)	115 (46)	IB
Cyclohexane	-4 (-20)	179 (82)	IB
p-Dioxane	52 (12)	214 (101)	IB
Ethanol	55 (13)	173 (78)	IB
Diethylether	-49 (-45)	95 (35)	IA
Heptane	25 (-4)	209 (98)	IB
Hexane	-7 (-22)	156 (69)	IB
Methanol	52 (11)	147 (64)	IB
M.E.K.	16 (-9)	176 (80)	IB
Octane	56 (13)	258 (126)	IB
n-Pentane	-40	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

CHAPTER 4

COMPRESSED GASES AND GAS REGULATORS

1.

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.

2.

All cylinders in operation or not, must always be firmly 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 trough concrete walls!

3.

When ordering new gas cylinders, consider purchasing gases in refillable containers. The disposal costs of empty containers often offset the increased initial cost of having to purchase a larger amount of gas.

4.

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.

5.

When installing a new cylinder, write your name on the cylinder information tag and attach it to the valve stem.

6.

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.

7.

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.

8.

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.

9.

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.

10.

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.

11.

IMPORTANT:

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 only on a specifically designed wheeled cart. Do Not use a regular hand which has no chain or strap to secure the cylinder.

12.

Cylinders should be located in the lab so that the cylinder valve is accessible at all times.

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 Centigrade.

13.

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.

14.

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).

15.

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.

16.

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).

CHAPTER 5

SAFETY IN THE MACHINE SHOP

Engineering students should consider familiarity with shop procedures a valuable asset for their future careers. Graduate students and undergraduate researchers are welcome to use the departmental student machine shop for research-related projects provided they obtain permission from the shop supervisor.

The shop supervisor will approve the use of any shop equipment and will assist you in starting-up equipment fabrication and modifications of existing equipment.

Following a few basic safety procedures will assure a hazard-free experience for you and others working in the shop.

1.

Safety glasses (see Appendix 1) 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.

2.

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.

3.

Do not operate any 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.

4.

Report all injuries (and near misses), no matter how small, to the Safety Committee or the Department Chairman and assistant.

5.

Always clean up the work before you leave.

APPENDIX 1

EYE PROTECTION

SAFETY GLASSES (see definition below) ARE THE MINIMUM EYE PROTECTION

REQUIRED AND MUST BE WORN AT ALL TIMES IN ALL EYE PROTECTION

AREAS. Side shields offer some protection from objects that approach from the side but may not provide adequate protection from splashes. Goggles should be used when significant splash hazard exists, such as when handling concentrated acids and bases. Special eye protection is required for the handling of toxic chemicals, for welding, machining operations, etc.

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 AT ALL TIMES.

Special protection is required when activities take place involving:

(A) Corrosive or other chemically hazardous materials

(B) Hot molten metals

(C) Heat treatment

(D) Gas or electric arc welding

(E) Machine shop operations

(F) Vacuum evaporation, use of cryogenic apparatus or any evacuated experimental system where an implosion hazard exists; (G) Operation of high-pressure reactors and reactions conducted in glass systems at any temperature or pressure.

Acceptable eye protection includes:

1.

Industrial safety glasses with side shields, provided by you or obtained from your advisor.

2.

Your prescription glasses with plastic lenses or impact resistant glass lenses and lens-retaining frames with the addition of side shields. Alternatively, safety glasses can be worn over prescription glasses.

3.

Visitor safety glasses with side shields that meet ANSI Z87.1-1979 standards. These can be worn over prescription glasses and are acceptable for temporary use in laboratory areas. It is the host's responsibility to provide adequate eye protection for lab guests.

APPENDIX 2

DISPOSAL GUIDELINES

Department of Environmental Health & Safety

Chemical Waste Pickup can be arranged on their website page:

http://ehs.virginia.edu/

Or phone @ 982-4911

Waste

We prefer to keep certain types of chemicals separated at the time of Segregation disposal. This method not only lowers disposal costs for the University, but also decreases the chances of incompatible materials from being added together. Keep the following groups to themselves whenever possible.

1

Non-halogenated organic solvents, <5% water

2

Non-halogenated organic solvents, >5% water

3

Halogenated solvents (% water unimportant)

4

Solutions containing compounds of the following metals: arsenic, barium, cadmium, chromium, lead, silver and selenium.

5

Any solution containing mercury or its compounds. (Mercury/mercury compounds should be kept separate from any liquid whenever possible.)

6

Acids, organic

7

Acids, mineral

8

Bases, organic

9

Bases, mineral

10

Acyl Halides (e.g. acetyl chloride, thionyl chloride, benzoyl chloride)

11

Cyanides

12

Sulfides

13

Organic peroxides

14

Inorganic Oxidizers

15

Photographic fixer

16

Photographic developer

17

Photographic stop bath

18

Water-reactive compounds (e.g. sodium, butyllithium, grignard reagents)

19

Pesticides

20

Oils

21

Paints

22

Formaldehyde Solutions

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.

When possible, keep all carcinogens/mutagens separate from other waste. Keep aqueous wastes separate from organic solvents. Keep halogenated solvents and wastes separate from non-halogenated solvents.

Do not put hazardous waste down the sink or in the trash.

Environment Health and Safety provides plastic-coated, 1-gallon glass and DOT-approved 5-gallon carboys.

Chemically contaminated needles should be placed in Sharps-a-gator boxes and will be disposed of by EHS.

Please Note from Environmental Health and Safety:

All chemical waste must be deposited in properly labeled waste containers. According to the Virginia Department of Waste Management, each waste container MUST be marked with a hazardous waste sticker (Appendix 2A). Any containers issued by our office will already contain this sticker. If you plan to use your own bottles as waste receptacles, you can receive the required stickers by contacting our office, (2-4911). In addition to waste stickers, all waste containers MUST contain a waste disposal label (Appendix 2A) issued by EHS. This includes chemicals still in their original containers. Waste will not be picked up if it is not labeled properly. If you need new labels, let us know and we will deliver them on our pickup.

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 label, or in such a way that we can remove the copy when we pick up the waste.

Please following all instructions from the Environmental Health and Safety website in regard to waste disposal methods: http://ehs.virginia.edu/

Information that is absolutely required on the chemical waste label includes:

A.

The name of all possible contents, including stains, water, or any solvents.

Do not use abbreviations or formulas.

B.

The percentages of each component (total must equal 100%0>

C.

The total quantity.

D.

The pH of the waste liquids if it is suspected to be below pH3 or above pH 10.

E.

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. If chemicals are not labeled disposal costs can be very high for the department.

DO NOT FILL CONTAINERS TO THE TOP. Fill plastic carboys ONLY to the fill line. Leave about "2 at the top of all other containers. 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 reasonable clean. Do Not put liquids (especially phenol) in bottles designed for solids.

They Leak!

The Virginia Department of Waste Management has stated that all chemical waste containers must remain CLOSED (capped) between chemical waste additions. When chemical waste containers are left uncapped, laboratory personnel are risk of chemical exposure due to inhalation of chemical vapors.

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

The Office of Environmental Health & Safety does not pick up empty bottles. They may be triple rinsed and discarded. They will supply empty bottles, as well as 5-gallon cans and carboys, for waste disposal. Call in advance for these items and we will bring them with your regular pickup.

Ethers tend to form extremely explosive compounds over time. Therefore, date all ether cans. Do Not keep an open ether can for more than 1 month, or an unopened can for more than 4 months. 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, stored in a safe location and picked up by EHS staff.

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.

Call 2-4911 or visit http://ehs.virginia.edu/

Go to online resources to schedule a waste pick-up. Chemical waste will be picked up within three working days from the date it is called in.

HAZARDOUS WASTE

KEEP CONTAINERS CLOSED AT ALL TIMES

DO NOT FILL WITHIN 2” OF CONTAINER TOP

Hazardous contents:

For emergencies or waste Pick Up, Call EHS 982-4911

This label must be affixed to any waste container. Use the EHS-issued self-adhesive labels, which come in various sizes.

APPENDIX 3

HAZARD REVIEW CHECKLIST

DEPARTMENT OF CHEMICAL 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 review checklist has been developed at the University of Delaware and is adapted from industrial hazard review forms in current use. 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:

Researcher: Office Location:

Advisor:

Unusual Hazards: (Toxic gases, flammable solvents, flammable gases, high pressure gas or liquid, biological hazard, carcinogen, radiation hazard)

APPENDIX 2A

STANDARD WASTE DISPOSAL LABELS

On April 8, 2018, the Commonwealth of Virginia adopted the Environmental Protections Agency's (EPA) Hazardous Waste Generator Improvements Rule. One major change this new regulation brings is more stringent labeling requirements for hazardous waste.

Previously, a container of hazardous waste needed to be labeled with either the words "Hazardous Waste" or a description of the contents of the container (e.g. "methanol", "flammable solvents").

The new regulations require containers of hazardous waste to be labeled with the words "Hazardous Waste" **AND** a description of the contents of the container.

In order to make compliance with these new requirements as easy as possible, EHS has redesigned UVA's Hazardous Waste Stickers, an example can be seen below.

This new sticker provides space on which to write the contents of the container and to select (check) the appropriate Globally Harmonized System (GHS) pictogram. The example below shows proper labeling for a flammable solution.

When filling out the stickers be sure to select the appropriate GHS pictogram **AND** to include the contents of the container.

These changes do not affect the requirement to fill out an EHS **Waste Disposal Ticket** for each container of waste **prior to pickup**.

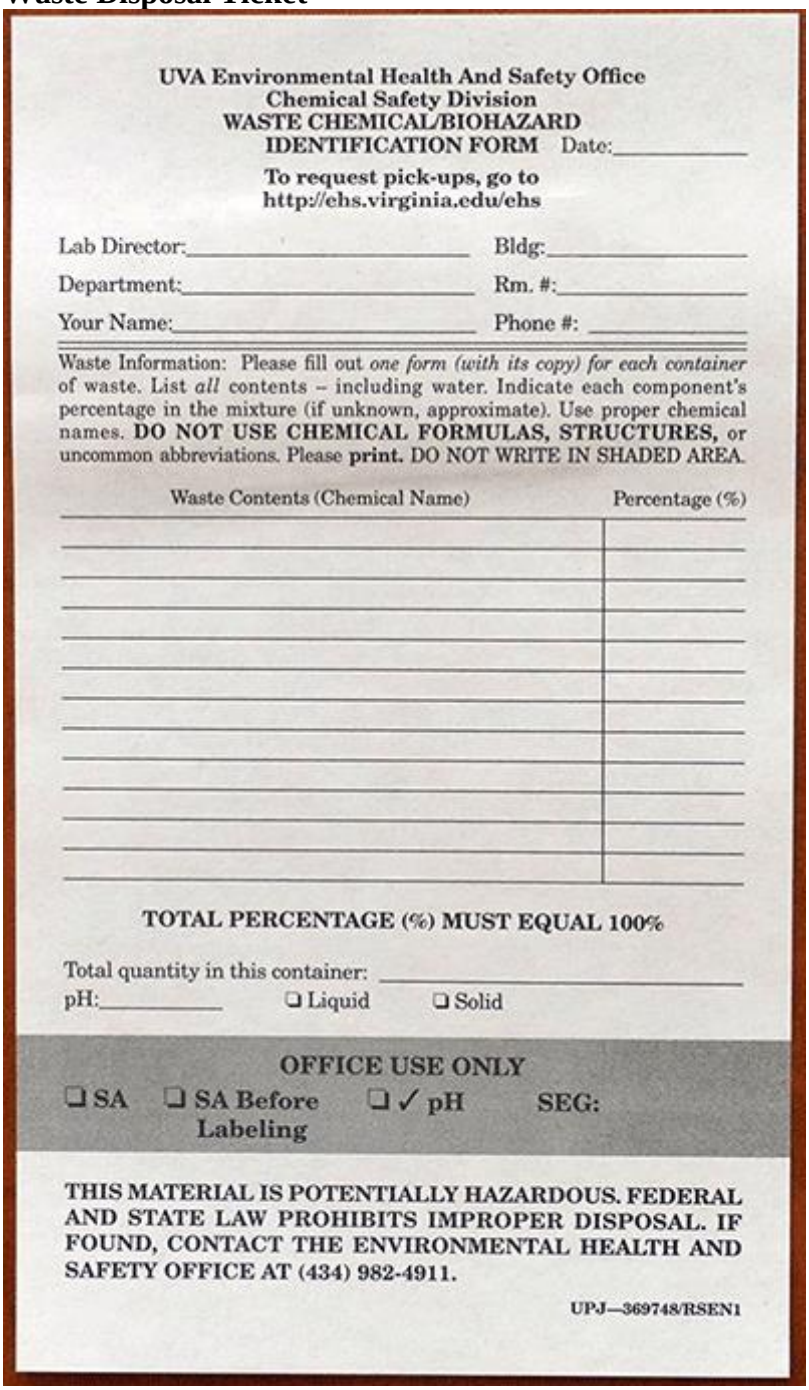
Hazardous Waste Sticker

In addition to waste stickers, **all waste containers MUST have a Waste Disposal Ticket** (see image below), affixed to it prior to pick up. This label is issued by EHS. This includes chemicals still in their original containers. Waste will not be picked up if it is not labeled properly. If you need new labels, let us know and we will deliver them. The label should be affixed to the waste container by a single piece of tape across the top of the label.

Waste Disposal Tickets must be filled out completely. This includes:

- Date, Lab Director (P.I.), Department, Name of the person filling out the label, Building, Room Number, Phone Number.
- The names of all the constituent contents of the container. Do not use abbreviations, chemical formulas or chemical diagrams.
- The corresponding percentages of these constituents.
- The total quantity of material in the container.
- pH (for liquids)
- **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 Disposal Ticket



UVA Environmental Health And Safety Office
Chemical Safety Division
WASTE CHEMICAL/BIOHAZARD
IDENTIFICATION FORM Date:_____

To request pick-ups, go to
http://ehs.virginia.edu/ehs

Lab Director:_____ Bldg:_____

Department:_____ Rm. #:_____

Your Name:_____ Phone #: _____

Waste Information: Please fill out *one form (with its copy) for each container* of waste. List *all* contents – including water. Indicate each component's percentage in the mixture (if unknown, approximate). Use proper chemical names. **DO NOT USE CHEMICAL FORMULAS, STRUCTURES,** or uncommon abbreviations. Please **print.** DO NOT WRITE IN SHADED AREA.

Waste Contents (Chemical Name)	Percentage (%)

TOTAL PERCENTAGE (%) MUST EQUAL 100%

Total quantity in this container: _____

pH:_____ ❑ Liquid ❑ Solid

OFFICE USE ONLY

❑ SA ❑ SA Before Labeling ❑ ✓ pH SEG:

THIS MATERIAL IS POTENTIALLY HAZARDOUS. FEDERAL AND STATE LAW PROHIBITS IMPROPER DISPOSAL. IF FOUND, CONTACT THE ENVIRONMENTAL HEALTH AND SAFETY OFFICE AT (434) 982-4911.

UPJ—369748/RSEN1

THIS PAGE LEFT INTENTIONALLY BLANK

EMERGENCY SHUTDOWN PROCEDURE:

Label all experimental equipment with emergency shutdown information so that a non-operator can easily shutdown your equipment. Information sheets and clipboards are available in the Department office. This is an example of questions to assess your project situation.

Device Shutdown Location:

Is Sequence important?

Where is the nearest:

Evacuation Alarm

Exit

Fire Extinguisher

Safety Shower

Eyewash Station

Special First Aid Procedures: What chemicals are being used? Etc.

Use the following checklist as a reminder to avoid unsafe practices and conditions in your equipment. Use Yes, No N/A

ELECTRICAL

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 Material Safety Data Sheets (MSDS) 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 LAB QUESTIONS:

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) Are 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 (PPE)

Please study the Environmental Health and Safety website section for proper PPE. If is very important for all lab personnel to have the appropriate PPE when performing and setting up their experiments.

https://ehs.virginia.edu/Chemical-Safety-PPE.html

GENERAL START UP EXPERIMENT QUESTIONS

1. What are the experimental equipment limitations? (Temperature, pressure, 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 assembly and 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 and routine safety inspections will you apply to your equipment to insure hazard-free service? Describe the records you will maintain.

APPENDIX 4

REFERENCES

Bretherick, L., Handbook of Reactive Chemical Hazards, 3rd ed., Butterworths, 1985

Compressed Gas Association, Inc., Handbook of Compressed Gases, 1981, 507 pp.,

VanNostrand Co., N.Y.

Hoffman, J. M. and D. C. Master, (ed), "Chemical Process Hazard Review", ACS Symposium

Series 274, American Chemical Society, 1985

Manning, W. R. D., and Labrow, S., High Pressure Engineering, London, L. Hill Co., 1971, 369 pp.

National Research Council. Committee on Hazardous Substances i the Laboratory. 1981,

Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, 289 pp., Washington, D.C.

NFPA 49, Hazardous Chemicals Data, 1975, National Fire Prevention Assoc., Boston, Mass. Sax, N. I., 1979, Dangerous Properties of Industrial Materials, 6th ed., 1118 pp., VanNostrand

Co., N.Y.