Laboratory Safety Manual

University of Arkansas for Medical Sciences

Occupational Health & Safety

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UAMS Emergency Phone Numbers

Fires	**686-5333**
Campus Operations Call Center	**526-0000**
Occupational Health & Safety(OH&S)	686-5536

OH&S Safety Officers

Biological Safety Officer Biological spills	686-5536
Environmental Programs Manager Hazardous Chemical/Substance Spill	686-6958
Fire/Life Safety Officer	686-6786
Industrial Hygiene Officer	686-5543
Radiation Safety Officer Radioisotope spills	686-7803

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DISCLAIMER

This Laboratory Safety Manual was prepared for use by the faculty, staff and students at the University of Arkansas for Medical Science (UAMS). It is provided as a means of presenting the regulations and standards pertaining to safely performing laboratory work, and as guidelines to illustrate standards, accepted practices for conducting laboratory investigations safely. Neither the author nor the University of Arkansas for Medical Science warrants its completeness or correctness. Any discrepancies noted should be brought to the attention of the UAMS Department Occupational Health & Safety.

For specific information on biological safety and radiation safety, refer to the Biological Safety and Radiation Safety Manuals.

LABORATORY SAFETY POLICY STATEMENT

The University of Arkansas for Medical Science is committed to insuring safe practices are utilized in laboratories and that safe facilities are offered to the UAMS Community. Maintaining compliance with federal, state, and local laws and regulations pertaining to laboratory safety and hazardous materials management is essential to this commitment. The UAMS Department of Occupational Health & Safety (OH&S) has overall responsibility for providing information and training concerning environmental health and safety to faculty and staff. Implementing safety and assuring students are informed and have a safe laboratory to conduct activities is the responsibility of individual colleges, departments, and or centers. Colleges, departments, centers, or other units may develop internal policies and procedures for laboratory safety but they must be at least as stringent as University guidelines and are subject to review by OH&S.

The Director of OH&S is responsible for (1) developing and maintaining University policies and guidelines related to conducting research and teaching activities safely, and (2) designing and conducting training programs for University personnel regarding regulatory requirements for safely conducting activities in UAMS laboratories. Schools, departments, or other units are responsible for maintaining accurate records related to departmental student training and incident/accident investigation.

The Director of Occupational Health and Safety or his/her appointee has supervisory responsibility for monitoring compliance with federal, state, and local regulations, and is responsible for identification of units within the University that may not be complying fully with regulations. The Director or his/her appointee is responsible for providing notification of non-compliance to the units involved and for providing consultation. When units fail to make necessary changes to comply with regulations, the Director is responsible for reporting such non-compliance to the Dean/Director/Chairman who has administrative responsibility over the unit involved.

PREFACE

The UAMS Laboratory Safety Manual serves as a tool to provide information to the University Community on minimal safety procedures required in campus laboratories. The information contained within this manual when paired with appropriate training should enable faculty, staff and students to avoid injuries, illnesses, and destruction of University property while working in their laboratory.

This manual also serves to promote the environmental health of the surrounding community. It is imperative that the UAMS faculty, staff and students involved in working in laboratories be knowledgeable in the proper procedures associated with the safe handling, storage, and disposal of laboratory chemicals and paraphernalia. Use of the guidelines herein is critical to accomplishing the UAMS environmental goal.

As we work to provide accurate laboratory safety information in this manual, please remit any comments and recommendations to the OH&S Department, 686-5536. Our goal is to provide service of the highest quality.

EXECUTIVE SUMMARY

The Laboratory Safety Manual was compiled to ensure that the University goals in environmental health and safety as they apply to laboratory activities are accomplished. Basic concepts in laboratory safety practices are covered. This Manual does not include in-depth information on biological safety, radiological safety, laser safety, or general industry safety. For detailed information on biosafety and radiation safety, refer to the Biosafety and Radiation Safety Manuals or contact the OH&S Department, 686-5536. In compiling this information guidelines and recommended practices were drawn from regulatory agencies such as: the National Fire Protection Agency, the Environmental Protection Agency, the National Institutes of Health, and the Occupational Safety and Health Administration. Knowledge and practice of the guidelines set forth in this manual will significantly reduce the risk of injury and facility loss and benefit the faculty, staff, and students who work in laboratories at the University of Arkansas for Medical Sciences.

The Laboratory Safety Manual outlines the basic safety requirements and responsibilities of faculty and staff utilizing and responsible for laboratories and laboratory facilities. The manual begins by discussing general personal safety practices, and then continues with standard and emergency laboratory safety equipment. Next guidelines for emergency response procedures for chemical spills fires and injuries are detailed. The injury procedures include the requirement to complete a standardized form during injury consultations. The form is designed to provide necessary information to the person who has been injured in a UAMS laboratory and for documentation purposes. Following the section on OH&S laboratory audits (Sections V), measures for best chemical hygiene practices are outlined. These measures include both requirements and information concerning chemical identification and inventorying, labeling, storage according to chemical compatibility's, general housekeeping and chemical waste disposal. The general housekeeping section includes laboratory close out procedures. Significant strides have been made at UAMS in minimizing the safety and environmental hazards associated with unknown laboratory products. By adhering to the laboratory close out procedures unknown chemical products will be virtually eliminated and incoming faculty and staff will be greeted with a research-ready laboratory. Fire prevention information and tips are provided in Section VII of the manual. The next three sections address identification of chemical hazards, identification and disposal of chemical and hazardous waste, and disposal of biological waste. Section XII discusses the research use of DEA controlled substances and the UAMS laser safety program is discussed in Section XIII. The manual concludes with the UAMS Hazardous Waste Management Plan (HWMP) which has been incorporated into the Laboratory Safety Manual as an appendix. The goal of the HWMP is to protect the health and safety of employees, students, and the environment while complying with the Resource Conservation and Recovery Act (RCRA). The HWMP provides guidelines for the management of hazardous waste from its point of generation to its final disposition/destruction. Violations of RCRA regulations can result in fines as much as $32,500 per day per violation. Criminal charges may be brought against individuals who knowingly violate state, federal, or local regulations. Therefore, failure to comply with the guidelines for handling hazardous waste can have serious ramifications to individuals as well as the University.

Introduction

The UAMS Laboratory Safety Manual is for use as a general guide in safety for laboratories on the UAMS campus. In depth information can be obtained from OH&S or a number of publications. ***Prudent Practices for Handling Hazardous Chemicals in Laboratories*** is a publication highly recommended for all laboratories utilizing hazardous chemicals.

I. Personal Safety

A. Training

Occupational Health and Safety has the responsibility for training faculty and staff. Training courses are offered monthly. The training provides an overview of federal, local, and state guidelines and University policy related to laboratory safety and environmental hygiene. Persons with primary responsibility for laboratories are responsible for training students in the safe handling of hazardous materials and laboratory technique.

B. Children in the Laboratory

Due to the hazards in laboratory areas, it is imperative that we do not allow children under the age of sixteen (16) in any of the laboratories or common areas. UAMS Administrative Guide policy, 3.1.42 outlines the responsibilities for approval of job shadowing. Children sixteen and older must comply with all regulations for labs including the dress code and are not to be left unattended.

C. SDS Availability

Safety data sheets (SDS) must be readily available for each laboratory. A centralized location for SDS is permissible. SDS must be available at all times and near the hazard source. Prior to the use of a new chemical the SDS must be provided to the chemical user and those persons in the lab for review.

D. Safe Use of Laboratory Equipment

Laboratory equipment must be used according to manufacturer guidelines. All best practices and procedures to minimize exposure must be followed. Appropriate training is the responsibility of the department in charge of the lab. Engineering and Operations is responsible for the maintenance of equipment installed by the University as part of the facility, e.g., fume hoods, safety showers, eyewashes, sinks, etc.

All equipment must be inspected prior to use to ensure that electrical cords are not damaged, safety interlocks have not been compromised and no chemicals have been spilled in the chambers of the equipment.

Equipment may be modified as necessary for research purposes. Clinical Engineering (526-0000) must be contacted prior to the use of modified equipment to verify the electrical and mechanical safety of the equipment.

E. Laboratory Doors

Laboratory doors must remain closed to ensure that any hazardous materials spills will be isolated to that laboratory/area. The last person out should follow a laboratory shutdown checklist and lock the door on his/her way out. The safety checklist should include items such as: turn off gas and heat sources, turn off water supply and equipment, ensure signage is posted on unattended experiments, return all chemicals to appropriate storage, ensure all chemicals and solutions or mixtures are labeled, turn off lights and lock the door(s). Laboratories using radioactive materials must ensure that the material is secured against unauthorized access or removal at all times. Radioactive materials laboratories must be physically occupied or locked at all times.

F. Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is gear or clothing used to protect the wearer from specific hazards and hazardous materials. It is the final protection system to be used when administrative and engineering controls do not reduce risk to an acceptable level. PPE does not reduce or eliminate the hazard but only protects the wearer.

PPE must be made available to laboratory workers to reduce exposures to hazardous biological, chemical and radioactive substances in the lab. Proper PPE includes items such as gloves, eye protection, lab coats, face shields, aprons, etc. PPE must be readily available and provided at no cost to the employee. It is the responsibility of the laboratory Principal Investigator to provide PPE to his/her employees.

Minimum PPE requirements to work in all UAMS laboratories include: full length lab coat, fully enclosed shoes, safety glasses/goggles and gloves.

Laboratory personnel must be trained in the selection, proper use, limitations, care, and maintenance of PPE. Examples of topics to be covered during the training include: When PPE must be worn; What PPE is necessary to carry out a procedure or experiment; How to properly put on, take off, adjust, and wear PPE.
- No open-toed shoes
- No shorts unless a full length lab coat is used and button all the way up.
- Restrain hair when working on bench top.
- Remove protective clothing in lab.
- Use the proper Personal Protective Equipment for the job.

Some operations and procedures may warrant additional PPE, as indicated by the Safety Data Sheet (SDS), the Standard Operating Procedures (SOP), facility policies, regulatory requirements, or the hazard assessment. These might include face shields, aprons, respiratory protection, hearing protection, cryogenic protective equipment etc.

G. Eating in the Lab and Food Storage

Eating, drinking, gum chewing, the use of tobacco, and the application of cosmetics are not allowed in laboratories. These actions may cause contamination of individuals who are involved in the activity. Food storage is not allowed in laboratories. Other actions that may result in contamination that should be noticed and avoided are: pencil chewing, touching the face, adjusting eyeglasses, scratching, etc. Lab coats must not be worn into eating and food preparation areas.

H. Hair

Long hair must be tied back to prevent possible contamination and injury.

I. Pipetting

Pipetting by mouth is not allowed. Use mechanical pipetting devices only.

J. Laundry

Lab coats and potentially contaminated clothing must be washed separate from other laundry items.

K. Hand Washing

Hands and forearms must be washed prior to leaving the laboratory.

L. Experiment Identification

Identification must be posted on unattended experiments. The identification must provide a point of contact, what the hazard is and in what quantity, and when the experiment will be discontinued, and any instrument settings that must be maintained.

M. Lockout Tagout

Ensure instrumentation that requires repair is not usable by disconnecting critical operating points and switches and labeling as broken.

N. Exposure Monitoring

Depending on the amount, type, and frequency of use, chemical exposure monitoring may be required for laboratory work. To determine the need for periodic monitoring, contact OH&S and schedule an appointment.

O. Dry Ice Handling Procedures

To ensure safe storage usage and handling of dry ice, all University lab employees and students responsible for shipping packages containing dry ice must read and follow these procedures.

1. Dry Ice is to be stored in a well-ventilated location and placed in a Styrofoam chest, insulated cooler, or a special cooler designed for the storage of dry ice,
2. Dry Ice is NEVER to be stored in any type of tightly sealed devices such as a standard freezer or plastic/glass container(s). If stored in an ultra-low freezer, dry ice must be placed in a Styrofoam container.
3. A five to ten pound(s) of Dry Ice will sublimate *(transition from a solid to a gas)* in a typical storage cooler within a 24 hour period. Plan on purchasing dry ice as close as possible for the time needed.

4. Dry Ice can cause burns to the skin in a short period of time. Thermal gloves are to be used when handling dry ice.
5. Dry Ice that is not stored in a well-ventilated area could cause a buildup of carbon dioxide and could suffocate the person(s)
6. Placing Dry Ice in a tightly sealed container can produce sufficient gas build up to cause an explosion.
7. When using dry ice to ship materials, the shipper must abide by all applicable shipping (DOT/IATA) regulations.
8. Disposal of unused dry ice.
    a. Let the unused portion sublimate *(transition from a solid to a gas, recommended for well-ventilated locations)*
    b. Never dispose dry ice in a sink, toilet or other drains *(such action can destroy the structure due to temperature differences)*

P. Usage and Storage of Liquid Nitrogen

The following information is provided to inform individuals who handle liquid nitrogen of the hazards and risks associated with storage and use. Areas where liquid nitrogen is used and stored must have adequate ventilation, which means oxygen levels must maintain a 20.9% concentration during normal storage and handling. Liquid Nitrogen rapidly vaporizes to gas with about 700 times the liquid volume. This displaces the oxygen in the air at a rapid pace which could asphyxiate individuals in the immediate proximity. Even a small leak can displace oxygen enough to lower the percent concentration in the area which may cause dizziness, impaired judgment, and unconsciousness. For this reason oxygen sensors must be present in labs where large amounts of cryogenic compounds are used. These sensors warn employees if the oxygen levels are too low or too high as some areas may use liquid oxygen in certain procedures. Exposure to higher levels of oxygen can result in oxygen poisoning or death.

1. Hazards of Liquid Nitrogen and Risks

The Hazards for using Liquid Nitrogen (LN_2) are:

a. Asphyxiation in oxygen deficient atmospheres – If vented into a closed space, Liquid Nitrogen will vaporize, displacing oxygen and possibly cause asphyxia.

b. Combustion and explosion hazard from oxygen enrichment of atmosphere, Liquid Nitrogen can condense air from the atmosphere, which can lead to production of liquid containing higher oxygen content than that of normal air. This higher oxygen content increases the combustibility of many materials, creating potentially explosive conditions.

c. Cold burns, frostbite and hypothermia - The extremely low temperature of liquid nitrogen (liquid nitrogen boils at -195 C) means that liquid, cold vapor or gas can produce serious skin burns. Objects and uninsulated items of equipment can stick to skin, and flesh may be torn on removal. Cold vapor or gas may cause frostbite given prolonged or severe exposure of unprotected body parts.

d. Embrittlement – Liquid Nitrogen can cause many common materials such as carbon steel, plastic and rubber to become brittle, or even fracture under stress. Materials, such as stainless steel, aluminum, brass, copper or high-nickel alloys may be used. Inspect all "Liquid Nitrogen" cylinders regularly for leaks or frost spots.

2. Personal Protective Equipment

The following personal protective equipment is required when handling or using LN_2:

a. **Hands** must be protected with water proof thermal insulated gloves (e.g., cryo gloves) that can be quickly removed if LN_2 is spilled on them. Insulated gloves are not intended for submersing hands into LN_2.

b. **Body** must be protected with pants, lab coats, and closed-toe shoes. Thermal insulated aprons should also be available.

c. **Eyes** are most sensitive to the extreme cold of LN_2 and its vapors.. Over-pressurization may result in the explosion of improperly vented equipment. Chemical splash goggles must be utilized when handling LN_2 and when handling sealed containers that have been stored in LN_2 (e.g., cryovails).

3. Storage of Liquid Nitrogen

Liquid nitrogen should only be stored in containers specifically designed to contain cryogenic fluids, all liquid nitrogen containers should be stored:

a. In a stable manner and on a sturdy surface; and
b. In a position that does not restrict access and egress; and
c. In a position where they are unlikely to be bumped by persons or other equipment.

The quantity of liquid nitrogen to be stored in an area depends on the volume and ventilation of the area. Areas with good natural ventilation are preferable for storage and decanting tasks because spills, splashes and evaporation are likely to cause an oxygen deficient atmosphere.

4. Handling and Storage

Laboratory personnel must be thoroughly familiar with the properties and safety considerations of LN_2 and its associated equipment prior to handling. Laboratory personnel must:

a. Always wear proper personal protective equipment.
b. Store and use LN_2 only in well ventilated areas. Do not store in a confined space or non-ventilated areas (e.g., cold rooms).
c. Store containers in an upright position. Do not drop, tip, or roll containers on their sides. Use only approved containers with lids to store and transport LN_2. Lids must be vented to allow the off gases of over-pressurized nitrogen gas.
d. Never vapor-seal LN_2 storage containers. Never plug, remove, or tamper with any pressure relief device. Under normal conditions, these containers are designed to periodically vent gas.

5. Safety Precautions

Use only manufacturer-approved containers (e.g., cryovials) for storage in LN_2. If storage in the LN_2 liquid phase is required, utilize manufacturer-approved cryovials specifically designed for liquid phase storage.

II. Standard Laboratory Safety Equipment

Areas utilized at UAMS for chemical laboratories must minimally be equipped with a drench hose, safety shower and/or eyewash and if chemicals having a primary or secondary hazard of flammability, combustibility or toxic a fume hood must be available. It is strongly recommended to perform all chemical manipulations in a fume hood. Additionally, all laboratories are equipped with a fire extinguisher and most are equipped with telephones. Fire/Emergency pull stations are located at or near each exit on each floor of the building and conform to applicable codes.

A. Fume Hoods

A fume hood is one of the most important pieces of laboratory safety equipment. A fume hood prevents the inhalation of potentially harmful substances, deters uncontrolled splashes and spills from entering the lab environment, and removes flammable vapors from the indoor atmosphere.

1. When to Use a Chemical Fume Hood

A chemical fume hood is a necessary part of your laboratory procedure when:

- Working with hazardous or suspect hazardous chemicals
- Working with chemicals having unknown properties
- Pouring, mixing, weighing and dispensing chemicals

2. Fume Hood Safety Practices

A chemical fume hood cannot provide complete safety against all hazards. A functioning fume hood and appropriate laboratory ventilation will provide adequate protection during standard laboratory manipulations. The fume hood should be used in conjunction with other safety equipment when toxic chemicals having exposure limits in the low parts per billion ranges are being utilized. More stringent safety requirements are left to the discretion of laboratory supervisors. The following is a list of mandatory laboratory safety practices.

- Keep all apparatus at least 6 inches from the face of the hood.

- Do not put your head in the hood when contaminants are being generated.
- Do not use the hood to evacuate containers of volatile waste chemicals.
- Minimize the quantity of chemicals and apparatus being used in the hood. Excessive storage of items in the fume hood will impair its performance.
- All operations that may generate air contaminants above their exposure limits must be conducted inside a fume hood.
- Do not use a fume hood if it is not working appropriately. Test the airflow periodically. If a flow meter is not available, a tissue placed at the base of the hood will be gently lifted when appropriate airflow is provided. The tissue should not be pulled into the exhaust. This indicates the airflow is too high.
- Maintain the slots in the hood baffle free from obstructions.
- Minimize traffic in front of the hood while in use.
- Keep laboratory doors and windows closed unless specifically designed for opened doors.
- Do not remove the hood sash, panels or sensors. Keep all wiring between hood electronics and sensors intact.
- The laboratory supervisor must approve the use of hazardous solids (powders). (Many potential problems arise when the solid is fine enough to become airborne.)
- Do not place receptacles or other sources of sparks inside the hood when flammable liquids or gases are present.
- Use an appropriate barricade if an explosion or other violent reaction is possible.
- Do not remove hood labels that indicate the maximum safe operating level of the sash.
- Use only specially designed fume hoods for operations involving the use of perchloric acid.
- Ensure all fume hoods have a spill protection lip.

3. **See Appendix A for Fume Hood Terms and Definitions and How a Fume Hood Works.**

B. Biological Safety Cabinets

Biological safety cabinets should be used during handling of biological organisms. Consult the Biological Safety Manual for more information in the requirements to use the different classes of biological safety cabinets.

C. Laminar Flow Hoods

The differentiating feature of laminar-flow vs. fume hood is that there is no contaminated positive air plenum. All work with organic solvents, concentrated carcinogens, and with toxic or corrosive contaminants should be performed in a fume hood.

D. Hood/Cabinet Maintenance and Repairs

It is highly recommended that all hood/cabinet flows be checked monthly by the person utilizing the laboratory. An anemometer or magnehelic gauge will verify the hood has negative pressure. Typically chemical fume hoods should operate at a flow of 80 – 120 feet per minute for optimum user safety. A record of this safety check should be kept. Inner surfaces of fume hoods may be cleansed using a dilute solution of soapy water, provided all spills have been cleaned appropriately. Minimally, gloves, goggles, and a lab coat must be worn during cleaning procedures. Immediately report fume hood malfunctions to 526-0000. Annually, OH&S verifies the face velocity of campus fume hoods and label them with a sticker denoting that the hood has passed the annual survey and is in compliance. The compliance standard requires a face velocity of 80-120 feet per minute at a sash working height of 12-18 inches. Questions or requests for assistance in the evaluation of fume hoods may be directed to OH&S at 686-5536.

III. Emergency Equipment

A. Eyewashes and Safety Showers

Emergency eyewashes are mandatory for chemical laboratories. Laboratory facilities at UAMS should be equipped with an eyewash station or drench hose. Safety showers must be within close proximity of hazardous chemical areas. Engineering and Operations must be contacted to install eyewash stations and safety showers when necessary. Optionally, portable eyewash station and showers may be purchased.

Engineering and Operations checks campus safety showers and emergency eyewashes monthly to verify that they function appropriately. Individuals responsible for laboratory areas are responsible for insuring eyewashes are **flushed weekly**. This will effectively flush the lines of any debris and potential microbial growth. Due to the nature of the work conducted in biological laboratories, a periodic wipe down of the safety shower with a commercially available disinfectant or a one-part bleach to ten-part water solution is highly recommended.

IV. Emergencies

A. Hazardous Materials Spills

Hazardous Chemical/Substance Spills **must be cleaned as soon as possible.** **If the spill exceeds five liters or is an acutely hazardous substance, as defined in Appendix E of this manual, OH&S must be contacted immediately.**

1. Chemical Spill Kit Materials

Laboratories should be prepared for chemical spills by having a spill kit and supervisory personnel trained to respond. The spill kit must be in an obvious location and all persons responsible for the activities conducted in the laboratory must be knowledgeable in the use of the spill kit. Spill kits can be specialized for individual laboratories or can contain general supplies necessary to handle a variety of spills. Spill kits are commercially available, or you may purchase a kit from OH&S.

2. General Chemical Spill Guidelines

Determine the extent and type of spill and contact OH&S if assistance is needed. Follow these general guidelines when mediating a spill:

a. Immediately alert area occupants and supervisor, and evacuate the area, if necessary.
b. Contact OH&S at 686-5536 or Campus Operations Call Center at 526-0000.
c. Immediately warn everyone when a volatile flammable material is spilled. Control sources of ignition. Ventilate the area by turning on the fume hoods with the sashes completely open.
d. Use the appropriate personal protective equipment for the hazard involved. Refer to the Safety Data Sheet or other available references for information.
e. The use of respiratory protection requires specialized training and medical surveillance. DO NOT enter a contaminated atmosphere without protection or use a respirator without training.

Call OH&S when respiratory protection is required, and there are no trained personnel available. When respiratory protection is used for emergency purposes, there must be another trained person outside the spill area. Cover or block floor drains or any other route that could lead to an environmental release.

f. Use the appropriate media when cleaning spills. Begin by circling the outer edge of the spill with absorbent. Next, distribute spill control materials over the surface of the spill. This will effectively stop the liquid from spreading and minimize volatilization.
g. Place absorbed materials in an appropriate container using a brush and scoop. Small spills can be placed in polyethylene bags. Larger quantity spills may require five-gallon pails or 20-gallon drums with polyethylene liners.
h. Absorbent materials used on the chemical spill will most likely require disposal as hazardous waste. Label the container with chemical name(s). Contact OH&S at 686-5536 for information concerning preparing waste for disposal and for a waste pick-up.
i. Clean the surface where the spill occurred using a mild detergent and water.

3. Organic Solvent Spills

a. Apply activated charcoal (preferred) or paper towels to the perimeter of the spill.
b. Mix until the spill has been completely absorbed.
c. Transfer the absorbed solvent to a hazardous waste bag, tie and attach an appropriate label.
d. Contact OH&S for pick-up.
e. Clean the area with soapy water.

4. Corrosive Spills (Acids and Bases)

Hydrofluoric acid *UN1790* requires special treatment. Contact OH&S at 686-5536 for specific information regarding use, storage, disposal and spill remediation.

5. Mercury Spills

a. Mercury is classified as a persistent bioaccumulative toxin (PBT). Additionally some forms of organic mercury readily absorb through gloves and skin. When any quantity of mercury has been spilled the following procedures are to be followed:Alert others in the area.
b. Mark off the area.
c. Contact the Environmental Programs Manager at 686-5536 or if after normal working hours call the Campus Operations Call Center at 526-0000.

6. Radioactive Material Spills

All spills of radioactive material must be cleaned up promptly. The responsibility for cleaning or for calling for experienced help rests on the individuals working in the area involved and responsible for the spill. A major spill is defined as an uncontrolled and inadvertent release of radioactive material which exceeds 100 microcuries and does not involve airborne contamination. Under no circumstances should any untrained person attempt to examine or clean up a major spill of radioactive material.

The Radiation Safety Officer (RSO) shall be notified immediately of all accidents involving possible body contamination or ingestion of radioactivity by personnel, over-exposure to radiation, contamination of equipment, spread of contamination or difficulty in cleaning up a contaminated area. The RSO must be notified immediately in the event of loss of radioisotopes.

A *minor incident* with radioactive materials is an abnormal occurrence involving low amounts (generally less than 100 microcuries) of radioactive materials, where the worker handling the spill knows how to clean it up, has the decontamination materials on hand, and can respond without incurring risk of exposures or spreading within a reasonably short time.

A *major incident* is an abnormal occurrence involving larger amounts (generally greater than 100 microcuries) of radioactive materials, high risk nuclides, contamination of a large area, contamination of the skin, airborne radioactivity, or any situation where contamination may have been spread outside the authorized area. Major spills must be reported to the Radiation Safety Officer or his/her designee immediately, as required by state and federal law. Call the OH&S Office (501-686-5536) during working hours (7:30 – 4:30 M-F) or the Radiation Safety Officer (870-818-6998) during non-working hours.

An *emergency* is an incident which involves serious injury or death, fire, explosion, or significant release of health or life threatening material, which is or may be coupled with a minor or major radiological incident.

NOTIFY CAMPUS OPERATIONS CALL CENTER IMMEDIATELY IF AN EMERGENCY HAS OCCURRED!! 526-0000.

In the event of a **MINOR radioactive spill** incident, these procedures should be followed:

a. Notify the authorized user and persons in the room at once.
b. Permit only the minimum number of persons in the area necessary to deal with the spill.
c. Confine the spill immediately.
d. Don protective gloves and drop absorbent paper on a liquid spill.
e. Decontaminate, using a monitor to check the progress of the work.
f. Monitor all persons involved in the spill and the cleaning.

In the event of a **MAJOR radioactive spill** incident, the following procedure should be instituted:

a. Notify all persons in the area that a major spill or incident has occurred and evacuate unnecessary personnel. Notify the authorized user and the Radiation Safety Officer.
b. If hands are protected from contamination (i.e., gloves), right the container of the spilled liquid. If possible, shield the source, but only if it can be done without significantly increasing your radiation exposure.
c. If the spill is on clothing, discard outer clothing at once.
d. Vacate the room and lock the doors in order to prevent entry.
e. If skin contamination has occurred, measure levels of contamination with a survey meter, record, and begin decontamination by gentle washing with warm water and soap, washing downwards towards extremities, not upwards.

In the event of an **EMERGENCY** in which radioactive materials are involved, the following procedure should be instituted:

a. Notify all persons in the area that an EMERGENCY has occurred and evacuate the area if a risk to persons present exists.
b. Notify Campus Operations Call Center (526-0000) of the nature of the emergency, number of persons involved, and the location.
c. AWAIT THE EMERGENCY RESPONDERS who will assist and provide direction, as well as contact any other necessary responders.

7. Biohazardous Radioactive Material Spills

Procedures for spill cleanup of a radioactive biological material require emergency procedures which protect the person from exposure to the radiochemical while disinfecting the biological material.

a. Avoid inhaling airborne material, notify other room occupants, and quickly leave the area.
b. Remove all contaminated clothing by turning exposed areas inward. Place in a biohazard bag.
c. Wash all exposed skin areas with a disinfectant soap. Rinse for a minimum of 15 minutes.
d. Inform the laboratory supervisor.
e. Post a spill sign and do not reenter the lab for at least 30 minutes.
f. Contact the Radiation Safety Officer at 686-5536, to confirm safe entry into the laboratory.
g. Utilize appropriate protective clothing and reenter the spill area. The use of respirators requires special training. Call OH&S if a respirator trained individual is required but not available for spill cleanup.
h. Cover the area with disinfectant soaked towels. Pour the disinfectant around the perimeter of the spill area. As the spill becomes diluted with disinfectant, increase the concentration of the disinfectant. Allow 20 minutes for disinfection. **Please note that the use of bleach on iodinated material may cause the release of radioiodine gas. An alternative such as, phenolic compounds or an iodophor should be used when radioactive iodine has been spilled.**
i. Collect any broken glass with forceps and place in an appropriate broken glass collection container. To clean splashed material, spray with disinfectant solution and wipe clean or saturate a paper towel with disinfectant solution and wipe clean.
j. Personal protective equipment (PPE) must be disinfected with bleach solution and disposed of as radioactive waste. Place the used PPE on absorbent paper. Spray the PPE with 10% bleach solution and allow a 20 minutes contact time.
k. Place all decontaminated waste materials in an approved container for radiation and label appropriately.
l. Wash hands and potentially exposed areas with a disinfectant.
m. Monitor laboratory occupants for contamination of radioactive materials.
n. Decontaminate under the advisement of the Radiation Safety Officer.
o. All contaminated persons must seek medical assistance after decontamination procedures have been completed.
p. Monitor the area for residual activity and handle it according to the Radiation Safety Manual guidelines.

8. Biological Spills or Exposures

Biological research has many safety and regulatory guidelines that must be met. Any person participating in biological research at UAMS should be familiar with the UAMS Biosafety Manual.

Appendix B provides information and guidance on decontamination principles, decontamination terms, and the variety of chemical and physical agents used to decontaminate.

Most research conducted at UAMS is classified as Biological Safety Level 1(BSL 1). A minor spill of a biological agent is defined as one that is contained within the biological safety cabinet and no one has come in contact with the spill. If a spill contains BSL 2 agents or greater, or the spill is too dangerous or large to be safely cleaned up by laboratory personnel, contact OH&S at 686-5536.

a. Biological Spill Kit

Laboratories utilizing biological materials should maintain a biological spill kit. Typical kits are packed in a 5-gallon plastic bucket or container. The bucket/container should be clearly labeled to indicate that it is a biological spill kit. Biological spill kits can be assembled to fit specific laboratory needs although basic kits must contain the following items:

- ✓ Concentrated household bleach
- ✓ A spray bottle for bleach solutions
- ✓ Face protection
- ✓ Utility gloves and nitrile gloves
- ✓ Paper towels or other sorbent
- ✓ Biohazard bags
- ✓ Forceps for handling sharps
- ✓ Biohazard symbol labels (for use on the bucket when the cleanup is complete)

9. Biological Spill Procedures

a. Blood Spills

Blood spills with low concentrations of infectious microorganisms must be handled in the following manner:

1. Wear at least the minimal required laboratory personal protective equipment.
2. Absorb blood with paper towels and place in a biohazard bag.
3. Collect any broken glass with forceps and place in an appropriate broken glass collection container.
4. Clean the area with a detergent.
5. Spray the area with a 10% bleach solution and allow to air dry for 15 minutes.
6. Wipe the area with disinfectant soaked paper towels.
7. Place all contaminated items in a biohazard bag, autoclave, and dispose of according to UAMS guidelines.

b. Ethidium Bromide Spill Clean-up and Disposal:

Ethidium bromide is a potent carcinogen. When handling ethidium bromide it is imperative that no skin contact occurs and thorough hand washing is performed after handling. In case of a small spill:

1. Absorb freestanding liquid with a compatible absorbent material.
2. Use ultraviolet light to locate the location of the spill material.
3. Prepare decontamination solution by mixing 4.2 grams of sodium nitrite and 20 mL of hypo phosphorous acid (50%) in 300 mL of water.

4. Wash the spill area with a paper towel soaked in the decontamination solution. Wash the spill area five more times with paper towels that have been soaked in the decontamination solution (using fresh paper towels each time).
5. After cleaning the area put all the used towels in the decontamination solution for 1 hour.
6. Check the completeness of decontamination using an ultraviolet light.
7. When the decontamination procedure is complete, transfer all the decontamination solution to an appropriately labeled waste container.
8. To request a chemical waste pickup, call OH&S at 686-5536 or complete the waste pickup form on the OH&S home webpage http://www.uams.edu/safety/ChemicalPickup.aspx.

To clean **contaminated equipment**: Laboratory equipment (e.g. transilluminators, laboratory floors and countertops, etc.) contaminated with aqueous solutions of more than 10 mg/L (0.01 %) ethidium bromide should be decontaminated using the spill clean-up procedures listed above.

10. Spill Procedures by Biological Safety Level 1 and 2

Inhalation of a Biological Material

When a biological material has been spilled take care to minimize aerosolization of the material.

a. Take the following steps if the spill has resulted in aerosolization:
b. Immediately notify all other persons in the laboratory, hold your breath, and evacuate.
c. Remove all personal protective equipment by turning it inwards to decrease the spread of contamination.
d. Wash hands and any other potentially exposed area with soap and water for a minimum of 15 minutes.
e. Post a spill sign and do not reenter the lab for at least 30 minutes.
f. Notify the laboratory supervisor,
g. Immediately seek medical assistance.

a. Biosafety Level 1 (BSL1) Spill

Biosafety Level 1 is the classification that applies to agents that are not known to cause disease in healthy adults.

1. Notify other laboratory occupants.
2. Remove contaminated clothing. If necessary use the safety shower or emergency eyewash. Wash affected area with a disinfectant.
3. When responding to the spill, wear at least the required laboratory personal protective equipment.
4. Cover the spill with paper towels. Pour disinfectant around the outside of the spill area and then add disinfectant over the spill area until the spill area has been completely covered. Allow the disinfectant at least 15 minutes to work. To clean splashed material spray with disinfectant solution and wipe clean or saturate a paper towel with disinfectant solution and wipe clean.
5. Pick up any pieces of broken glass with forceps and discard in a broken glass container.
6. All clean up materials must be placed in a biohazard bag, autoclaved and appropriately disposed.
7. Wash hands thoroughly with soap and a hand washing disinfectant.

b. Biosafety Level 2 (BSL2) Spill

Biosafety Level 2 is the classification that applies to agents that are associated with human disease, which is rarely serious, and for which preventative or therapeutic intervention are often available.

1. Immediately notify all other persons in the laboratory, hold your breath, and evacuate.
2. Remove all personal protective equipment and turn inwards to decrease the spread of contamination.
3. Wash hands and any other potentially exposed area with soap and water for a minimum of 15 minutes.
4. Post a spill sign and do not reenter the lab for at least 30 minutes.
5. Notify the laboratory supervisor and contact OH&S.
6. Immediately seek medical assistance if exposure has occurred.
7. After allowing the aerosols to settle for 30 minutes, put on protective clothing. Long-sleeved garments should be used to minimize the contamination of skin or street clothes. In circumstances where it is anticipated that splashes may occur, the garment must be resistant to liquid penetration to protect clothing from contamination. If the garment is not disposable, it must be capable of withstanding sterilization, in the event it becomes contaminated. At a minimum, a laboratory coat should be worn in all laboratories working at a BL-2. Additional criteria for selecting clothing are: comfort, appearance, closure types and location, antistatic properties and durability. Protective clothing must be removed and left in the laboratory before leaving for non-laboratory areas. Disposable clothing should be available for visitors, maintenance and service workers in the event it is required. Only trained individuals may utilize respirators. For certain protocols and projects (consult SDS), additional PPE like respiratory protection may be required. Respirator selection is based on the hazard and the protection factor required. Personnel who require respiratory protection should contact OH&S for assistance in selection of proper equipment and training in its usage. Contact OH&S if cleanup requires the use of a respirator.
8. Cover the spill with paper towels. Pour disinfectant around the outside of the spill area and then add disinfectant over the spill area until the spill area has been completely covered. Allow the disinfectant at least 20 minutes to work. To clean splashed material spray with disinfectant solution and wipe clean or saturate a paper towel with disinfectant solution and wipe clean.
9. Pick up any pieces of broken glass with forceps and discard in a broken glass container.
10. Spray the area with a 10% bleach solution and allow to air dry. Alternatively, spray the area with the bleach solution, allow 10 minutes for disinfection, and then wipe the area down.
11. All clean up materials and contaminated protective clothing must be placed in a biohazard bag, autoclaved and appropriately disposed.
12. Wash hands and potentially contaminated skin areas with a hand washing disinfectant or antiseptic soap and water.

B. <u>Fires</u>

Laboratory workers must know building evacuation routes in case of fire. It is the laboratory supervisor's responsibility to provide this information. In the event of a fire, immediate evacuation is essential. On the way out of the building remember these safety precautions:

- Never enter a room containing a fire.

- Never enter a room that is smoke filled.
- Never enter a room in which the top half of the door is hot to the touch.
- Never use the elevator.

1. **Small Fires**
   a. Pull the fire alarm and call the Campus Operations Call Center at 686-5333 to report the fire.
   b. Alert people in the area to evacuate. Assist those individuals with disabilities.
   c. Turn off gas main.
   d. If you have been trained to use a fire extinguisher, do so while maintaining a clear exit path behind you.

Operate the extinguisher using the P-A-S-S method:

P – Pull the pin located on the extinguishers handle.
A – Aim the nozzle at the base of the fire.
S – Squeeze or press the handles together.
S – Sweep from side to side at the base of the fire until it is out.

2. **Large Fires**
   a. Pull the fire alarm, when in a safe area, call Campus Operations Call Center at 686-5333.
   b. Alert people in the area to evacuate. Assist those individuals with disabilities.
   c. Turn off gas mains, only if time permits.
   d. Close the doors to confine the fire.
   e. Move to a designated assembly area away from and upwind from the building.
   f. Persons having knowledge about the incident and location must provide this information to emergency response personnel.

C. Weather Alerts

1. When a severe weather siren is identified or a Code Gray is announced, immediately request all persons in the laboratory to turn off any gases, hotplates, and pressure reactive experiments.
2. Immediately leave the area in an orderly manner. Use the innermost stairway and take cover in the lowest most internal compartment of the building.

D. First Aid/Responding to Injuries

The first line of defense for any person working or performing research in a laboratory is knowledge. Always be aware of what you and others in the surrounding area are working with and the associated hazards. This information is available on the product safety data sheet (SDS). SDS must be available for review by faculty, staff, researchers and students prior to utilizing any new chemical product or procedure involving the chemical product.

Emergency responders also must have chemical information readily available. A safe laboratory will have a posted inventory at each main laboratory entrance. To ensure emergency response preparedness the laboratory supervisor **must submit** the chemical inventory to OH&S on an annual basis.

i. Following an injury, the person involved in the incident or the person in charge of the laboratory must complete an injury incident report form at the time of occurrence. The injury incident report form serves as a guideline for appropriate information communication to the injured person and as a notification to the Occupational Health & Safety Department. The information will be used to better prepare the University faculty and staff in the prevention and response to accidents and injuries. Injury incident report forms are available on line http://www.uams.edu/safety/Accident.aspx. Before seeking medical treatment for non-emergency injuries the employee or the supervisor **MUST** call the Company Nurse Injury Hotline 1-855-339-1893. Regardless of the severity of incident, injury or exposure the Injury incident form must be completed.

ii. DO NOT CALL THE COMPANY NURSE IF NO MEDICAL TREATMENT IS NEEDED.

1. First Aid Kits

It is highly advised for each academic unit to provide and maintain first aid kits in a centralized location. Typical first aid kits will contain a variety of prepackaged items. Upon each use immediately replenish the first aid kit items.

2. Needle sticks and Puncture Wounds

a. **IMMEDIATELY wash effected area with antiseptic/antibiotic soap and water for 15 minutes.**
b. Notify the laboratory supervisor.
c. **Seek medical assistance immediately**, go to Employee Health/Student Preventative Services, 686-6565 (M-F 8:00-4:00). If injury occurs at night or on weekends, please go to the Emergency Room.

3. Chemical Injury or Exposure Response

When an injury has occurred general response guidelines are as follows:

a. Protect yourself from exposure and stabilize the injured person. When possible wash your hands prior to and after giving first aid. Use gloves whenever possible.
b. Offer the injured person medical attention. Contact 911 immediately if he or she desires medical attention by an emergency room physician. After contacting 911, call the UAMS Police at 686-7777 and notify them that 911 has been called.
c. Call Campus Operations Call Center at 526-0000 when not sure how to respond.
d. Utilize the safety shower available in the laboratory when appropriate. Clothing must be removed to prevent prolonged chemical contact with the skin. Rinse the exposed area for at least 15 minutes.
e. Use the emergency eyewash stations to rinse harmful chemicals from the eyes when appropriate. Eyes must be rinsed for a minimum of 15 minutes.
f. Contact Campus Operations Call Center at 526-0000 to report all injuries and complete an injury incident report form. An injury incident report should be completed within 24 hours of the incident.
g. Report all accidents involving injuries to OH&S within 24 hours of the incident.

4. Wounds

a. Small Cuts and Scratches

1. Clean the area with soap and water.

2. Apply a clean dressing over the wounded area.

b. Significant Bleeding

1. Immediately call 911. Then call UAMS Police at 686-7777 and notify them that 911 has been called.
2. Reassure the injured person.
3. Lay the injured person down.
4. **Do not** remove any objects that may have impaled the person.
5. Place direct pressure on the wound with a clean cloth or sterile bandage. Do not apply a tourniquet.
6. If the pressure does not slow the bleeding, elevate the wound above the level of the heart.
7. If the bleeding is severe, elevate the person's legs approximately 12 inches.

c. Thermal Burns

First degree burns are characterized by pain, redness and swelling.

1. Run cool water over the burn or soak it for a minimum of 10 to 15 minutes.
2. Cover the burn with a sterile bandage or clean cloth.
3. Do not apply any ointments, salves, or sprays.

Second and third degree burns are characterized by red mottled skin and blisters. White or charred skin is indicative of a third degree burn.

1. Immediately Call 911. Then call UAMS Police at 686-7777 and tell them that 911 has been called.
2. Do not remove any burnt clothing.
3. Cover the burns with dry sterile or clean bandages.
4. Do not apply ointments, salves, or sprays.

d. Chemical Burns

When necessary, use the eyewash or safety shower as instructed in the procedures below. Ensure your own safety by wearing the appropriate personal protective equipment.

Chemical Burns to the Skin

1. Remove the victim's clothes, including his/her shoes.
2. Rinse the area for a minimum of 15 minutes.
3. Do not apply burn ointments to injured areas.
4. Call 911, when the burn is large.
5. If 911 is called, contact UAMS Police at 686-7777 and let them know.

Chemical Burns to the Eyes

1. Forcibly open the eyelids to ensure the entire chemical is removed.
2. Wash from the nose to the ear to ensure the chemical does not wash back into the eye.
3. The wash must continue for a minimum of 15 minutes.
4. Cover the injured person's eyes with clean, preferably sterile gauze.
5. Call 911 then contact UAMS Police at 686-7777 and let them know.

e. **Responding to Hydrofluoric Acid Burns**
   If you or personnel in your laboratory will be using hydrofluoric acid please consult with either the Chemical Hygiene Officer or Environmental Programs Manager for special instructions.

5. **Ingestion of Chemicals**
   a. Immediately call 911 then contact UAMS Police at 686-7777 and let them know.
   b. Refer to the SDS to effectively treat the injured person.
   c. If the injured person(s) is unconscious, turn his/her head or entire body onto the left side. Be cautious about performing CPR. This could potentially poison you from the mouth-to-mouth contact. If available, use a mouth-to-mouth resuscitator.

6. **Inhalation of Chemicals**
   a. Evacuate the area and move the victim to fresh air.
   b. Immediately call 911 then contact UAMS Police at 686-7777 and let them know.
   c. When the victim is not breathing, perform CPR. Be cautious as the mouth-to-mouth contact can result in the responder becoming poisoned. Where available use a mouth-to-mouth resuscitator.
   d. When the victim is breathing, loosen his/her clothing and maintain the airway.
   e. Place one hand under the injured person’s neck and gently lift.
   f. Rotate the injured person’s head back to obtain maximum extension of the neck by pressing down on his/her forehead with your free hand.
   g. If additional airway extension is necessary, pull the injured person’s lower jaw into a jutting-out position.
   h. Treat the person for chemical burns of the eyes and skin if applicable.

V. OH&S Safety Audits

The Laboratory Safety Coordinator conducts annual safety audits of laboratories containing chemical materials and lasers to offer guidance and information in maintaining safer laboratory facilities and regulatory compliance. The Laboratory Safety Coordinator will review the lab’s Statement of Procedures (SOP) for compliance. The Laboratory Safety Coordinator will identify safety issues that may affect personal safety, indoor air quality, building safety, and environmental degradation.

How are audit results reported:

The Primary Investigator (PI) of a laboratory that meets and/or exceeds laboratory safety standards, receives an audit report that the area was inspected and all guidelines have been met or exceeded.

When deficiencies are noted, an audit report is sent to the PI outlining the deficiencies/hazards found in the laboratory and requests that the PI correct the deficiency/hazard. A written response is requested outlining the corrective actions. A follow-up audit is scheduled for 30 days after the first audit.

On the follow-up (first) audit, if deficiencies remain a second audit report is sent to the PI and the PI’s department chairman outlining the deficiencies and requesting a response for plans of correction. A second follow-up audit is scheduled for 30 days after the first follow-up.

On the second follow-up audit, any remaining safety hazards will result in a third notice of deficiency that is sent to the PI, the Department Chairman and the Vice Chancellor for Research.

Failure to correct deficiencies/hazards may result in closure of the laboratory.

VI. Housekeeping

Working laboratories often become cluttered with empty and partially full containers, glassware, and other apparatus. Floors and countertops can also become contaminated due to unattended spills. It is important for the safety of those persons utilizing and maintaining UAMS facilities that the laboratory is not contaminated or presents a fire hazard. Maintaining a good state of order in laboratory facilities will significantly decrease risk.

A. Elements of Good Housekeeping

1. Glassware Cleansing

It is highly recommended that detergents be used to clean glassware rather than chromate and sulfuric acid. Hexavalent chromium is a carcinogen and chromic acid mixtures are expensive to dispose of as hazardous waste.

2. Work Surfaces and Floors

Dry sweeping laboratories must be avoided. Floors can be cleaned with a vacuum equipped with a high efficiency particulate air (HEPA) filter or by wet mopping. Protect work surfaces with disposable bench paper. Change the bench paper regularly and dispose of immediately after a spill. It is a good practice to decontaminate glassware prior to washing. Fume hood surfaces may be wiped down with dilute detergent and water solution, after all spills have been appropriately cleaned.

3. Chemical Storage

The failure to store chemicals according to their properties poses a risk to personnel, to property, and possibly to intellectual value of accumulated research data files. For these reasons, hazardous chemicals must be stored according to compatibility and in chemical safety cabinets or in the ventilated base cabinet of the fume hood. Fisher and Mallinckrodt chemicals are color coded for ease of segregation. Non-hazardous chemicals may be kept on lab benches.

The following general suggestions for safe storage of chemicals in the laboratory should be implemented.

- The quantities of chemicals that are stored within a laboratory should be minimized, as specified by IBC or AFPC Sections 300 & 400, NFPA 45 and OSHA. Many authorities recommend that the NFPA guidelines for maximum quantities and sizes of containers should be reduced to one-half or even one-third of the recommended values. (NFPA guidelines are provided in the fire prevention section.)
- Bulk quantities of chemicals (i.e., larger than one-gallon) must be stored in a separate storage area. Transfer of flammable liquid from 5 gallon or larger metal containers may not be done in the laboratory.

- Chemicals must be stored at an appropriate temperature and humidity level. This can be especially problematic in hot, humid climates. As a rule, chemicals should not be stored near heat sources, such as steam pipes or laboratory ovens. Chemicals should never be stored in direct sunlight.
- Chemicals should be dated when received and when opened. If the chemical is one that degrades in quality or becomes unsafe after prolonged storage, the shelf-life expiration date should also be included.
- Storing peroxide-formers: See Appendix C.

Chemicals should not be routinely stored on the bench top. In such locations they are unprotected from exposure and in a fire situation are more readily knocked over. Each chemical should have a specific storage area and be returned there after use. Large quantities of flammable materials should not be stored in the laboratory. Only the amounts needed should be kept on bench top, the remainder should be kept in flammable storage cabinets.

Never allow containers to hang off the edge of a shelf. Liquid or corrosive chemicals should never be stored on shelves above eye-level. Glass containers should not touch each other on the shelves. Secondary containers or trays should be used for chemical storage whenever possible to minimize the flow of material should a spill or rupture occurs. Round bottom flasks should always be supported properly in cork rings or by other means to keep them from tipping.

Adequate security must be provided so that unauthorized personnel do not have access to hazardous materials.

Chemicals must never be stored on the floor, not even temporarily.

Chemicals that are no longer to be used for research purposes should be properly disposed of or given to another research group that has a use for it.

Flammable materials must never be stored in domestic-type refrigerators. Only explosion-proof or flammable material refrigerators should be used for storage of these chemicals within a laboratory environment.

All containers stored within the refrigerator should be tightly capped to keep vapors from interacting with each other and to alleviate "odor" problems. Flasks with cork, rubber or glass stoppers should be avoided because of the potential for leaking. All containers stored in the refrigerator must be properly labeled.

Inventory the materials in your refrigerators and freezers frequently to avoid overcrowding with materials that have long since been forgotten. Also make it a point to defrost refrigerators and/or freezers occasionally so that chemicals do not become trapped in unique ice formations!

Before flammable materials are stored in a refrigerator, it should be determined if keeping the material chilled will serve any purpose. No benefit is derived from refrigerating a chemical that has a flash point below the temperature of the refrigerator. Never store peroxide formers (i.e., ether) in a refrigerator!

Fume hoods should not be used as general storage area for chemicals. This may seriously impair the ventilating capacity of the hood.

Gas cylinders must be securely strapped to a permanent structure (wall, lab bench, etc.). When they are not in use they should be capped off. When they are empty they must be labeled as such.

Upon termination, graduation or transfer of any laboratory personnel, all hazardous materials must be properly disposed of through OH&S.

Segregation based on hazard classes in addition to general safe storage practices is a must. At a minimum, laboratories should separate chemicals according to similar hazards, such as flammability, corrosiveness, sensitivity to water or air, and toxicity. Segregation of the following major categories of chemicals, each of which will be discussed in greater detail, is strongly recommended:

- Flammables
- Oxidizers
- Corrosives
- Highly Reactives
- Extremely Toxic (Acutely Hazardous)
- Other Regulated Materials
- Low Hazard

Below, you will find a few potential problems that arise with the general segregation of chemicals.

1. **The actual identification of the hazards themselves**. Recent legislation has made this task somewhat easier since all chemical manufacturers are now required to list all hazards on outgoing chemical containers and each chemical must be accompanied by a Safety Data Sheet (SDS). The chemical label thus furnishes a quick method of determining whether the material is a fire hazard, health hazard, or reactivity hazard. The SDS furnishes more detailed information regarding toxicity exposure levels, flashpoints, required safety equipment and recommended procedures for spill containment.

2. **Multiple hazards for chemicals**. Most chemicals have multiple hazards and a decision must be made as to which storage area would be most appropriate for each specific chemical. Determine the priority of each hazard and which provides the highest risk.

    a. When establishing a storage scheme, the number one consideration should be the flammability characteristics of the material. If the material is flammable, it should be stored in a flammable cabinet.

    a. If the material will contribute significantly to a fire (i.e., oxidizers), it should be isolated from the flammables. If a fire occurs in the lab and response to the fire with water would exaggerate the situation, isolate the water reactive material away from contact with water.

    b. Next look at the corrosiveness of the material, and store accordingly.

    d. Finally, consider the toxicity of the material, with particular attention paid to regulated materials. In some cases, this may mean that certain chemicals will be isolated within a storage area, for instance, a material that is an extreme poison but is also flammable, should be locked away in the flammable storage area to protect it against accidental release. There will always be some chemicals that will not fit neatly in one category or another, but with careful consideration of the hazards involved, most of these cases can be handled in a reasonable fashion. For the safety of all personnel and to protect the integrity of the facilities, hazardous materials must be segregated.

1. EPA Compatibility Table

To use the table, choose the group that the chemical belongs. Group A and B on the same row are not compatible with each other. The third column provides information on the hazard of mixing Groups A and B of the same row.

Group 1-A	**Group 1-B**	**Potential Consequences**
Acetylene sludge Alkaline caustic liquids Alkaline cleaner Alkaline corrosive liquids Alkaline corrosive battery fluid Caustic wastewater Lime sludge & other corrosive alkalis Lime wastewater Lime and water Caustic	Acid sludge Acid and water Battery acid Chemical cleaners Electrolyte, acid Etching acid liquid or solvent Pickling liquor and other corrosive acids Acid, including mixtures of acids and sulfuric acid	Heat generation; violent reaction
Group 2-A	**Group 2-B**	**Potential Consequences**
Aluminum *Beryllium* *Calcium* Lithium Magnesium Potassium Sodium Zinc powder Other reactive metals and metal hydrides	Any Group 1-A or 1-B	Fire explosion; generation of flammable hydrogen gas
Group 3-A	**Group 3-B**	**Potential Consequences**
Alcohols Water	Any concentrated item from Groups 1-A or 1-B Calcium Lithium Metal hydrides Potassium SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3 Other water-reactives	Fire, explosion, or heat generation; generation of flammable or toxic gases
Group 4-A	**Group 4-B**	**Potential Consequences**
Alcohols, Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other reactive organic compounds and solvents	Concentrated Group 1-A or 1-B Group 2-A	Fire, explosion, or violent reaction
Group 5-A	**Group 5-B**	**Potential Consequences**
Cyanide and sulfide solutions	Group 1-B	Generation of toxic hydrogen cyanide or sulfide gas
Group 6-A	**Group 6-B**	**Potential Consequences**
Chlorates, Chlorine, Chlorites Chromic acid Hypochlorites Nitrates, Nitric acid, fuming Perchlorates Permanganates Peroxides Other strong oxidizers	Acetic acid and other organic acids Concentrated mineral acids Group 2-A Group 4-A Other flammable and combustible waste	Fire, explosion, or violent reaction

B. Laboratory Closeout

Occasionally laboratories cease operations. This may be due to a change of directors, supervisors, or researchers, or due to a change in research opportunities. When this happens, it is mandatory to contact OH&S for laboratory clearance two weeks prior to out-processing. The same procedures should be utilized when transferring laboratories on campus. Failure to appropriately clear a laboratory may result in the collection of fees for services provided by OH&S.

During closeout of a laboratory, it is important to be thorough and inspect all areas and equipment including: autoclaves, refrigerators, incubators, centrifuges, ovens, cabinets, freezers, cold rooms, stock rooms, fume hoods, etc. Mishandling of regulated materials may result in the assessment of fines and/or the loss of the right to use these materials. It is therefore of utmost importance that close-out procedures be implemented and strictly adhered to within each department.

Specific closeout requirements are detailed in Appendix D.

VII. Fire Prevention

Preventing fires in the lab can be largely achieved by close adherence to the National Fire Protection Association (NFPA) guidelines for storage of flammable materials, attention to chemical incompatibilities, care in the use of flammable materials and chemical reactions, appropriate maintenance of equipment, and good housekeeping. All fires require a fuel source, an ignition source, and oxygen to burn. Minimizing any one of these will decrease the risk of fire.

A. Common Laboratory Ignition and Fuel Sources

Ignition sources must be located away from flammable and combustible materials. Always use heating apparatus, Bunsen burners, and flammable and combustible chemicals in the fume hood. There are many potential ignition and fuel sources in laboratories. The most common are:

- Bunsen burners
- Hot plates and heating mantles
- Peroxides and peroxide formers
- Damaged electrical cords and extension cords
- Class III and IV lasers
- Flammable and combustible chemicals

B. Fire Safety Equipment

Fire extinguishers must be available in all chemical laboratories. Fire extinguishers must be checked monthly to ensure they are adequately charged. Contact the Engineering and Operations (526-0000) for any information concerning fire extinguishers, or to request a repair or recharge.

C. Fire Risk Minimization

Minimize the risk of fire in laboratories by utilizing the following practices:

- Purchase small amounts of flammables.
- Store flammable materials in flammable chemical storage cabinets and segregate from incompatible materials.
- Adhere to the guidelines for storage of flammable materials as found in NFPA 45 and 30.
- These guidelines are provided below:
  - Ethers must be inhibited.
  - Use ethers before they expire.
  - Contact OH&S immediately upon discovery of expired ethers.

- Electrical and extension cords must be double insulated or grounded. Extension cords must not be used as permanent wiring and must be suitable for the environment in which they are used.

1. NFPA 45 – (Standard on Fire Protection for Laboratories Using Chemicals)

Terms

Laboratory Unit Fire Hazard Classification:
Class A: High fire hazard
Class B: Moderate fire hazard
Class C: Low fire hazard
Class D: Minimal fire hazard

Flammable Liquid: Any liquid that has a closed-cup flash point below 100°F. Flammable liquids are classified as Class I liquids as follows:
Class I Liquid – any liquid that has a closed cup flash point below 100°F and a Reid vapor pressure not exceeding 40 psi at 100°F.
Class IA Liquids – those liquids that have flash points below 73°F and boiling points below 100°F.
Class IB Liquids – those liquids that have flash points below 73°F and boiling points at or above 100°F.
Class IC Liquids – those liquids that have a flash point at or above 73°F but below 100°F.

Combustible Liquid: Any liquid that has a closed-cup flash point at or above 100°F. Combustible liquids are further classified as follows:
Class II Liquids – any liquid that has a flash point at or above 100°F and below 140°F.
Class IIIA Liquids – any liquid that has a flash point at or above 140°F but below 200°F.
Class IIIB Liquids – any liquid that has a flash point at or above 200°F.

Maximum Allowable Quantities of Flammable and Combustible Liquids and Liquefied Flammable Gases in *Sprinkled* Laboratory Units Outside of Approved Storage Cabinets (Table 1)

Lab Unit Fire Haz Class	Flammable Combustible Liq. Class		Excluding Quantities in Storage Cabinets or Safety Cans: Max. Quant. per 100 ft^2 of Lab L	gal	Max Quant per Lab L	gal	Including Quantities in Storage Cabinets or Safety Cans: Max. Quant. per 100 ft^2 of Lab L	gal	Max. Quant per Lab L	gal
A	I	38	10	2270	600	76	20	4540	1200	
	I, II, IIIA		76	20	3028	800	150	40	6060	1600
B	I	20	5	1136	300	38	10	2270	600	
	I, II, IIIA		38	10	1515	400	76	20	3028	800
C	I	7.5	2	570	150	15	4	1136	300	
	I,II, IIIA		15	4	757	200	30	8	1515	400
D	I	4	1.1	284	75	7.5	2	570	150	
	I, II, IIIA		4	1.1	284	75	7.5	2	570	150

This category includes Class I flammable liquids and liquefied flammable gases·

Maximum Allowable Quantities of Flammable and Combustible Liquids and Liquefied Flammable Gases in *Non-Sprinkled* Laboratory Units Outside of Approved Storage Cabinets (Table 2)

Lab Unit Fire Haz Class	Flammable Combustible Liq. Class	Excluding Quantities in Storage Cabinets['] or Safety Cans: Max. Quant. per 100 ft^2 of Lab L	gal	Max Quant per Lab L	gal	Including Quantities in Storage Cabinets['] or Safety Cans: Max Quant. per 100 ft^2 of Lab L	gal	Max. Quant per Lab L	gal
A	I[#]	*Not Permitted*		*Not Permitted*		*Not Permitted*		*Not Permitted*	
	I[#], II, IIIA	***Not Permitted***		***Not Permitted***		***Not Permitted***		***Not Permitted***	
B	I[#]	***Not Permitted***		***Not Permitted***		***Not Permitted***		***Not Permitted***	
	I[#], II, IIIA	***Not Permitted***		***Not Permitted***		***Not Permitted***		***Not Permitted***	
C	I[#]	7.5	2	284	75	15	4	570	150
	I[#], II, IIIA	15	4	380	100	30	8	760	200
D	I[#]	4	1.1	140	37	7.5	2	284	75
	I[#], II, IIIA	4	1.1	140	37	7.5	2	284	75

['] This category includes Class I flammable liquids and liquefied flammable gases.

[#] This category includes Class I flammable liquids and liquefied flammable gases.

VIII. Chemical Inventories and Labeling

A. Inventories

A dated inventory of incoming chemicals and their quantities must be kept in each laboratory. Upon complete use of the material or transfer to another lab, the material must be removed from the list. Many researchers prefer to keep a copy of the inventory on the laboratory door. This is an excellent method of alerting emergency responders of the chemicals stored and in use in the laboratory. OH&S will request a copy of the chemical inventory annually. OH&S's copy is used in creating a master list of hazardous chemicals required for maintaining compliance with the Emergency Planning and Community Right to Know Act (EPCRA).

B. Labeling

All chemical containers (including laboratory solutions and mixtures) used in the laboratory must have labels indicating what they are. Labels must indicate the components, their quantities, and a date. Containers without appropriate labeling will be treated as an unknown chemical. Unknown chemicals and wastes present safety, environmental, regulatory, and monetary concerns. Therefore, it is of utmost importance that all chemical containers are appropriately labeled. Chemical waste labeling is discussed later in this manual.

IX. Identification of Chemical Hazards

A. Right-To-Know & Safety Data Sheets

OSHA mandates that users of hazardous chemicals be informed of the hazards of the material they are working with prior to use of the material. This is commonly called Right- To-Know. To accomplish this, safety data sheets (SDS) must be provided to the user. It is the responsibility of the person requesting the purchase of the chemical to ensure that the SDS have been placed in an area in which the users have access. Copies of SDS should be forwarded to OH&S. UAMS must retain on file copies of SDS for a minimum of 25 years.

Chemical manufacturers supply SDS to purchasing parties. Unless it is written on the purchase order, the SDS is sent to the accounts payable office. The accounts payable office forwards the SDS to OH&S. OH&S will make every effort to relinquish the SDS to the appropriate user. If you have not received an SDS prior to initial use of a chemical, contact OH&S at 686-5536.

SDS provide a variety of information to the chemical user. The American National Standards Institute (ANSI) recommends that SDS have 16 sections. A description of each of these sections is outlined below.

Section 1 – Chemical Product and Company Identification
Identifies the product and its synonyms. Gives the chemical and SDS supplier's name. Often will give the chemical abstracts service identifying number. The manufacturer's name is required to be listed on the SDS by OSHA.

Section 2 – Hazards Identification and Emergency Procedures Overview Provides an overview of emergency procedures. Lists information on the potential adverse human health effects and symptoms that may result from exposure to the material.

Section 3 - Composition or Ingredients

Lists hazardous components as specified by the Occupational Safety and Health Act (OSHA) in their relative concentrations. Often significant non-hazardous components are listed. May also include other information related to the chemicals such as personal exposure limits and time weighted averages.

Section 4 - First Aid Measures

Provides instructions to be taken if accidental exposure requires immediate treatment. May also include instructions to medical professionals. Always provide an SDS to the emergency medical care provider.

Section 5 - Fire fighting measures

Provides basic fire fighting guidance, including appropriate extinguishing media. Describes other fire and explosive properties useful for avoiding and fighting fires involving the material, such as flash point or explosive limits.

Section 6 - Accidental release measures

Describes actions to be taken to minimize the adverse effects of an accidental spill, leak or release of the material.

Section 7 - Handling and storage

Provides information on appropriate practices for safe handling and storage.

Section 8 - Exposure controls/personal protection

Provides information on practices, or equipment, or both, that are useful in minimizing worker exposure. May also include exposure guidelines. Provides guidance on personal protective equipment.

[Comment: Good example: "When spraying this paint outside in open areas, wear a dust mask. Indoors in well ventilated areas, wear a respirator with organic vapor cartridge. In poorly ventilated areas you must wear a supplied air respirator."]

Section 9 - Physical and chemical properties

Provides additional data that can be used to help characterize the material and design safe work practices.

Section 10 - Stability and reactivity

Describes the conditions to be avoided or other materials that may cause a reaction that would change the intrinsic stability of the material.

Section 11 - Toxicological information

May be used to provide background toxicological information on the material, its compounds, or both.

Section 12 - Ecological information

May be used to provide information on the effects the material may have on plants or animals and on the material's environmental fate.

Section 13 - Disposal considerations

May provide information that is useful in determining appropriate disposal measures.

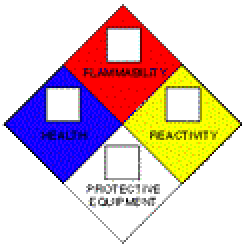
Section 14 - Shipping information
May provide basic shipping classification information.

Section 15 - Regulatory information
May be used to prove any additional information on regulations affecting the material.

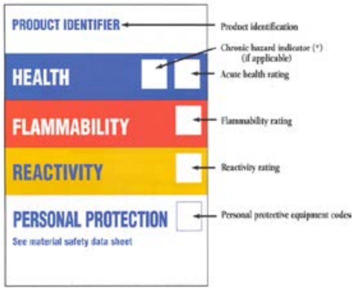
Section 16 - Other information
May be used to provide any additional information.

B. Product Labels

The product label is likely to have information that provides useful information concerning the hazardous properties of the product. Manufacturers may place the primary hazard code on the container in the form of a pictograph, e.g. a skull and crossbones denoting poisons, a flame for flammable, etc. While other manufacturers will include a fire diamond or bar graph on hazardous materials containers. The fire diamond and bar type hazard indicators on hazardous material labels provide the same information in different formats. They each have four squares, in the case of the fire diamond it is a square on point. Each square is indicative of flammability, health effects, reactivity, and special hazard conditions.



Fire Diamond



Bar Type Hazard Indicator

Each square will have a number from zero to four. The following information explains these numbers.

The health indicator is on the far left and is normally blue in color. It indicates the short-term degree of hazard.
0 = represents ordinary combustible hazards in a fire
1 = slightly hazardous
2 = hazardous
3 = extreme danger
4 = deadly

The flammability rating is on the top, is red, and indicates the propensity of the material to burn.
0 = will not burn
1 = will ignite if preheated
2 = will ignite if moderately heated
3 = will ignite at normal room temperature; will burn quickly
4 = will burn easily and rapidly at room temperature/pressure; or will ignite spontaneously when exposed to air

The far right position indicates the reactive nature (instability) of the material and the energy released if the material is burned, decomposed or mixed. It is denoted with a yellow color.
0 = stable and not reactive with water
1 = unstable if heated; changes or decomposes on exposure to air, light or moisture
2 = violent chemical change; reacts violently with water or forms potentially explosive mixtures with water
3 = shock and heat may detonate; reacts explosively with water without heating or confinement
4 = may detonate

The bottom position is white and contains special hazard symbols.
OX = oxidizer = may not burn itself but, may ignite and intensify burning of combustible materials.
A W with a line drawn horizontally through the center = Use no water. The material reacts with water; may become explosive, may produce a flammable or poisonous material, may produce excessive heat.

X. Chemical and Hazardous Waste Identification and Disposal

For a complete guide to handling hazardous waste refer to The UAMS Hazardous Waste Management Plan in Appendix E.

A. Chemical Waste Minimization

The U.S. Congress has made waste minimization a national policy and it must be incorporated as a goal of each chemical waste generator. As a generator of chemical waste you have the responsibility to minimize the waste you generate. Waste minimization has benefits such as decreasing your exposure to hazardous substances, protection of the environment, and decreasing the cost of purchase and disposal. Waste minimization should be considered at all times. Waste minimization begins in the research and education planning stages. The following are suggestions for minimizing waste.

Purchase only the quantity of chemical that you need. Hazardous waste often is a result of outdated and or unused chemicals. Hazardous waste costs much more to dispose of than the cost of purchasing smaller quantities of chemicals. Substitute less or non-hazardous materials for hazardous materials. Use dilute rather than concentrated solutions. Use micro or semi-micro techniques.

B. Chemical and Hazardous Waste Identification

UAMS laboratories fall under the federal regulations outlined in the Resource Conservation and Recovery Act (RCRA), and at the state level as outlined in the Arkansas Department of Environmental Quality (ADEQ) Regulation 23. Both specify the requirements for handling hazardous materials from “cradle to grave”. Complete guidelines for handling chemical waste can be acquired from the UAMS Hazardous Waste Management Plan (Appendix E) via OH&S or its web site http://www.uams.edu/safety/ChemicalDisposal.aspx. The following UAMS guidelines will assist laboratory users in determining what a hazardous chemical waste is and how to appropriately label them. Appropriate labeling of hazardous chemical wastes will assist in accomplishing University goals of maintaining safety within laboratories, protecting the environment, and supporting regulatory compliance. A major obstacle in minimizing the quantity of unknown chemical waste is the performance of laboratory closeout procedures prior to faculty or staff relocating. Refer to laboratory close out procedures in the Housekeeping section for appropriate procedures when research is completed or when laboratories change responsible parties.

UAMS has a strict “NO DRAIN” policy that does not allow any chemical to be disposed of by the sanitary sewer or down the drain.

According to RCRA, the two types of regulated hazardous waste are “listed” and “characteristic”. An outline of listed chemical wastes can be found in the appendices of the UAMS Hazardous Waste Management Plan (HWMP). Hazardous chemicals that are not listed may fall under the definition of a RCRA characteristic hazardous waste. The four RCRA classifications of characteristic hazardous waste are defined in the HWMP and below. Chemical wastes that do not exhibit any of the four characteristics of hazardous waste and are not listed are not considered hazardous waste. This does not mean that the chemical does not have dangerous properties. Protective measures are outlined in most safety data sheets and should be taken when handling chemicals. Call the Environmental Programs Manager at 686-5536 for guidance when unsure of the hazard status or handling procedures for chemicals and wastes.

Characteristic Hazardous Waste

a. **Corrosive:** Aqueous and has a pH less than or equal to 2 (acidic) or greater than or equal to 12.5 (basic).

b. **Flammable:** Any material that has a flash point of 140 ˚F or less.

c. **Reactive:** Any waste having one or more of the following criteria is considered reactive.
   - Normally unstable and readily undergoes violent change without detonating, e.g., propargyl alcohol
   - Reacts violently with water, e.g., sodium metal
   - Forms potentially explosive mixtures with water, e.g., trichlorosilane
   - When mixed with water it generates toxic gases, fumes, or vapors in a quantity sufficient to present a danger to human health or the environment, e.g., phosphorous pentachloride
   - Sulfide or cyanide bearing waste that when exposed to pH conditions *between* 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment, e.g., calcium cyanide
   - Capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement, e.g., 1,4-dioxane
   - Readily capable of detonation or, explosive decomposition, or explosive reaction at standard temperature and pressure, e.g., diborane
   - DOT forbidden explosive, e.g. trinitrotoluene.

d. **Toxic**: Toxic chemicals are listed as “D wastes” in RCRA and a listing is also provided in the HWMP. Common toxic metals as listed by EPA are arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Common toxic organic compounds are pyridine, benzene, carbon tetrachloride, dichlorobenzene, and methyl ethyl ketone. These chemicals have regulatory limits on the quantities that are considered hazardous waste. The concentration should be noted on any solutions containing toxic chemicals.

C. Organic Solvents

Aqueous organic solvents must be segregated as chlorinated and non-chlorinated and waste accumulated in solvent safety cans. Chlorinated solvents are typically not flammable and are more expensive to treat. Non-chlorinated solvents are typically flammable and are less expensive to treat. Labels should be placed opposite of the pour spout. Ensure that all components are specified on the label, e.g., sulfuric acid, basic (NaOH), reactive (C, N, S), toxic chemicals (mercury, lead), etc.

D. Peroxide Forming Compounds

All peroxide forming chemicals turned into the OH&S for disposal must have dates corresponding to when the bottle was received and first opened. Additionally, the date and results of testing to determine the concentration of peroxides must be included on the label. Without this information peroxide forming chemicals are treated as highly reactive. Highly reactive chemicals significantly increase the cost of disposal for the University.

E. Deactivation and Disposal of Ethidium Bromide

General Information: Ethidium Bromide (EtBr) is used as a stain in the visualization of nucleic acids in agarose gels. It is not regulated as a listed hazardous waste although, the mutagenic properties may present a hazard when not managed properly in the laboratory.

Wear a lab coat, nitrile gloves, and chemical splash goggles when handling EtBr. When using an ultraviolet (UV) light source on your cultures stained with EtBr ensure that skin and eye protection are employed. Avoid exposing unprotected skin and eyes to intense UV sources. Wear a face shield if the UV source is pointing upwards. Also, when working with a UV source for a long time, wrap up lab coat sleeves with tape or other means where the wrist could be exposed.

Electrophoresis gels containing less than 0.1% EtBr do not pose a serious hazard and can be discarded in the trash if properly bagged and secured. (Please note that this only applies to electrophoresis gels and not EtBr solutions.) Place gels that contain *more than* 0.1% EtBr in an appropriate container and dispose of as hazardous waste.

Ethidium bromide is mutagenic and should be handled carefully. For disposal of EtBr call OH&S. You may request a pick-up from the OH&S by calling 686-5536 or you can request a chemical pick waste pick up form on the OH&S home webpage http://www.uams.edu/safety/ChemicalPickup.aspx. You should ensure that the container is appropriately labeled prior to requesting pickup.

F. Unknown Chemical Waste

Unknown chemical waste is any chemical that cannot be identified. Disposal of unknown wastes can be difficult and extremely expensive & dangerous. In the event an unknown chemical waste is found, call OH&S at 686-5536.

G. Characterizing Unknown Chemical Wastes

Unknown chemical wastes are those chemical wastes that cannot be identified. "Unknowns" present safety, disposal, and regulatory compliance issues that must be avoided whenever possible. Minimizing unknowns generated on campus can be accomplished by labeling all chemical containers upon receipt or production. Laboratory waste that cannot be identified is subject to a hazard characterization procedure prior to disposal. The characterization is used to determine how to handle and properly dispose of the waste. Unknowns should be turned in to OH&S for hazard characterization.

Please note that there is often danger involved with handling chemical unknowns. If the sample displays physical characteristics indicative of potentially reactive or peroxide forming chemicals (as listed below), or is suspected to be radioactive, contain biological materials, or pose any other unreasonable risk, **discontinue or stop** the characterization procedure and contact OH&S immediately. Specialized equipment and handling practices may be required.

Potentially reactive chemical characteristics:

- solid materials under liquids
- bi-layered or multi-layered
- bulging, pressurized, or leaking containers
- corroded, rusted, or deteriorating caps

Peroxide forming compound characteristics:

- cloudy liquid crystals forming in bottles and around lids of partially or completely evaporated liquids

Note: Potential peroxide containing compounds must be labeled as "Possible Peroxide".

Minimal precautionary measures to be taken while handling all unknowns must include:

- Do not work alone.
- Handle the sample under a functioning fume hood with the sash pulled to the lowest level possible.
- Wear chemical resistant gloves, lab coat or apron, goggles, and a face shield.
- Ensure that a safety shower and eye wash station is within reasonable distance.
- Ensure an ABC fire extinguisher is readily available.

Procedures for departmental characterization of unknown chemical wastes are outlined in Appendix E. Undergraduate students are not allowed to perform unknown hazardous waste analysis. It is recommended that all physical and chemical tests and observations be recorded in a permanent logbook for future reference. Characterized unknown waste must be appropriately labeled, regardless of its hazard status, and submitted to the OH&S for disposal.

H. Labeling Chemical Waste

Guidelines for labeling chemical waste are derived from EPA regulations. Each chemical waste label must contain the word waste, followed by an accurate description of the waste and a date. An accurate description includes each chemical component and its corresponding concentration. Ex: Waste 30% hydrogen peroxide, Waste 2M sulfuric acid, 500 mg/l lead oxide, 300 PPM barium oxalate, Waste

Flammable liquid (30% acetone, 50% acetonitrile, 20% methanol), etc. The date listed must correspond to the date the chemical was determined to be a waste.

I. Requesting a Chemical Waste Pick-up

To request a chemical waste pick up, contact OH&S by phone at 686-5536 or by completing a chemical pick waste pick up form on the OH&S home webpage http://www.uams.edu/safety/ChemicalPickup.aspx.

XI. Biological Waste Disposal

Some waste associated with biological materials must be disposed of in special ways because they may have been contaminated with infectious organisms or agents. These potential infectious or biohazardous materials are defined by Arkansas regulations as **Regulated Medical Waste**.

A. Definitions

- **Biohazardous agent** refers to an agent that is biological in nature, capable of self-replication, and has the capacity to produce deleterious effects upon biological organisms. Biohazardous agents include, but are not limited to; bacteria, fungi, viruses, rickettsiae, chlamydia, prion, parasites, recombinant products, allergens, cultured human and animal cells and the potentially biohazardous agents these cells may contain, infected clinical specimens, tissue from experimental animals, plant viruses, bacteria and fungi, toxins, and other biohazardous agents as defined by State and Federal regulations.

- **Biological waste** is any material that contains or has been contaminated by a biohazardous agent. Biological waste includes, but is not limited to; Petri dishes, surgical wraps, culture tubes, syringes, needles, blood vials, absorbent material, personal protective equipment and pipette tips.

- **Sharps** are items that are capable of puncturing, cutting or abrading the skin. Sharps include, but are not limited to; glass and plastic pipettes, broken glass, test tubes, razor blades, syringes, and needles.

B. Waste Types

- **Biological Versus Chemical Waste:**

  Biological waste must be managed separately from chemical waste. The most common example where chemical waste is mistaken for biological waste is agarose gel contaminated with ethidium bromide or heavy metals (i.e. arsenic, chromium). This type of material should always be managed as chemical waste. When both chemical and biological waste types exist, the biological agent(s) should be treated first. Once the biological agents have been deactivated by either autoclave or chemical disinfection, the remaining chemical waste should be managed through OH&S, http://www.uams.edu/safety/WasteDisposal.aspx or call 686-5536.

- **Sharps:**
  All sharps should be placed into properly labeled sharps containers or other rigid, puncture-proof containers. Make sure the container is sealed, labeled, and intact.

Contaminated sharps should be managed as follows:

  - Biological contaminated sharps should be treated and managed by contacting OH&S, http://www.uams.edu/safety/WasteDisposal.aspx or by calling 296-1294.
  - Chemical contaminated sharps should be submitted to OH&S, http://www.uams.edu/safety/WasteDisposal.aspx or by calling 686-5536.
  - Biological and chemical contaminated sharps should be treated first as a biological waste. Once the biological agents have been deactivated by either autoclave or chemical disinfection, the remaining chemical waste should be disposed by contacting OH&S, http://www.uams.edu/safety/WasteDisposal.aspx.

- **Liquid Waste:**

  Liquid biological waste should be collected in containers for autoclaving or chemical disinfection. Autoclaved or chemically disinfected liquid wastes can be disposed via the laboratory sink. Do not pour melted agarose down the drain. Allow it to cool and solidify, then dispose of it as solid waste in biohazard waste bags.

- **Solid Waste:**

  Solid biological waste, including solidified agarose gels, should be collected in appropriate biohazard waste autoclave bags. Once the waste has been autoclaved or chemically disinfected, the bags can be taped or tied shut and contact OH&S for waste pickup, http://www.uams.edu/safety/WasteDisposal.aspx. If autoclaved waste can be verified as disinfected via the use of autoclave tape, waste can be discarded as regular trash. Prior to disposal, the autoclaved waste container MUST BE defaced of the biohazard symbol or the waste container must be placed inside an outer unmarked container.

C. Guidelines for Disposal

For disposal of these wastes, the lab personnel should follow the following guidelines:

- Sterilize or disinfect waste materials associated with viral, bacterial or other agents infectious to humans (by autoclave or chemical treatment equivalent to 1:10 bleach solution).
- Place all biohazardous wastes, except for sharps, directly into the red bag-lined medical waste boxes or containers
- Place sharps into labeled sharps containers which when filled are disposed through OH&S by http://www.uams.edu/safety/WasteDisposal.aspx or by calling 296-1294.
- When the Medical Waste box is filled, seal the bag liner and notify OH&S for pick-up, http://www.uams.edu/safety/WasteDisposal.aspx.

XII. Non-Human Research Use of DEA Controlled Substances

The Controlled Substance Act (CSA) places all substances which were in some manner regulated under existing federal law into one of five schedules. The placement is based upon the substance's medical use, potential for abuse, and safety or dependence liability. UAMS requires that all individuals conducting non-human research activities with DEA controlled substances be registered with the DEA and Arkansas Department of Health Pharmacy Services and Drug Control (ADH) and comply with state and federal regulations regarding the acquisition, storage, use and disposal of those substances.The UAMS Non-Human Research Use Controlled Substances Policy (UAMS Administrative Guide 16.1.13) covers all UAMS research faculty operating on the UAMS campus. The Office of Research Compliance with the assistance of Occupational Health and Safety is responsible for implementation and oversight of this program.

A. Registration

Each principal investigator or faculty conducting non-human research with DEA controlled substances will be responsible for registering with the DEA and ADH and for assuring compliance with applicable state and federal regulations. Office of Research Compliance will assist individuals in complying with applicable rules and regulations by educating researchers about the requirements, assisting as necessary during implementation, and providing regular oversight to ensure compliance is being maintained.

B. Employee Screening Procedure

In accordance with regulations, "Agents of the registrant" (Laboratory staff) may engage in approved activities under the direction of the registrant (Principal Investigator – PI). The PI is required to screen employees prior to allowing them to access or work with controlled substances.

C. Responsibilities

1. Inventory

Initial (at time of receipt) and biennial (two year) inventories are required for controlled substances. <u>Initial inventories must be performed each time a new controlled substance is added to the inventory.</u>

To ensure accountability, a complete and accurate continuing record log (e.g., real-time inventory) is required for each substance and must be maintained on a current basis. It is the investigators' or his/her designee's responsibility to audit the controlled substances on a day of use basis.

Inventories (biennial and real-time/continuing records) and other records including copy of certificate of registration, purchase orders, copy of DEA Form 222 (if applicable), loss records, and screening questionnaires must be kept at the registered location and made available if requested during a compliance audit review.

2. Labeling

If controlled substances are removed from their original packaging and compounded, diluted or combined, each new container must be labeled and tracked. The label must include: the name of the controlled substance, the lot number (or tracking number), the date opened, the final concentration, the amount per container and the expiration date.

3. Security

Substances are required to be stored under **double-lock security in a substantially constructed permanently mounted cabinet or safe.**

Registrants are required to report any significant loss or thefts to the local DEA office (Little Rock) by using DEA Form 106. Immediate notification must also be made to ADH by calling 501-661-2325 and faxing DEA Form 106 to 501-661-2769. Thefts must be reported whether or not the controlled substances are subsequently recovered and/or the responsible parties are identified and action taken against them.

4. Disposal

All DEA controlled substances must be accounted for upon their disposal. Empty syringes and vials may be discarded in laboratory sharps containers. All unused or expired substances must be surrendered to ADH Pharmacy Services. Form PHA:DC-1 **Report of Drugs Surrendered** must be completed and must accompany the drugs when surrendered in person to ADH Pharmacy Services at 4815 West Markham, Little Rock, AR. Contact the Office of Research Compliance for the form and for assistance with disposal of unused or expired substances. Keep all disposal records for at least two years.

5. Audits

Compliance with applicable rules and regulations will be reviewed during the semi-annual laboratory audits conducted by the Institutional Animal Care and Use Committee (IACUC) as well as the routine audits conducted by the Office of Research Compliance.

The Office of Research Compliance will issue notifications of noncompliance. Responses to the items of noncompliance will be submitted to Research Compliance and follow-up audits will be performed as necessary. In the event a response is not submitted within 30-days or an item is not corrected, Research Compliance will notify the registrant’s Department Chair, Dean, or the Vice Chancellor for Research to request their assistance in obtaining a response or correction of the item of noncompliance. Consequences for continued noncompliance will be determined by the Department Chair, Dean or Vice Chancellor for Research.

D. Summary

UAMS Administrative Guide 16.1.13, UAMS Non-Human Research Use Controlled Substances Policy outlines the requirements and responsibilities of individuals who possess and use DEA Controlled Substances for non-human research use on the UAMS campus. Refer to the Policy for specific details.

XIII. Laser Safety

A laser is a device that emits an intense, pencil-thin light beam. The term laser is an acronym for Light Amplification by Stimulated Emission of Radiation.

Lasers are classified according to their capability of injuring personnel. Class 3B will cause injury upon direct viewing of the beam and specular reflections (mirror-like reflections from a single beam of light striking a surface). Class 4 lasers pose eye, skin, fire, airborne contaminant and electrical hazards. In addition, viewing the beam or specular reflections or exposure to diffuse reflections can cause eye and skin injuries.

UAMS policy requires an Approved Investigational Laser User to oversee all laser studies utilizing a Class 3B or Class 4 laser systems. Approval is granted by the UAMS Laser Safety Committee in accordance with Policy 11.4.32 found in the UAMS Administrative Guide. This same Policy restricts operation of Class 3B & IV laser to individuals that have obtained Approved Research Laser Operator privileges.

The following rules apply to the use of lasers in research:

- Only trained, authorized personnel may operate lasers. Authorization is received from the Laser Safety Committee, Laser Safety Officer and laser lab manager.

- A Standard Operating Procedure will be developed and approved by the Laser Safety Officer prior to the operation of Class 3B and Class IV lasers. The Standard Operating Procedure will detail safety instructions, laser operation and all required special alignment procedures.

- An ABC fire extinguisher must be readily available when a Class 3B or Class 4 laser is used. Should the laser catch fire, never attempt to suppress with water. Remove flammable material from the beam path. Acetone and alcohol are often used to clean optics and should be protected from accidental exposure to the beam.

- Appropriate warning/danger signs will be posted at lab entrances during laser operation. Ensure door entrance controls are implemented and all windows are considered for beam containment. Laser protective eyewear is required whenever persons are within the nominal hazard zone (NHZ) and lasers are activated. Unless clearly defined and marked otherwise, the entire lab area is considered a nominal hazard zone. Remember that Class 4 lasers can produce hazardous diffuse reflections, so the nominal hazard zone will need to account for this. Eyewear must be of the correct optical density and protect against the specific wavelength(s) of the laser(s) in use as defined within the Standard Operating Procedures As a minimum, the use of Plano safety glasses is recommended when outside of the nominal hazard zone.

- NEVER attempt laser service or maintenance without appropriate training and approval from the Laser Safety Officer. Most ocular injuries occur during alignment procedures. Any service, maintenance or alignment process will require an approved written procedure. Lethal high voltage may be present with laser skins removed.

- Use a verbal announcement and a visual check to ensure all personnel within the lab are appropriately protected prior to laser activation.

- NEVER put yourself into any position where your eyes approach the axis of a laser beam (even with eye protection on). Keep beam paths below or above standing or sitting eye level. Do not direct them towards other people.
-
- Do not damage laser protective housings, or defeat the interlocks on these housings.
- Eliminate all reflective material from the vicinity of the beam paths and terminate beams into appropriate dumps that would otherwise exit the optical set-up.
- Never use viewing instruments to look directly into a laser beam or its specular reflection. If this is necessary, install an appropriate filter into the optical element assembly. The use of cameras for beam visualization is encouraged when necessary and possible.
- Keep ambient light levels as high as operations will permit.
- Do not work alone when performing high power laser operations.
- Laser material interactions that generate laser plume require local exhaust ventilation and/or appropriate respiratory protection.
- Always place the laser in standby when the laser is not being actively used.
- Visitors should not be permitted to observe a laser experiment without first receiving a laser safety briefing and being issued laser eye protection. They will be escorted by knowledgeable personnel at all times.
- LSO approval is required for deviations from these procedures.

For additional information regarding the use of lasers in research, contact the, Laser Safety Officer through the OH&S office.

XIV. Nanotechnology

Currently, there is limited occupational safety information on nanoparticles and nanomaterials in the university research environment. The purpose of this policy is to proactively address the safety issues in the emerging field of nanotechnology and ensure that UAMS employees performing nanotechnology research are aware of the potential hazards and risks involved and the control measures that should be utilized to limit exposures.

Nanotechnology involves the manipulation of matter at nanometer scales to produce new materials, structures, and devices. Nanoparticles are materials that have been engineered to have a size with at least one dimension (length, width, or depth) between 1 and 100 nm and may exhibit unique physical and chemical properties not seen in larger molecules of the same composition. Nanoparticles may be suspended in a gas, suspended in a liquid or embedded in a matrix. When in these states they are commonly referred to as nanomaterials. Substantial private and public investments are flowing into the exploration and development of products that can take advantage of the unique properties of nanomaterials. Currently there are no federal regulations that specifically address the environmental, health and/or safety issues of nanotechnology. At the UAMS, several research groups are utilizing nanomaterials for use in various applications. Researchers must consider the potential health and environmental risks that might result during this research and development. This policy will provide guidance to UAMS researchers in achieving this goal and will evolve as nanotechnology regulations increase.

Working Safety with Nanomaterial

A. Inhalation Exposure Control Methods

Nanoparticles will follow airstreams so they can be easily collected and retained in standard ventilated enclosures such as fume hoods and biosafety cabinets with HEPA filters.

- Synthesis in enclosed reactors or glove boxes will prevent airborne exposures.
- Inhalation exposures can occur when processing materials are removed from the reactors. These activities should be performed in fume hoods and, where practicable, those with HEPA filters such as biosafety cabinets.
- Maintenance on reactor parts that might cause the release of residual particles should be performed in a fume hood and, where practicable, those with HEPA filters such as biosafety cabinets.
- Work with nanomaterial in solution form should be carried out in a fume hood or, where practicable, in a hood with HEPA filters.
- Research techniques should stress slow and careful handling of the material to prevent aerosolization.

B. Dermal Exposure Control Measures

Since the ability of nanoparticles to penetrate skin is unknown at this time, gloves should be worn when handling particulates or particles in solution.

- For Liquids, the glove should have good chemical resistance to the solute.
- For dry particulate, a sturdy glove, such as nitrile lab gloves with good integrity, should be used.
- Disposable nitrile lab gloves should provide good protection for most lab procedures that don’t involve extensive skin contact, If contact is extensive, then double-gloving should be performed.
- There should be no exposed skin around the hands and wrists.
- Check gloves regularly for holes, cracks, etc.
- Wash hands immediately after removing gloves.

C. Ingestion Control Measures

Follow normal hygienic principles:

- Scrupulously avoid hand-to-mouth contact.
- Wear gloves at all times where there is potential for exposure to nanoparticles.
- Wash hands immediately after removing gloves.
- No eating, drinking, smoking, applying cosmetics, etc., in the lab or before hands are washed.

D. Injection Control Measures

Follow normal laboratory sharps work procedures.

E. Cleanup

- Use dampened cloths to wipe up powders. Apply absorbent materials suitable for the solute to large liquid spills.
- Dry sweeping or using compressed air is never appropriate cleanup methods.
- Use a HEPA filtered respirator and double gloves when cleaning up large spills.

F. Disposal

- Never dispose of nanoparticles waste in regular trash or down the drain.
- When disposing of dry nanoparticle waste, use a sealable container that remains closed.
- Dispose of all nanoparticle waste, including contaminated debris, as you would the base material (i.e., carbon nanotubes should be disposed of as carbon, metallic particles consistent with base metal).
- If the nanoparticles are in solution, they should be managed as a solution of the solvent and the parent nanomaterial (e.g., flammable solvents are handled as flammable waste materials).
- All nanoparticle waste must be labeled with the base metal or solute and identified as containing nanomaterial.
- Proper disposal of nanoparticle waste will be based on the type of material and will be coordinated through our waste disposal contractor.
- Please call OH&S at 686-5536 regarding questions pertaining to disposal.

Ensure that laboratory personnel are aware of and trained in the hazards and uncertainties associated with nanomaterials by utilizing nanotechnology safety resources such as OSHA Fact Sheet: Working Safely with Nanoparticles www.osha.gov/Publications/OSHA_FS-3634.pdf and Department of Health and Human Services and NIOSH "Safe Nanotechnology in the Workplace" pamphlet at www.cdc.gov/niosh/docs/2008-112/

APPENDIX A

Fume Hoods

Common Fume Hood Terms & Definitions

Airfoil – Shaped or streamlined member at hood entrance designed to enhance air movement into the hood. The airfoils are designed to keep a minimal disturbance in the airflow pattern entering into the fume hood. This disturbance is called turbulence. Turbulence in the fume hood can negatively affect the containment of chemical fumes.

Air Volume – Rate of airflow, normally expressed in cubic feet per minute (cfm).

Auxiliary Air – Supply or make-up air delivered external to the chamber of a fume hood to reduce air consumption.

Baffle – Panels located across the back of hood interior that control pattern of air moving through the hood.

Blower – Air-moving device (or fan) consisting of a motor, impeller and scroll.

Combination Sash – Moveable horizontal front panels in a vertically rising frame.

Damper – Device installed in duct to control airflow volume.

Duct – Round, square or rectangular tube used to enclose moving air.

Exhaust Volume – Quantity of air exhausted by the fume hood. The exhaust volume is dependent upon the blower size and is expressed in cubic feet per minute (cfm).

Face Velocity – Speed of air moving into the fume hood through the face opening (sash), measured in feet per minute (fpm).

Fume Hood – Five-sided ventilated enclosure used in laboratories to collect, confine and exhaust contaminants.

Lintel – Portion of fume hood front located above access opening.

Louvers – Slit-like openings in the lintel that allow bypass air to enter the hood when the sash is closed.

Manometer – Device used to measure air pressure differential.

Sash – Sliding glass panel set in the fume hood face that protects the user’s eyes, nose, mouth and breathing area from contact with dangerous chemicals and fumes inside the hood.

Variable Air Volume – Type of fume hood exhaust system that typically maintains constant fume hood face velocity by adjusting blower motor speed or a balance damper in response to changes in sash position.

Velometer – Instrument used to measure airflow velocity.

How A Fume Hoods Work

Fume hoods are minimally equipped with a blower, cabinet, and exhaust ductwork. The cabinet is designed to contain hazardous chemicals. The blower is designed to pull air away from the front of the cabinet and keep the hazardous chemicals from reaching the indoor environment and user. The exhaust ductwork is independent from other indoor air ductwork and is used to transport any hazardous chemical fumes, gases, vapors, or aerosols to the outside environment.

Baffles are located across the inside rear of the hood. They assist in controlling the airflow pattern through the hood. Baffles can be adjusted to minimize hazards caused by the different characteristics of chemicals being utilized in the hood system. For normal use, the top, bottom, center and side slots are all adjusted to the open position to provide an even airflow. Gases or fumes that are heavier-than-air require the baffles to be adjusted for the maximum airflow at the bottom of the hood. Close the top slot. Arrange the center, bottom, and side slots in the open position. Gases or fumes that are lighter-than-air require a maximum airflow at the top of the hood. Open the top baffles to their maximum position. Maintain the side and center baffles in their normal position and completely close the bottom slot.

A fume hood must have a face velocity sufficient to pull the air away from the user. The American National Standards Institute (ANSI) recommends that laboratory fume hood face velocity be between 80 to 120 feet per minute (fpm) for optimal safety. One hundred fpm is approximately the same as three miles per hour, which feels like the air going past somebody who is walking briskly. In traditional systems, the user does not have control over the face velocity or exhaust rate of the hood. Exhaust rates in newer fume hoods are often controlled by a variable air volume system.

Variable air volume (VAV) technology allows for the maintenance of a constant face velocity while varying exhaust volume in response to changes in the sash position. The exhaust volume is varied in response to a series of sensors that receive and send signals to the exhaust valve. Annual calibration of the VAV system is necessary to ensure the appropriate flow is being afforded the user. The point of optimal flow is established through calibration of the equipment. When the sash is opened above or below the optimal flow point the face velocity will decrease.

The exhaust capacity of each fume hood is controlled by a variable air volume (VAV) exhaust system. The hoods are calibrated to have the maximum exhaust when the sash is opened approximately 14 inches from the airfoil. This is the optimal operating height. Identification of this point is provided with labels.

a. Survivair Fume Hood Operation

The following are descriptions of fume hood monitor controls. The controls are necessary to alert the user to situations that do not provide the optimal protection.

The **Power light** is green and indicates that power is being applied to the system.

The **Flow Alarm light** is red and indicates that a low-flow situation has been detected. The flow alarm light and the caution LED warning are identical in function.

The **Energy Use Meter** indicates the relative energy use of the fume hood. While it does not indicate the airflow it is directly related to the exhaust airflow velocity. (Typically, the airflow increases with the increase in energy use.)

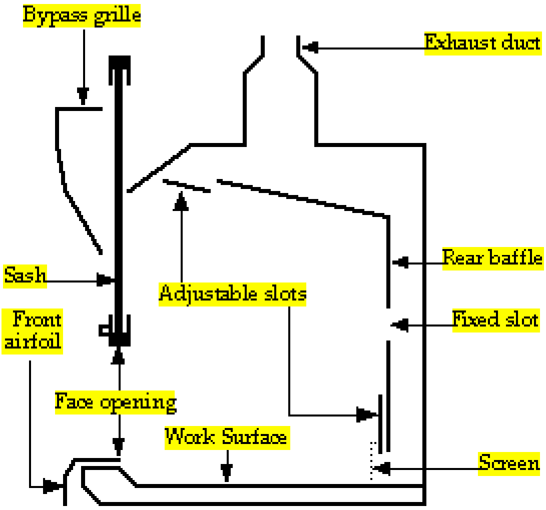
The **System Normal LED** is a green LED that indicates all systems are functioning. When this light is not on and no other LED's are on, then the power to the fume hood system has been lost. There is no exhaust flow.

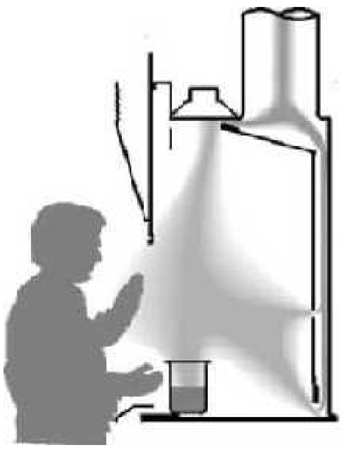
The **Caution LED or Flow Alarm** is a red LED that comes on when the flow is below what is considered a safe level. A slipping or broken belt, a motor fault or overload, a drive failure, a severe brownout, or a severely blocked duct can cause an alarm. The flow alarm is disabled for 45 seconds when the sash is moved or the system is powered up.

The **Emergency Exhaust Switch** is a button that enables the user to reset or set the emergency exhaust mode. When in this mode the blower is at its maximum speed. Depressing the button once will set the mode and turn on the red SET LED. Depressing the button a second time will unlatch the SET and turns off the emergency exhaust mode. Once the emergency exhaust has been activated, the button must be depressed twice to reset the system to its normal operating mode. The emergency exhaust mode can be activated by both the user and internally by the Phoenix Controls system. The emergency exhaust mode can be activated internally by the remote energy exhaust switch, thermostat, gas sensor or other monitor. A red LED indicates when the emergency exhaust in being utilized.

The **Night Waste LED** is activated when the lights are turned off and the sash is left 6 inches above the constant flow position. This serves as an energy saving and safety device.

The **Mute Switch** is a button that will silence the audible alarm when depressed. After all conditions causing the audible alarm have been corrected the mute mode is disabled.

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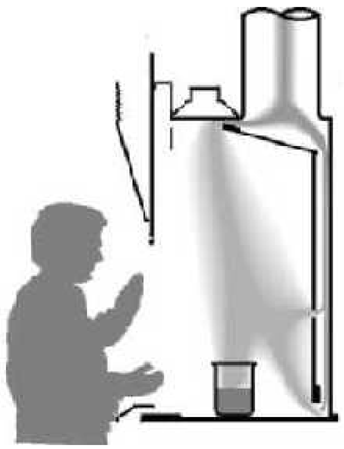
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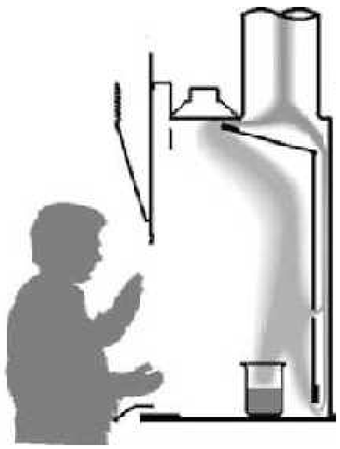
BEST PLACEMENT

APPENDIX B
Decontamination and Antimicrobials

TABLE OF CONTENTS

1.0 Introduction and Scope

This appendix primarily provides information and guidance on decontamination principles, decontamination terms, and the variety of chemical and physical agents used to decontaminate. Information used to develop this appendix was taken from a wide variety of Web pages and documents. Primary sources are listed in the reference section at the end of this appendix.

2.0 Decontamination Principles and Terms

Decontamination is a process that uses an antimicrobial to reduce or inactivate biological contaminants or components to an acceptable level so as to reduce or eliminate the possibility of transmitting pathogens to undesired hosts. An **antimicrobial** is the chemical or physical agent that is used in a decontamination process to prevent microbial growth. Prevention of microbial growth and pathogen transmission is needed to control contamination of the work and prevent disease in hosts such as laboratory workers, the general public, and other organisms in the environment. The decontamination process, level, antimicrobial, frequency, and specific method are based on the work activity, agents that need inactivation, and decontamination objective or requirements.

Sterilization, disinfection, sanitization, and antisepsis are decontamination processes that result in different levels of decontamination or decontamination of different types of objects.

2.1 Decontamination Processes and Levels

2.1.1 Sterilization

Sterilization is the process of completely destroying all living microorganisms and viruses on an object. Any item, device, or solution is considered to be **sterile** when it is completely free of all living microorganisms and viruses. Sterility is an absolute term (an item is either sterile or it is not), but sterilization procedures must be defined to achieve sterility. A **sterilization procedure** is a treatment process to which an item is subjected after which the probability of a microorganism or virus (including a high number of bacterial endospores) surviving on the item is less than 1 in 1 million. This level of killing efficacy is referred to as the **sterility assurance level**.

Sterilization can be accomplished by heat (e.g., autoclave or incineration), ethylene oxide gas, hydrogen peroxide gas, plasma, ozone, and radiation. Solid biohazardous waste is typically sterilized prior to disposal.

2.1.2 Disinfection

Disinfection is generally a less lethal process than sterilization. **Disinfection** is the process of generally eliminating nearly all recognized pathogenic microorganisms but not necessarily all microbial forms (e.g., bacterial spores) on inanimate objects (e.g., work surfaces, equipment). Disinfection does not ensure “overkill" and therefore lacks the margin of safety achieved by sterilization procedures. Longer disinfection times or higher concentrations of disinfectant may be needed if the effectiveness of a disinfection procedure is reduced significantly by a number of factors such as:

1. More resistant microorganisms (especially bacterial spores)
2. Higher microbial concentrations
3. Presence of more organic matter (e.g., soil, feces, or blood)
4. Rougher surfaces or more porous equipment or material
5. Lower temperatures

Disinfection may involve chemical or physical agents, but the term disinfection more commonly implies the use of chemical germicides or disinfectants on inanimate objects.

Disinfection is a process that reduces the level of microbial contamination, but there is a broad range of activity that extends from sterility at one extreme to a minimal reduction in the number of microbial contaminants at the other. By definition, chemical disinfection and in particular, high-level disinfection differs from chemical sterilization by its lack of sporicidal power. This is an oversimplification of the actual situation because a few chemical germicides used as disinfectants do, in fact, kill large numbers of spores even though high concentrations and several hours of exposure may be required. Nonsporicidal disinfectants may differ in their capacity to accomplish disinfection or decontamination. Some germicides rapidly kill only the ordinary vegetative forms of bacteria such as staphylococci and streptococci, some forms of fungi, and lipid-containing viruses, whereas others are effective against such relatively resistant organisms as *Mycobacterium tuberculosis* var. *bovis*, nonlipid viruses, and most forms of fungi.

Levels of chemical disinfection and activity levels for chemical disinfectants (or germicides) on inanimate surfaces may be used to assist in categorizing and selecting disinfection methods and disinfectants. Levels of chemical disinfection are categorized in Table 1, and activity levels of selected disinfectants are shown in Table 2.

Table 1
Levels of Chemical Disinfection

Level	Level Definition and Description
High	High-level disinfection kills vegetative microorganisms and inactivates viruses, but not necessarily high numbers of bacterial spores. Such disinfectants are capable of sterilization when the contact time is relatively long (e.g., 6 to 10 hours). As high-level disinfectants, they are used for relatively short periods of time (e.g., 10 to 30 minutes). These chemical germicides are potent sporicides and, in the United States, are classified by the Food and Drug Administration (FDA) as sterilant/disinfectants. They are formulated for use on medical devices, but not on environmental surfaces such as laboratory benches or floors.
Intermediate	Intermediate-level disinfection kills vegetative microorganisms, including *Mycobacterium tuberculosis*, all fungi, and inactivates most viruses. Chemical germicides used in this procedure often correspond to Environmental Protection Agency (EPA)-approved "hospital disinfectants" that are also "tuberculocidal." They are used commonly in laboratories for disinfection of laboratory benches and as part of detergent germicides used for housekeeping purposes.
Low	Low-level disinfection kills most vegetative bacteria except *M. tuberculosis*, some fungi, and inactivates some viruses. The EPA approves chemical germicides used in this procedure in the U.S. as "hospital disinfectants" or "sanitizers."

Source: adapted from Biosafety in Microbiological and Biomedical Laboratories (*BMBL*)*, fifth edition, Appendix B.*

Table 2
Activity Levels of Selected Liquid Germicides

Procedure/Product	Aqueous Concentration	Disinfection Activity Level
Sterilization		
glutaraldehyde	variable	N/A
hydrogen peroxide	6–30%	N/A
formaldehyde	6–8% b	N/A
chlorine dioxide	variable	N/A
peracetic acid	variable	N/A
Disinfection		
glutaraldehyde	variable	high to intermediate
ortho-phthalaldehyde	0.5%	high
hydrogen peroxide	3 to 6%	high to intermediate
formaldehyde	1 to 8%	high to low
chlorine dioxide	variable	high
peracetic acid	variable	high
chlorine compounds c	500 to 5,000 mg/L available chlorine (or 1 to 10% household beach in water)	intermediate
alcohols(ethyl,isopropyl) d	70%	intermediate
phenolic compounds	0.5 to 3%	intermediate to low
iodophor compounds e	30 to 50 mg/L free iodine up to 10,000 mg/L available iodine 0.1 to 0.2%	intermediate to low
quaternary ammonium compounds		low

Source: adapted from BMBL, fifth edition, Appendix B.

Footnotes:

a. This list of chemical germicides centers on generic formulations. A large number of commercial products based on these generic components can be considered for use. Users should ensure that commercial formulations are registered with the EPA or by the FDA.

b. Because of the ongoing controversy of the role of formaldehyde as a potential occupational carcinogen, the use of formaldehyde is limited to certain specific circumstances under carefully controlled conditions, e.g., for the disinfection of certain hemodialysis equipment. There are no FDA- cleared liquid chemical sterilant/disinfectants that contain formaldehyde.

c. Generic disinfectants containing chlorine are available in liquid or solid form (e.g., sodium or calcium hypochlorite). Although the indicated concentrations are rapid acting and broad spectrum (tuberculocidal, bactericidal, fungicidal, and virucidal), no proprietary hypochlorite formulations are formally registered with EPA or cleared by FDA. Common household bleach is an excellent and inexpensive source of sodium hypochlorite. Concentrations between 500 and 1,000 mg/L (or ppm) chlorine are appropriate for the vast majority of uses requiring an intermediate level of germicidal activity. Higher concentrations are extremely corrosive as well as irritating to personnel, and their use should be limited to situations where there is an excessive amount of organic material or unusually high concentrations of microorganisms (e.g., spills of cultured material in the laboratory).

d. The effectiveness of alcohols as intermediate-level germicides is limited because they evaporate rapidly, resulting in short contact times, and also lack the ability to penetrate residual organic material. They are rapidly tuberculocidal, bactericidal, and fungicidal, but may vary in spectrum of virucidal activity (see text). Items to be disinfected with alcohols should be carefully precleaned and then completely submerged for an appropriate exposure time (e.g., 10 minutes).

e. Only those iodophors registered with EPA as hard-surface disinfectants should be used, closely following the manufacturer's instructions regarding proper dilution and product stability. Antiseptic iodophors are not suitable for disinfecting devices, environmental surfaces, or medical instruments.

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An understanding of the resistance of organisms to chemical germicides should also be considered when selecting the disinfection methods and disinfectants. Table 3 shows the resistance of selected organisms to decontamination, from most to least resistant.

Table 3
Descending Order of Organism Resistance to Germicidal Chemicals

BACTERIAL SPORES *Bacillus subtilis, Clostridium sporogenes* ↓
MYCOBACTERIA *Mycobacterium tuberculosis* var. *bovis*, nontuberculous mycobacteria ↓
NONLIPID OR SMALL VIRUSES Poliovirus, Coxsackievirus, Rhinovirus ↓
FUNGI *Trichophyton* spp., *Cryptococcus* spp., *Candida* spp. ↓
VEGETATIVE BACTERIA *Pseudomonas aeruginosa, Staphylococcus aureus, Salmonella choleraesuis,* Enterococci ↓
LIPID OR MEDIUM-SIZE VIRUSES Herpes simplex virus, cytomegalovirus, respiratory syncytial virus, hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), Hantavirus, Ebola virus

Source: adapted from BMBL, fifth edition, Appendix B

Note: There are exceptions to this list. *Pseudomonas* spp. are sensitive to high-level disinfectants, but if they grow in water and form biofilms on surfaces, the protected cells can approach the resistance of bacterial spores to the same disinfectant. The same is true for resistance to glutaraldehyde by some nontuberculous mycobacteria, some fungal ascospores of *Microascus cinereus* and *Cheatomium globosum*, and the pink-pigmented *Methylobacteria*. Prions are also resistant to most liquid chemical germicides and are discussed in the last part of this section.

2.1.3 Sanitization

Sanitization is the process of generally reducing microorganisms by the use of general cleaning agents. Sanitization is less effective than disinfection at reducing the number of microorganisms. General cleaning of laundry or laboratory, restroom, room, and equipment surfaces with soap and water or another cleaning agent are examples of sanitization. A particular cleaning method might use a chemical germicide or disinfectant, but the cleaning process is considered sanitization if the process only generally reduces the number of microorganisms.

2.1.4 Antisepsis

Antisepsis is the application of a liquid antimicrobial chemical to human or animal living tissue. The purpose of antisepsis is to prevent sepsis by destroying potentially infectious organisms or by inhibiting their growth and multiplication. **Sepsis** is the presence of infectious organisms in the blood or other tissue of the body. No sporicidal activity is implied. Examples of antisepsis include application of a germicide to the injection site on a research animal, and hand washing with germicidal solution. With hand washing, the objective includes preventing the spread of infectious or contaminating agents for safety and quality control.

2.2 Antimicrobial Categories

Chemical or physical agents or substances that can decontaminate under ideal conditions have specific terms with specific meanings. The broadest term for such agents is the term antimicrobial. **Antimicrobial** is a chemical or physical agent that can prevent microbial growth either by some static action or by the direct killing of microbes. Categories of antimicrobials include:

- **Sterilant.** An antimicrobial chemical or physical agent that is capable of killing all microbes including their spores to the sterility assurance level.
- **Germicide.** An antimicrobial substance or physical agent that kills microbes. Germicides are a broader category of antimicrobials than disinfectants, since some germicides are active against endospores and viruses. Germicides, which are also known for the specific microorganisms they kill, end with the suffix *–cidal* (e.g., bacterio*cide*, spor*icide*, fung*icide*, viru*cide*).
- **Disinfectant.** A chemical germicide or physical agent that is applied to inanimate objects to kill microbes, but is not capable of killing endospores, some viruses, or mycobacterium. Disinfectants are typically chemical germicides.
- **Antiseptic.** A disinfecting chemical agent applied to living tissue and used to prevent sepsis. Antiseptics are a subset of disinfecting chemical agents. A few agents are suitable as both disinfectants and antiseptics, although most disinfectants are too harsh for use on delicate skin.

2.3 Antimicrobial Selection and Registered Disinfectants

When using a chemical or physical antimicrobial to ensure decontamination is accomplished for biosafety purposes (i.e., protection of workers, public, agriculture, or environment):

- There should be information indicating that the selected antimicrobial will be effective when used in a certain manner for the biological materials or agents and equipment or surfaces that need to be decontaminated; and
- The antimicrobial should be used in accordance with its antimicrobial activity capabilities and conditions of use.

Antimicrobial information in this appendix, information provided by manufacturers (e.g., labels or technical specifications), and other information may be used for selecting and using the appropriate antimicrobial. Selecting a commercially available chemical antimicrobial product registered with the EPA or cleared by the FDA and using the product within its manufacturer-specified limits also ensures effective decontamination. The following lists of antimicrobials registered with EPA and FDA are available online:

- Selected EPA-registered Disinfectants including sterilizers, tuberculocides, and antimicrobial products against certain human public health bacteria and viruses

- FDA-Cleared Sterilants and High-Level Disinfectants with General Claims for Processing Reusable Medical and Dental Devices

The **Occupational Safety and Health Administration** (OSHA) Bloodborne Pathogens (BBPs) Standard requires that work surfaces that are contaminated with BBP material must be cleaned with an "appropriate disinfectant." Appropriate disinfectants include:

- Household bleach (i.e., approximately 5.25% sodium hypochlorite) diluted to concentrations ranging from 1% (1:100) to 10% (1:10) in water.
- EPA-registered products as sterilants (List A)
- EPA-registered products as tuberculocides (List B)
- EPA-registered products effective against HIV/HBV (List D), or
- FDA-cleared sterilants and high-level disinfectants

Any of the above products are considered effective when used according to the manufacturer's instructions, provided the surfaces have not become contaminated with agents, or volumes or concentrations of agents for which higher level disinfection is recommended. Also note that the EPA lists contain the primary registrants' products only. The same formulation is frequently repackaged and renamed and distributed by other companies. These renamed products will not appear on the list, but their EPA Registration Number must appear on the label. Products cleared solely by the FDA will not have an EPA Number.

3.0 Chemical Antimicrobials

This section summarizes basic types and characteristics of antimicrobials that are chemical agents. Section F.4 below summarizes antimicrobials that are physical agents.

All chemical antimicrobials harm microorganisms in some manner, but different chemical antimicrobials have different mechanisms of action. Mechanisms of harm include protein denaturation, membrane disruption, nucleic acid damage, and inhibition of metabolism. Chemical antimicrobials that are summarized in this section include surfactants, halogen-containing compounds, alcohols, phenol and phenol derivatives, oxidizing agents, and alkylating agents.

3.1 Surfactants (Soaps and Detergents)

A **surfactant** is a ***surf***ace ***act***ive ***a***gen***t*** that is usually an organic compound that possesses both hydrophilic (water-loving) and lipophilic (fat-liking) properties that make the compound soluble in water and lipids. Surfactants therefore increase the solubility of lipids in water solutions and increase the ability of water solutions to wet (i.e., move across or penetrate) lipid surfaces. Soaps and detergents are examples of surfactants.

3.1.1 Soaps

Soap is sodium or potassium salts of fatty acids. Soaps are therefore alkaline (pH greater than 7). Soaps either harm bacteria that are sensitive to high pH, or remove pathogens from surfaces by cleaning the surface.

3.1.2 Detergents and Quaternary Ammonium Compounds

Detergent is a synthetic surfactant. A detergent may be cationic (positively charged) or anionic (negatively charged). Cationic detergents are better at inactivating bacteria than anionic detergents.

One commonly used type of cationic detergent disinfectant is a quaternary ammonium compound. **Quaternary ammonium compound** or **quat** is a cationic detergent compound derived from ammonia by replacing the hydrogen atoms with organic radicals, and the compound is especially important as surface-active agents or disinfectants, or in drugs. Quats have strong surface activity and can be used for general cleaning and low-level disinfection. Additional properties of quaternary ammonium compounds include the following:

- Active against Gram-positive bacteria and lipid-containing viruses. They are less active against Gram-negative bacteria and are not active against nonlipid-containing viruses and bacterial spores.
- Less effective or inactivated by organic materials, soaps or anionic detergents, or salts of metals found in water. Quats are often mixed with another agent to overcome some of these problems.
- Built-in cleaning properties and relatively nontoxic (e.g., can be used for general cleaning and food equipment).
- Has no odor but acts as a deodorizer.
- Effective at temperatures up to 212°F.
- More effective in alkaline than in acid solutions.
- Typically nonirritating to the skin when used in proper dilution, but prolonged skin or eye contact should be avoided.
- Stable in storage.

3.2 Halogens (Chlorine and Iodine)

Halogens are a group of elements on the periodic table. Chlorine and iodine are two halogens that are routinely used as antimicrobials.

3.2.1 Chlorine and Sodium Hypochlorite

Chlorine-containing solutions are commonly used disinfectants, and sodium hypochlorite in the form of household bleach is the most common solution used for chlorine disinfection. These solutions have broad-spectrum antimicrobial activity, but their decay rates and corrosive nature limit their use. The following bullets provide additional information:

- Concentrations and Effectiveness: Chlorine-containing solutions have broad spectrum activity, but the concentration of the chlorine-active ingredient in the solution at time of use affects germicidal activity. Low concentrations of available chlorine (2 to 500 ppm) are active against vegetative bacteria, fungi, and most viruses. Effectiveness increases with concentration of available chlorine. Rapid sporicidal action can be obtained at about 2,500 ppm.
- Active Ingredient Decay: The chlorine-active ingredient typically decays or is consumed. Decay or decomposition typically occurs over time and is accelerated by unfavorable storage conditions. Chlorine is also consumed by excess organic materials. Use of sufficient concentrations and quantity of chlorine, along with precleaning items to be disinfected, ensures sufficient chlorine is available for disinfection.
- Corrosiveness: Chlorine-containing solutions are strong oxidizers and are very corrosive to personnel and some surfaces. Personnel handling these solutions must wear required hand, eye, and body protection. Surfaces such as stainless steel may be corroded and should be wiped or rinsed with water following disinfection.

One of the most common and effective disinfectants used in the laboratory is sodium hypochlorite (NaOCl) in water or “bleach.” **Household bleach** is a water-based solution of sodium hypochlorite with a typical concentration of 5.25% by weight (or 52,500 ppm) of the active sodium hypochlorite ingredient. Commercial supplies are also available in the 12 to 15% dilution range, but household bleach is typically sufficient for laboratory use. Many brands and formulations of bleach are registered with the EPA as a disinfectant that is effective against bloodborne and other common human pathogens. Clorox® is the best-known brand of bleach in the U.S.

Common applications and mixtures of household bleach are listed below.

- Work Surfaces and Equipment: Hard work surfaces and equipment may be disinfected with 1% solution of fresh household bleach (or 500 ppm sodium hypochlorite). A 1% household bleach solution can be made by mixing 1 part household bleach with 99 parts water, or 1/8 to 1/4 cup household bleach with water in a gallon container, or 10 ml of household bleach with water in a 1 L container. Contact time for bleach is generally considered to be the time it takes the product to air dry.
- Spills and Liquid Waste: Biohazardous spills and liquid waste may be decontaminated by adding household bleach to water or the liquid to be decontaminated until a 10% concentration of household bleach is achieved (or 5,000 ppm sodium hypochlorite). A 10% household bleach solution can be made by mixing one part household bleach with 9 parts water, or 1.5 cups household bleach with water in a gallon container, or 100 ml of household bleach with water in a 1 L container. The bleach should remain in contact with the spill or waste material for approximately 20 minutes to ensure adequate germicidal action.
- Sodium hypochlorite solutions are not very stable, and the antimicrobial activity of the chlorine typically decays over time. This decay is accelerated by unfavorable storage conditions and must be compensated by mixing fresh solutions. Favorable storage conditions include: temperature below 70°F, plastic container (not metal or glass), opaque container (to minimize exposure to light), and closed container (to minimize exposure to air). It is common to measure 50% decay within one month under favorable storage conditions. Since bleach antimicrobial activity decays over time, bleach solutions must be sufficiently fresh so that the solution to be used for decontamination has sufficient antimicrobial activity. Fresh solutions of diluted household bleach made up daily are recommended for disinfection of work surfaces.

3.2.2 Iodine and Iodophors

Iodine is another halogen that is routinely used as an antimicrobial (at 70 to 150 ppm total iodine), and iodine has properties similar to chlorine. **Iodophor** is a preparation containing iodine complex with a solubilizing agent, such as a surfactant or povidone (a type of water soluble polyvinyl polymer). The resulting iodophor is a water-soluble material that increases penetration (as a surfactant) and slows the release of free iodine over long periods (as a disinfectant) when in solution. Iodophors are prepared by mixing iodine with the solubilizing agent. Wescodyne® is a common laboratory disinfectant iodophor.

Additional properties of iodophors include:

- Rapid germicidal action. Effective against vegetative bacteria, Gram-positive bacteria, Gram-negative bacteria, fungi, viruses, and tubercle bacilli. Poor activity against bacterial spores.
- Most effective in acid solutions.
- Should not be used in hot water, since iodine is vaporized at 120 to 125°F. For optimal germicidal activity, dilute with warm acidic water. Resulting solutions are less stable but have a higher germicidal activity.
- Effectiveness reduced by organic matter (but not as much as hypochlorites).
- Stable in storage if kept cool and tightly covered.
- Relatively harmless and nontoxic to humans.
- The solution has germicidal activity if the color is brown or yellow.
- Solutions of sodium thiosulfate can be used to inactivate iodophors and remove iodophor stains.

Iodophors may also be used as antiseptics. Betadine and isodine are examples of antiseptic iodophors. Iodine may also be used in an alcohol solution (i.e., or tincture) as an antiseptic.

3.3 Alcohols

Ethyl or isopropyl (rubbing) alcohol concentrations of 70 to 90% in water are good general-use disinfectants with some limitations. Alcohol-water mixtures are more penetrating than pure alcohols, and therefore provide better disinfection. Alcohol concentrations above 90% are less effective than 70 to 90% concentrations.

Alcohols have some positive and negative characteristics, including:

- Alcohols are effective against a broad spectrum of bacterial species and many viruses, but they are less active against nonlipid viruses and ineffective against bacterial spores.
- Alcohols evaporate quickly and leave no residue. These characteristics often make alcohols convenient and efficient, but provide limited penetration and disinfection time.

3.4 Phenol and Phenol Derivatives (Phenolics)

Phenol and phenol derivatives (or phenolics) come in various concentrations ranging mostly from 5 to 10% phenol-based compounds. These disinfectants are especially useful for disinfecting materials contaminated with organic materials and contaminated surfaces. Lysol® is an example of a phenol-based disinfectant.

Additional properties of phenol and phenol derivatives include the following:

- Effective at killing Gram-negative and Gram-positive bacteria including *Mycobacterium tuberculosis*, fungi, and lipid-containing viruses. Not active against spores or most nonlipid viruses.
- Low solubility in water unless combined with detergent.
- Stable in storage.
- Less adversely affected by organic matter than other common disinfectants.
- Effective over a relatively large pH range.
- Prolonged contact deteriorates rubber.
- Can cause skin and eye irritation.
- Not for use on food contact surfaces.
- Some phenolics are mild enough for use as antiseptics whereas others are too harsh or otherwise dangerous to be employed on living tissue.

3.5 Oxidizing Agents (Hydrogen Peroxide)

Hydrogen peroxide is an oxidizing agent and may be used as a liquid or vapor antimicrobial. Hydrogen peroxide vapor may be used for decontamination of equipment such as biosafety cabinets or high-containment (Biosafety Level 3) rooms that may be sealed during the decontamination process.

3.6 Alkylating Agents (Formaldehyde, Glutaraldehyde, Ethylene Oxide)

Formaldehyde, glutaraldehyde, and ethylene oxides are alkylating agents. These agents add carbon-containing functional groups to biological molecules.

3.6.1 Formaldehyde

Formaldehyde may be used as a liquid or gaseous antimicrobial. When used as a liquid, formaldehyde may be mixed with water as formalin or mixed with alcohol. Formaldehyde is also a human carcinogen, creates respiratory problems, and has a very low occupational exposure ceiling and short-term exposure limits that are approximately equal to the odor threshold.

Additional information on formaldehyde antimicrobials are listed below:

- Formalin is 37% solution of formaldehyde in water. Dilution of formalin to 5% results in an effective disinfectant. A concentration of 8% formaldehyde exhibits good activity against vegetative bacteria, spores, and viruses.
- Formaldehyde and alcohol solutions (8% formaldehyde in 70% alcohol) are considered very good disinfectants because of their effectiveness against vegetative bacteria, fungi, spores, and viruses. This is the disinfectant of choice for many applications.
- Formaldehyde gas may be generated by heat-accelerated depolymerization of flake paraformaldehyde. The resulting gas may be used to decontaminate equipment such as biosafety cabinets that may be sealed prior to decontamination.

3.6.2 Glutaraldehyde

Gluteraldehyde may be used for cold sterilization of equipment (e.g., medical) that cannot be steam sterilized, but sterilization often requires many hours of exposure. Two percent solutions exhibit good activity against vegetative bacteria, spores, and viruses. Its use, however, must be limited and controlled due to its toxic properties and ability to damage the eyes.

Glutaraldehyde is slightly acidic in aqueous solution and typically used at ambient temperature. When these solutions are adjusted by sodium bicarbonate (or other buffers) to a pH of 7.5 to 8.5, glutaraldehyde is considered to be activated and the antimicrobial activity enhanced. Activated glutaraldehyde has limited stability after activation.

3.6.3 Ethylene Oxide

Ethylene oxide is a gaseous chemical antimicrobial used to sterilize laboratory, medical, and pharmaceutical products and equipment that would be damaged by high-temperature steam sterilization (e.g., prepackaged plastic Petri dishes). This gas is especially useful because it penetrates very well into small crevices.

4.0 Physical Antimicrobials

This section summarizes basic types and characteristics of antimicrobials that are physical agents. Physical antimicrobials summarized in this section include dry heat, wet heat, ultraviolet radiation, ionizing radiation, visible light, and filtration.

4.1 Heat

Dry heat (e.g., oven) and moist heat (e.g., autoclave) may be used to sterilize materials and equipment. The following principles and comparisons generally apply to sterilization with dry and moist heat:

- Moist heat is more effective than dry heat at a given temperature or length of exposure.
- Moist heat is more penetrating than dry heat.
- Temperature and length of exposure are inversely related, and penetration is critical.
- Temperature and length of exposure needed to achieve sterilization are inversely related (i.e., lower temperatures require longer exposure times).
- Time to achieve sterilization does not start until heat has penetrated into the item and the required temperature in the item has been achieved.

4.1.1 Dry Heat (Baking and Incineration)

Dry heat sterilization may include baking or incineration.

- Baking in an oven to achieve sterilization typically requires 171°C for at least 1 hour, 160°C for at least 2 hours, or 121°C for at least 16 hours.
- Incineration may also be used to achieve dry heat sterilization. Examples include off-site incineration of biohazardous or pathological waste by an LBNL subcontractor or heating an inoculating loop in an infrared heat chamber at 815°C (1,500°F).

  Specific times and temperatures must be determined for each type of material being sterilized. Generous safety factors are usually added to allow for variables that can influence the efficiency of dry heat sterilization, such as:

- The moisture of the sterilization environment as well as the moisture history of organisms prior to heat exposure.
- The heat transfer properties and the spatial configuration or arrangement of articles in the load.

4.1.2 Wet Heat (Boiling and Autoclaving)

Use of wet heat may include boiling an item in water or processing the item in an autoclave. Boiling water is a common means of applying moist heat, but boiling does not kill endospores and all viruses. Boiling water is 100°C (212°F) at standard atmospheric pressure. Higher wet-heat temperatures and sterilization efficacy may be achieved with a pressurized autoclave.

Autoclaves are commonly used to sterilize laboratory equipment or materials such as glassware, media, reagents, or waste. See Section F.5 below for general information and guidelines on autoclave principles, operation, and maintenance.

4.2 Ultraviolet (UV) Radiation

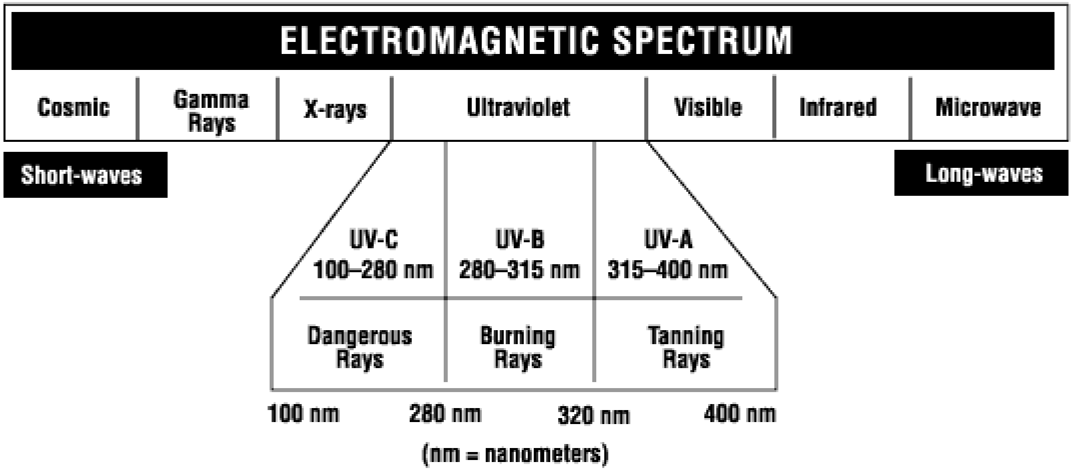
UV radiation or **UV light** is electromagnetic radiation with a wavelength shorter than that of visible light but longer than X-rays. They are in the range of 10 nanometers (nm) to 400 nm, and energies from 3 electron volts (eV) to 124 eV. UV radiation is so named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet.

4.2.1 UV Light Health Effects and Categories

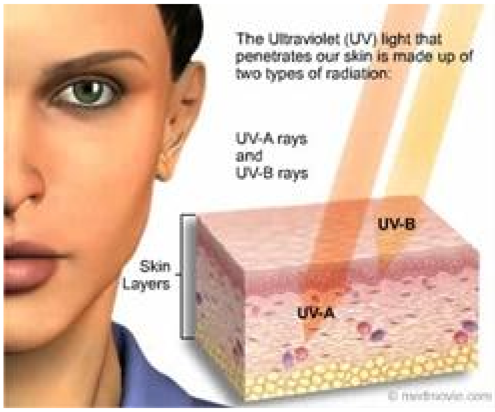
UV radiation may affect or damage the skin and eyes depending on the wavelength, intensity, and duration of exposure. Other organs are typically not affected because UV light does not penetrate deeply into tissue. Acute effects to the skin and eyes are generally not permanent but can be quite painful.

The UV spectrum is divided into three wavelength bands primarily based on their biological effects:

- **UVA** (315 to 400 nm) is long-wave UV or "back light" and is used in dentistry and tanning. UVA rays can penetrate the middle layer of skin (dermis) and cause darkening and toughening of the skin. Overexposure to UVA has also been associated with suppression of the immune system and cataract formation.
- **UVB** (280 to 315 nm) is medium-wave UV and is used for fade testing and photocuring of plastics. UVB rays reach the outer layer of skin (epidermis) and cause skin burns, erythma (reddening of the skin), and darkening of the skin. Prolonged exposures increase the risk of skin cancer.
- **UVC** (100 to 280 nm) is short-wave UV and is used as a germicidal (e.g., inside biosafety cabinets). UVC poses the most risk to skin. Although UVC from the sun is absorbed by the atmosphere, manmade sources of UVC need to restrict their intensity and control exposure.



Electromagnetic spectrum. Source: CCOHS, OSH Answers, Physical Agents, Ultraviolet Radiation (February 2010).



UV light that penetrates skin. Source: FDA, Radiation-emitting Products, Ultraviolet Radiation (February 2010).

The eyes are particularly sensitive to UV radiation. Even a short exposure of a few seconds can result in painful but temporary inflammatory conditions known as photokeratitis and conjunctivitis. Examples of eye disorders resulting from UV exposure include "flash burn," "ground-glass eye ball," "welder's flash," and "snow blindness.” The symptoms are pain, discomfort similar to the feeling of sand in the eye, and an aversion to bright light.

The eyes are most sensitive to UV radiation from 210 nm to 320 nm (UVC and UVB). Maximum absorption by the cornea occurs around 280 nm. UVA absorption by the lens may be a factor in producing a cataract (a clouding of the lens in the eye).

All wavelengths less than 320 nm (UVB and UVC) are actinic, which means they are capable of causing chemical reactions. Wavelengths below 180 nm are of little practical biological significance since the atmosphere readily absorbs them.

4.2.2 Biosafety Cabinet UV Light

Long-term exposure to UV light may be used for disinfecting surfaces and air; however, UV light is not recommended or necessary for use inside biosafety cabinets (BSCs). This is because UV light is limited by many factors (see bulleted list below) as a disinfectant and harmful to human tissue. Other means of disinfection (e.g., chemical) are recommended for use inside BSCs.

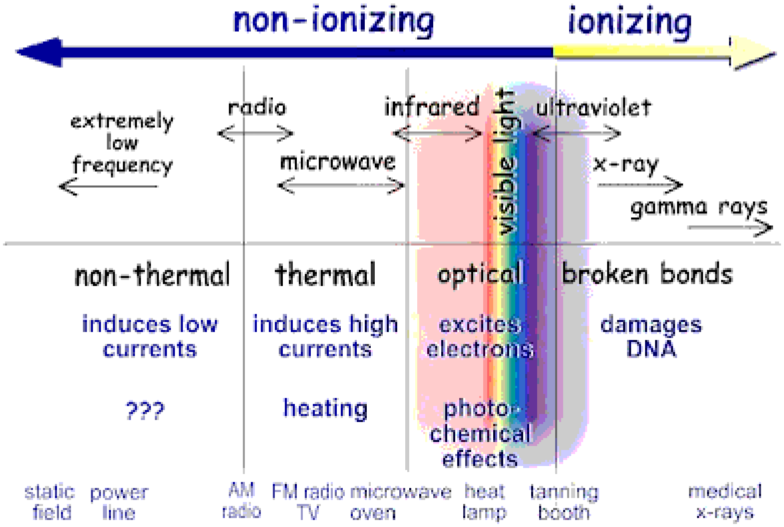
UV light's ability to disinfect inside BSCs is limited by a number of factors including:

- **Penetration:** UV light lacks penetrating power. Microorganisms beneath dust particles or beneath the work surface are not affected by the UV radiation.
- **Relative Humidity:** Humidity decreases the effectiveness of UV light. Antimicrobial effects of UV light drops off precipitously above 70% relative humidity.
- **Temperature and Air Movement:** Optimum temperature for UV light output is 77 to 80°F. Temperatures below this optimum temperature result in reduced output of the antimicrobial wavelength. Moving air tends to cool the lamp below its optimum operating temperature and results in reduced output.
- **Lamp Cleanliness:** Dust and dirt can block the antimicrobial effectiveness of UV lights. UV lamps need to be cleaned weekly with an alcohol and water mixture.
- **Lamp Age:** The intensity of UV light emitted from UV lamps decreases with age, and bulb ratings (hours of use) may vary by manufacturer. UV lamps need to be checked periodically (approximately every six months) to ensure the intensity and wavelength of UV light needed for antimicrobial activity is being emitted.

If UV light is used as an antimicrobial but is not a required biosafety control, then maintenance and testing of the UV lights is not required for biosafety purposes. For example, germicides are used as the primary means of BSC disinfection, so maintenance and testing of the UV light inside the BSC is not required for biosafety purposes.

4.3 Ionizing Radiation

Ionizing radiation is radiation of sufficiently high energy to cause ionization in the medium through which it passes. This radiation may be of a stream of high-energy particles (e.g. electrons, protons, alpha particles) or short-wavelength electromagnetic radiation (e.g., ultraviolet, X-rays, gamma rays). This type of radiation can cause extensive damage to the molecular structure of a substance either as a result of the direct transfer of energy to its atoms or molecules, or as a result of the secondary electrons released by ionization. The effect of ionizing radiation in biological tissue can be very serious, usually as a consequence of the ejection of an electron from a water molecule and the oxidizing or reducing effects of highly reactive species. Biological effects on living cells may include DNA damage and mutations.



Ionizing and nonionizing radiation. Source: Wikipedia, "Nonionizing Radiation" (February 2010).

Different types of ionizing radiation display different degrees of penetration and may be used to sterilize equipment (e.g., medical instruments) or biological materials (e.g., inside human cadaver bones). Use of ionizing radiation as an antimicrobial requires established and specialized methods known to sterilize specific items.

4.4 Visible Light

Strong visible light can decrease bacterial viability. Drying laundry on a clothesline is an example of disinfection by using detergents and strong visible light.

4.5 Filtration (HEPA Filters)

Filtration is used as an antimicrobial treatment for air and liquids.

- High-efficiency particulate air (HEPA) filters are used to filter air flowing into aseptic areas (e.g., the work area inside a BSC) and out of potentially contaminated areas (e.g., exhaust from a BSC).
- Filtration is commonly used when materials are heat labile, but sterilization is not necessarily achieved unless the filter has very small filter pores. Smaller filter pores will also slow filtration speed.

5.0 Autoclave Sterilization and Safety

This section provides general information and guidelines on autoclave principles, operation, and maintenance typically needed to sterilize materials or equipment and ensure operator safety. **Autoclave** is a piece of equipment with a chamber that is used to sterilize items by applying wet heat (i.e., high-pressure steam) at temperatures above the normal boiling point of water and pressures above normal atmospheric pressure.

Autoclaves are used to sterilize laboratory equipment or materials such as glassware, media, reagents, or waste. Autoclaves are commonly used because they are a dependable means of achieving the necessary level of killing efficacy (or sterility assurance level) for most biological materials. In addition, autoclaves do not generate other chemical antimicrobial waste or sources of contamination. See Section 2.1.1 for general information on sterilization and killing efficacy.

Autoclaves must be operated and monitored properly to achieve sterility and safety. Operator safety is a concern because autoclaves may pose physical hazards (e.g., heat, steam, pressure) and biological hazards.

5.1 Autoclaves and Sterilization

Autoclaves achieve higher sterilization efficacy in part because they generate wet-heat temperatures (e.g., 121°C or 250°F) higher than those achieved under standard atmospheric pressure (i.e., 100°C or 212°F). Exposure of material in an autoclave to 121°C (250°F) for 15 or more minutes is typically sufficient for sterilization, but the material’s temperature must be 121°C before the time to achieve sterilization is started. Large items, large volumes, and items that are poorly penetrated by the autoclave’s steam may take much longer than 15 minutes to sterilize. If penetration of moisture into the item is blocked, sterilization may not be achieved.

Autoclave conditions critical to ensuring reliable sterilization methods are proper temperature and time and the complete replacement of autoclave chamber air with steam (i.e., no entrapment of air). Some autoclaves utilize a steam-activated exhaust valve that remains open during the replacement of air by live steam until the steam triggers the valve to close. Others utilize a precycle vacuum to remove air prior to steam introduction.

Standard autoclave conditions for the types of materials that need sterilization should be established. Autoclave treatment conditions to achieve sterility will vary in relation to the volume of material treated, volume of the autoclave, the contamination level, the moisture content, and other factors. Treatment conditions for typical materials are listed below:

- Laundry: 121°C (250°F) for a minimum of 30 minutes.
- Trash: 121°C (250°F) for at least 45 minutes per bag. Size of the autoclave and size of the bags greatly affect sterilization time. Large bags in a small autoclave may require 90 minutes or more.
- Glassware: 121°C (250°F) for a minimum of 25 minutes.
- Liquids: 121°C (250°F) for 25 minutes for each gallon.
- Animals and bedding: Steam autoclaving is not recommended (sterilization time required would be at least 8 hours). Incineration in an approved facility is the recommended treatment of these wastes.

5.2 Autoclave Operation and Safety

This section provides general autoclave operation information and guidelines that should be used when applicable to the operation and as needed to ensure operator safety and sterilization. In addition, specific requirements and operational procedures noted in the autoclave owner's manual should be followed since each autoclave may have unique characteristics. The owner's manual should be readily available to answer autoclave operational questions.

5.2.1 Autoclave Instruction

The supervisor and work lead must ensure that the autoclave operator understands the autoclave hazards, controls needed to protect themselves, and any procedures necessary to accomplish sterilization for biosafety purposes.

5.2.2 Autoclave Operation Modes

Autoclaves typically use different combinations and patterns of high heat, vacuum, and pressure to sterilize the load. These combinations and patterns are used in autoclave run cycles or *runs* and are based on the type of material to be sterilized. General types of runs include *liquids* for any type of water-based solutions, *dry goods with vacuum*, and *dry goods without vacuum*. Autoclaves often have an additional *drying* cycle in which hot air is drawn through the chamber to dry materials after sterilization. Controls for different autoclaves vary, so the manufacturer's instructions regarding loading, load sizes, cycle types, and settings should be carefully followed. Additional information typical of these different run cycles is listed below:

- Liquids Run. This run is longer than the other two runs, but uses lower temperatures to minimize evaporation of the liquids being sterilized.
- Dry Goods with Vacuum Run. This run moves steam and heat into the deepest parts of large bags or bundles of materials and provides the best conditions for killing resistant organisms. During this type of run, the chamber alternates between cycles of high pressure, steam, and vacuum. It is important that steam and pressure be able reach the entire load, so bag closures should be carefully loosened once they are in the autoclave.
- Dry Goods without Vacuum Run. This run pressurizes the chamber with steam for the duration of the cycle and then returns to normal. This process is used primarily for items that have been cleaned but need to be sterilized. Materials should be packed so that the heat and pressure can readily reach the whole load.

5.2.3 Autoclave Container Selection

Bags, pans, and other containers are used in the autoclave to provide primary and secondary containment for the materials and items that need to be autoclaved. Additional considerations and practices regarding these containers include:

- Polypropylene Autoclave Bags. Autoclave or biohazard bags that may be used to contain solid materials are tear-resistant but can be punctured or burst in the autoclave. These bags should therefore be placed in a rigid container during autoclaving. Bags are available in a variety of sizes, and some are printed with an indicator that changes color when processed.
- Polypropylene Containers and Pans. Polypropylene is a plastic capable of withstanding autoclaving, but it is resistant to heat transfer. Materials contained in a polypropylene pan will therefore take longer to autoclave than the same materials in a stainless steel pan. The time required to sterilize material in a polypropylene container may be reduced by removing the container's lid, turning the container on its side, or selecting a container with the lowest sides and widest diameter that will fit in the autoclave.
- Stainless Steel Containers and Pans. Stainless steel is a good conductor of heat and is less likely to increase sterilizing time, but it is more expensive than polypropylene.

5.2.4 Autoclave Preparation and Loading

- Wear long pants, closed-toe shoes, body protection such as a lab coat, gloves, and safety glasses or goggles.
- Before loading the autoclave, check inside the autoclave for any items left behind by the previous user that could pose a hazard (e.g., sharps), and then clean the drain strainer.
- Load the autoclave properly according to manufacturer's recommendations. Typical loading practices are listed below.
- Do not autoclave items containing materials such as corrosives, solvents, volatiles, or radioactive materials that may contaminate the autoclave, create an inhalation hazard, or explode.
- Use autoclave bags and autoclavable polypropylene or stainless steel pans. Other plastics may melt.
- Load liquids as follows:
  - Fill liquid containers only half full.
  - Loosen caps or use vented closures so that heated and expanding liquids and vapors do not cause explosion of bottles or tubes.
  - Use only borosilicate glass (e.g., PyrexTM or KimaxTM) that can withstand the high autoclave temperature.
  - Use a pan with a solid bottom and walls to contain the liquid and catch spills.
- Load autoclave bags as follows:
  - Put bags into pans to catch spills.
  - Gather bags loosely at the top and secure the top with a large rubber band or autoclave tape. This will create an opening through which steam can penetrate. Bags are impermeable to steam and therefore should not be twisted and taped shut.
- Load dry goods such as glassware as follows:
  - Check plastic materials to ensure they are compatible with the autoclave.
  - Put individual glassware pieces within a heat-resistant plastic tray on a shelf or rack and not on the autoclave bottom or floor.

  - Add 1/4 to 1/2 inch of water to the tray so the bottles will heat evenly.
- Leave space between items in the load to allow steam circulation.

5.2.5 Autoclave Cycle and Time Selection

Ensure the door to the autoclave is fully closed and latched, and the correct cycle and time has been selected before starting the cycle. Cycle selection should be based on the type of items and packs to be autoclaved:

- Use liquid cycle with slow exhaust when autoclaving liquids to prevent contents from boiling over.
- Use fast exhaust cycle for glassware.
- Use fast exhaust and dry cycle for wrapped items.

Time selection should be based on the items' sizes, volumes, insulating capacity, and other characteristics as follows:

- Take into account the size of the items to be autoclaved. Larger items with more volume take longer to autoclave. For example, a 2-liter flask containing 1 liter of liquid takes longer to sterilize than four 500 ml flasks that each contain 250 ml of liquid.
- Materials with a high insulating capacity such as animal bedding or high-sided polypropylene containers increase the time needed for the load to reach sterilizing temperatures.
- Autoclave bags containing biological waste should be autoclaved for 50 minutes to ensure decontamination.

5.2.6 Removing Autoclave Loads

Practices that should be used to prevent the operator from being injured or burned while removing the load from the autoclave include:

- Wear long pants, closed-toe shoes, body protection such as a lab coat, safety glasses or goggles, and heat-resistant gloves to open the autoclave door and remove nonliquid items from the autoclave.
- When handling large volumes of liquid, wear waterproof boots (e.g., rubber), a rubber or plastic apron that extends past the top of the boots, and sleeve protectors in addition to the clothing and personal protective equipment listed above.
- Check that the run cycle is finished and the chamber pressure is zero.
- Open the door in the following manner to prevent burns caused by steam rushing out the door: Stand behind the door, slowly open the door a crack, and keep head and hands away from the opening.
- Allow liquids to cool for 10 to 20 minutes before removing the load from the autoclave. Liquids removed too soon may boil up and out of the container and burn the operator. Then let the liquids cool for an extended period (e.g., one hour) before touching the load with ungloved hands. Be sure others in the area know a heat hazard is present.
- Allow loads containing only dry glassware to cool for 5 minutes before removing the load from the autoclave. Then let the glassware cool for about 15 minutes before touching with ungloved hands.

5.2.7 Autoclave Material Staging

The following guidelines apply to staging materials for autoclaving and cleaning:

- Materials or equipment that will be reused and are contaminated with biohazardous material or waste should be autoclaved before being washed and stored.

- Laboratories and other areas where materials or equipment are staged for autoclaving or cleaning should have separate areas or containers for items designated as “Biohazardous—To Be Autoclaved” and “Not Biohazardous—To Be Cleaned.”
- Biohazardous materials or equipment being staged for autoclaving should be sterilized or safely confined and identified at the close of each workday. Such items should not be placed in autoclaves overnight in anticipation of autoclaving the next day.

5.2.8 Burn Emergencies

If you are burned, seek medical treatment as soon as possible. Burns to the face, third-degree burns, or burns over large areas of the body should be treated as emergencies. Please call 911, UAMS Police at 686-7777 and report injury to OH&S. Minor burns should be treated by using first aid procedures. These procedures include immersing the burn immediately in cool water, removing clothing from the burn area, and keeping the injured area cool for at least 5 minutes and preferably longer. Any burns to the face or eye or any burns that blister should be seen by a physician. Regardless of the degree of severity, report the burn to your supervisor and OH&S as an occupational injury.

5.3 Autoclave Maintenance and Monitoring

Assurance is needed that the autoclave is operating properly and sterilizing the load. Assurance includes routine autoclave maintenance, monitoring autoclave conditions, and maintaining documentation.

Maintenance described in the autoclave owner’s manual should be performed to ensure the autoclave is operating properly. This maintenance typically includes periodic maintenance performed by a qualified technician and more frequent maintenance procedures performed by the operator.

Monitoring the sterilization process and efficacy typically includes the use of different monitoring methods including:

- Mechanical Monitoring. Mechanical monitoring, a secondary method for ensuring sterilization, involves observing and recording physical aspects of the cycle such as temperature, pressure, or time. Thermometers, pressure gauges, clocks, and logs are commonly used to observe and record the run’s physical parameters. Some autoclaves have recording devices to assist in recording run cycle conditions.
- Chemical Monitoring. Chemical monitoring uses chemical indicators that change color or physical form when an autoclave bag or pack is exposed to certain autoclave temperatures. Examples include autoclave tape and special markings on autoclave bags that are used as external indicators on the outside of the load. These indicators are typically considered process indicators since they only show that the item has been processed through the autoclave at a certain temperature, but they do not show that:
    - Sterilization has been achieved or that a complete sterilization cycle has occurred.
    - Temperature was achieved in the innermost parts of the load unless they are carefully placed in the load. An easy way to check interior temperature is to wrap an item such as a plastic test tube or pipette tip with autoclave tape, attach string to the item, and put the item deep into the load. Then, tape the other end of the string to the outside of the bag so that the indicator can be pulled out of the bag. Recover the indicator after the run and confirm that it has also changed color. Warning: do not open a bag of material that may present a hazard to the operator (e.g., Risk Group 2 material) to bury an indicator inside.
- Biological Monitoring. Biological monitoring (or spore testing) uses live, resistant bacterial spores on strips or in self-contained vials as biological indicators that sterilization has been achieved as demonstrated by the death of the bacterial spores. Use of appropriate biological indicators at locations throughout the autoclave is considered the best and most direct indicator of sterilization. The biological indicator most widely used for wet heat sterilization is *Bacillus stearothermophilus* spores. Biological

indicators must be used to test the efficiency of the autoclave when the autoclave is used as the final treatment of the item prior to disposal as medical waste/biohazardous waste, or when the item will be reused and is contaminated with RG2 biological materials. In these cases, tests should be performed periodically, and test records should be maintained for three years.

The autoclave and process should be evaluated and corrected if monitoring indicates that the autoclave run conditions were not correct, temperatures were not sufficient as shown by chemical indicators, or spores on biological indicators were not killed. Discontinue use of the autoclave if it is not working properly and post a "do not use" sign. Mechanical failures need to be attended by a qualified autoclave technician. When the problem is corrected, the load should be re-autoclaved to ensure sterility.

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APPENDIX C

Storing Peroxide-Formers

Peroxides are very unstable and some chemicals that form peroxides are commonly used in laboratories. This makes peroxide-forming materials some of the most hazardous substances found in a lab. Peroxide-forming materials are chemicals that react with air, moisture, or impurities to form peroxides. The tendency to form peroxides by most of these materials is greatly increased by evaporation or distillation. Organic peroxides are extremely sensitive to shock, sparks, heat, friction, impact, and light. Many peroxides formed from materials used in laboratories are more shock sensitive than TNT. Just the friction from unscrewing the cap of a container of ether that has peroxides in it can provide enough energy to cause a severe explosion.

Do not open the chemical container if peroxide formation is suspected. The act of opening the container could be sufficient to cause a severe explosion. Visually inspect liquid peroxide-forming materials for crystals or unusual viscosity before opening. Pay special attention to the area around the cap. Peroxides usually form upon evaporation, so they will most likely be formed on the threads under the cap. If it is deemed safe to open the container, peroxide papers may be used for a quick determination of peroxide concentration. Peroxide papers are commercially available from laboratory supply companies.

Mark all containers with peroxide forming materials with the date received and the expected shelf life. Chemicals such as diisopropyl ether, divinyl acetylene, sodium amide, and vinylidene chloride should be discarded after three months. Chemicals such as dioxane, diethyl ether, and tetrahydrofuran should be disposed after one year.

Store all peroxide-forming materials away from heat, sunlight, and sources of ignition. Sunlight accelerates the formation of peroxides.

Secure the lids and caps on these containers to inhibit the evaporation and subsequent concentration of these chemicals.

Never store peroxide-forming materials in glass containers with screw cap lids or glass stoppers. Friction and grinding must be avoided. Also, never store these chemicals in a clear glass bottle where they would be exposed to light.

Contamination of ether by peroxides or hydroperoxides can be detected simply by mixing the ether with 10% (wt/wt) aqueous potassium iodide solution - a yellow color change due to the oxidation of iodide to iodine confirms the presence of peroxides. Small amounts of peroxides can be removed from contaminated ethers via distillation from lithium aluminum hydride (LiAlH-4-), which both reduces the peroxide and removes contaminating water and alcohols. However, if you suspect that peroxides may be present, call the OH&S for disposal. If you notice crystal formation in the container or around the cap, do not attempt to open or move the container. Call OH&S for proper disposal.

Never distill ether unless it is known to be free of peroxides.

Visual inspection of the material and its container should be conducted routinely. Indications for disposal include:

- Cloudiness in liquids
- Material changing color
- Evidence of liquids in solids or solids in liquids
- “Puddling” of material around outside of container
- Pressure build-up within bottle
- Obvious deterioration of container

APPENDIX D

Closeout Procedures for Hazardous Material Laboratories

The following are guidelines for use when faculty and staff members responsible for laboratory facilities are leaving the University or transferring to a new laboratory.

Chemicals

- All containers of chemicals must be securely closed and appropriately labeled.
- All laboratory glassware containing residues or chemicals must be emptied and disposed of appropriately.
- Please remember that UAMS has a “No Drain” policy for chemical wastes. Ensure all areas of the lab have been inspected for chemical wastes.
- Chemicals that will be transferred to other laboratories must be segregated.
- The chemicals must be packed according to compatibility and safe-handling techniques must be utilized. Contact OH&S staff for more information.
- The laboratory supervisor receiving the chemicals must provide an updated chemical inventory to OH&S.
- Fume hoods and countertops must be washed.

Gas Cylinders

- Cylinders must be disconnected; their valve caps replaced and must be returned to suppliers.
- Non-returnable cylinders must be manifested for submission to OH&S as hazardous waste.
- When empty, it is imperative to label all non-returnable cylinders as empty.
- Cylinders must be stored appropriately at all times.

Animal and Human Tissue

- Animal tissue must be separated from liquid.
- The liquid must be manifested and submitted to OH&S.
- All waste must be placed in appropriate biohazard bags and containers.

Microorganisms and Cultures

- Inventory the area and decontaminate non-regulated microorganisms.
- If samples must be saved notify your department head and ensure that another faculty or staff member takes responsibility for the samples.

Radioactive Materials

- The close-out of laboratories containing radioactive materials must be completed in collaboration with the Radiation Safety Officer.
- Transfer of radioactive materials must be approved by the Radiation Safety Officer.
- The area must have a complete survey upon removal of radioactive materials.

- All equipment including items for surplus must be surveyed.
- When necessary additional decontamination procedures must be completed until the survey proves the instrumentation/equipment has reached releasable limits.
- See Radiation Safety Manual for more information.

APPENDIX E

Hazardous Waste Management Plan - Part II
University of Arkansas for Medical Science
Program Overview

INTRODUCTION

Hazardous Waste Management Program is designed to:

1. Minimize environmental impacts;
2. Minimize potential liabilities from University activities;
3. Complies with Federal, State, and local regulations.
4. Protects employees, students, and visitors.

PURPOSE

The Hazardous Waste Management Plan will address the requirements of the RCRA regulations written by the Arkansas Department of Environmental Quality (ADEQ) Regulation 23 and Arkansas Department of Health, Rules and Regulations, Medical Waste from Generators and Health Care Related Facilities.

SCOPE

This plan refers to all hazardous waste generated by campus laboratories, classrooms, research areas, clinical areas and operations, and to all faculty, staff, and students who have the potential to handle hazardous chemicals or waste. UAMS Administrative Guide policy, 11.4.24, implements the Hazardous Waste Management Program. Part II is the UAMS Hazardous Waste Management Plan. Copies of Part II will be maintained by the UAMS Occupational Health and Safety Department (OH&S) and is available on the OH&S website. Questions regarding this policy may be directed to OH&S.

DEFINITION

<u>Hazardous Waste</u>: A waste that is listed in the RCRA regulations found in 40 CFR on one of the four hazardous waste lists (F-list, K-list, P-list, or U-list), or exhibits at least one of four characteristics – ignitibility, corrosivity, reactivity, or toxicity. These wastes have properties that make them dangerous or potentially harmful to human health or the environment. Hazardous waste may be liquid, solid, contained gases, or sludges. They can be the by-products of manufacturing processes or simply discarded commercial products, like cleaning fluids, pesticides, or leftover chemicals as defined in the RCRA Regulations.

<u>Universal Waste:</u> a subsection of hazardous wastes that are managed under the RCRA regulations as universal wastes. These include batteries, certain pesticides, mercury-containing equipment, and spent mercury-containing lamps.

<u>Used Oil</u>: Used oil means any oil that has been refined from crude oil, or any synthetic oil, that has been used and as a result of such use is contaminated by physical or chemical impurities.

<u>Medical Waste</u>: Regulated medical waste is waste which may contain:

Pathological waste – waste which contains all human unfixed tissues, organs and anatomical parts, other than intact skin, which emanate from surgeries, obstetrical procedures, dental procedures, autopsies and laboratories. Such waste shall be exclusive of bulk formaldehyde and other preservative agents.

Liquid or semi-liquid blood such as human blood, human blood components and/or products made from human blood (e.g., serum, plasma) and other potentially infectious materials, to include regulated human body fluids such as semen, vaginal secretions, cerebrospinal fluid, pleural fluid, pericardial fluid, synovial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood and all body fluids where it is difficult or impossible to differentiate between body fluids, not to include urine or feces, which cannot be discharged into the collection system of a publicly owned treatment works (POTW) within the generating facility.

Contaminated items to include dressings, bandages, packings, gauze, sponges, wipes, personal protective equipment, cotton rolls and balls, etc., which cannot be laundered or disinfected and from which blood, blood components, or regulated body fluids drip freely, or that would release blood or regulated body fluids in a liquid or semi-liquid state if compressed or are caked with dried blood or regulated body fluids and all capable of releasing these materials during handling.

a. Contaminated disposable, single-use gloves such as surgical or examination gloves shall not be washed or decontaminated for reuse and are to be handled as a contaminated item.

b. Protective coverings such as plastic wrap and aluminum foil used to cover equipment and environmental surfaces when removed following their contamination are considered a contaminated item.

c. All patient care items from hospital isolation rooms and end-stage renal dialysis units, or from patients with communicable diseases, which cannot be laundered and which are contaminated with regulated body fluids or blood or potential infectious material, must be considered a contaminated item.

Microbiological waste which includes, but is not limited to, cells and tissue cultures, culture medium or other solutions and stocks of infectious agents, organ cultures, culture dishes, devices used to transfer, inoculate and mix cultures, paper and cloth which has come in contact with specimens or cultures and discarded live vaccines.

Contaminated sharps which includes, but is not limited to, any contaminated object that can penetrate the skin, e.g., hypodermic needles, intravenous tubing with needles attached, syringes with attached needles, razor blades used in surgery, scalpel blades, Pasteur pipettes, capillary tubes, broken glass from laboratories, and dental wires. (Potential breakable container(s) of blood, regulated body fluid, microbiological waste, or infectious material must be treated as contaminated sharps when disposed of.

ROLES AND RESPONSIBILITIES

Occupational Health and Safety (OH&S):

- Maintain hazardous waste site operations registrations.
- Develop and maintain protocols for the University's Hazardous Waste Management Plan.
- Act as the point of contact for United States Environmental Protection Agency (EPA) and Arkansas Department of Environmental Quality (ADEQ).
- Obtain analysis of waste streams when constituents/concentrations are unknown.
- Develop and maintain hazardous waste profiles for all materials shipped from the facility.

- Assist with training Hazardous Waste Handlers annually.
- Ensure Hazardous Waste is packaged and labeled per Department of Transportation requirements.
- Schedule and complete periodic shipments to remain within the permitted accumulation time for the facility.
- Offer all hazardous wastes for shipment on EPA Uniform Hazardous Waste Manifests.
- Sign reports and notification forms submitted to United States Environmental Protection Agency or Arkansas Department of Environmental Quality
- Ensure shipping containers of 55 gallons or less are marked with "Hazardous Waste - Federal Law prohibits improper disposal
- Minimize waste generation where possible.
- Maintain inventory of hazardous waste generated in the department and
- Identify and train Hazardous Waste Handlers for each area that generates chemical waste.
- Contact OH&S Office at 686-5536 or through the online service for waste removal, scheduling waste pick-ups, and other relative waste management tasks.
- Maintain inventory of waste management supplies such as containers, labels, secondary containment, spill absorbent, handling tools, funnels, etc
- Transport and packaging of medical waste for disposal by vendor.
- Assist staff with bloodborne pathogens training.

Hazardous Waste Handlers:

- Attend initial and annual refresher training.
- Wear safety glasses/goggles and any other specified personal protective equipment when handling hazardous wastes.
- Inspect waste containers before use.
- Ensure waste is properly identified with chemical identity and labeled as hazardous waste.
- Ensure that waste containers are kept closed.
- Ensure waste containers have secondary containment, such as plastic trays or tubs.
- Accumulate used chemical products in designated containers.
- Keep waste separated by compatibility. Segregate incompatible wastes, such as flammables and miscellaneous items from corrosives and oxidizers.
- Maintain waste containers, satellite accumulation areas and storage accumulation facilities.
- Maintain appropriate container labeling and collection records.
- Inspect hazardous waste accumulation areas weekly and document inspections.
- Properly dispose of empty containers by triple rinsing before discarding.
- Properly segregate biohazardous waste from other types of waste.
- Properly store biohazardous waste for pickup by biohazard team.

STORING WASTE

Per RCRA regulations, chemical hazardous waste may be stored in two different types of areas:

1. Satellite Accumulation Area/OH&S Lab
2. Flammable Storage.

Biohazardous waste is accumulated in the clinical setting in biohazard waste closets. The Biohazard team will have routine pickups in clinical areas to remove waste from the biohazard closets. Research labs accumulate waste at the site of generation. Staff notifies the biohazard team when a pickup is needed. All biohazard waste is stored before transport in the biohazard waste facility and is shipped five days a week, Monday – Friday.

1. F-Level Parking 2

Satellite Accumulation Areas

Satellite accumulation containers storing incompatible hazardous chemical wastes must be physically segregated, labeled as to contents and with the words “hazardous waste”, and kept closed. Segregation and containment may be provided by storing the containers in plastic trays or bins.

Satellite accumulation areas must maintain less than 55 gallons of hazardous waste or the area will be determined to be an Accumulation Area. If 55 gallons are collected within the satellite accumulation area or if a waste container is full, the container label must be labeled and dated with the accumulation date. The accumulation date is the date on which the container becomes full and/or is being moved to the Accumulation Area to wait for disposal. When full, the container must be moved to the Accumulation Area within 3 days. Each department is responsible to maintain and control inventory of waste volume per satellite accumulation area and for ensuring that waste containers are properly labeled, kept closed, correctly segregated, and placed in secondary containment.

Inspect Satellite Areas once a week per Arkansas Department of Environmental Quality Regulation 23

Flammable Storage Area shall be inspected weekly for xylene, Sodium Azide (N3Na) leaks and evidence of deterioration. Inspection results or observations shall be recorded on the Hazardous Waste Accumulation Area Inspection Form and maintained on file within the OH&S department. Keep completed inspection forms on file for 3 years in a place readily accessible for EPA or ADEQ inspections.

Accumulation Containers and Labeling:

- Containers used to accumulate hazardous chemical waste must be in good condition and compatible with the waste.
- Containers shall be kept closed except when adding or removing waste.
- The containers must be clearly labeled as hazardous waste.
- The container must also be labeled with the waste name and accumulation start date.
- The accumulation start date is the date in which the container is placed in the accumulation area.
- Labels must be visible, legible, and durable.
- Biohazardous waste must be placed in red liners and/or in containers clearly labeled with the biohazard sign.

UNIVERSAL WASTE AND USED OIL CONTAINERS

Universal waste containers i.e. lamps, batteries, mercury containing equipment, must be labeled as universal waste and with the identity of the contents. They must be kept closed.

Used oil should be labeled as used oil. No further description is necessary on the label.

WASTE DETERMINATION & CHARACTERIZATION

It is the generator’s responsibility to determine when waste is a waste. In a coordinated effort between the generators of the waste, the OHS Office, and contracted Treatment, Storage and Disposal Facilities (TSDF), waste characterization will be determined and a profile will be developed if not already existing.

WASTE PROFILES

- As new waste streams are generated, profiles will be developed through coordinated efforts of the generator of the waste stream, Chemical Lab Packs require profiling before shipment.
- Waste profiles are maintained in the OH&S Office.

TREATMENT OF WASTE

Treatment of chemical waste by the generator is prohibited under RCRA regulations. This includes, but is not limited to the neutralization of acids and bases, evaporating chemicals in a fume hood, and so on.

MANIFESTS

Signing the Hazardous Waste Manifest

- Only personnel who have received training per CFR 40 in Hazardous Waste Management may sign the manifest.
- No other person is authorized to sign the manifest.

Hazardous Waste Manifest Recordkeeping

A completed manifest is the copy that has been signed by a representative of the Treatment, Storage or Disposal Facility. This signifies that the shipment has reached its destination. Once the completed manifest is received, it will be filed in the hazardous waste files located in the OH&S Office.

- If a completed manifest is not received back within 35 days, the OH&S Office will contact the designated facility and determine if the shipment has been received.
- When the manifest package is complete the OH&S Office will place this record into the Hazardous Waste files.
- Manifests for the active year plus the previous three years shall be kept on file in a readily accessible location and filed along with other manifests will be archived indefinitely.

REGULATORY REFERENCE

Federal Regulation- 40 CFR Parts 260-270
Federal Regulation- 40 CFR Part 273
Federal Regulation- 40 CFR Part 279
Federal Regulation- 49 CFR Parts 170-172
Arkansas Rules and Regulations; Act 96 of 1913 as amended, Act 41 of 1992, Act 491 of 1993, and Act 861 of 1993, Act 150 of 1999
Hazardous Materials and Waste Management, Administrative Guide, 11.4.24

UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES
HAZARDOUS WASTE MANAGEMENT PLAN
Part II

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APPENDIX C. CHEMOTHERAPY DRUG SPILL CHECKLIST

1.0 INTRODUCTION

The goal of the University of Arkansas for Medical Science Hazardous Waste Management Plan (HWMP) is to protect the health and safety of employees, students, and the environment while complying with applicable state and federal regulations. Implementation of a waste minimization program is vital to an effective hazardous waste management program. Utilizing procedures established within the HWMP the quantity and cost of hazardous waste disposals can be effectively reduced, the environment will be protected and employee safety will be enhanced. Planned purchases of only necessary quantities chemicals and closeouts of laboratories will greatly reduce the hazardous waste output at UAMS.

The objective of this plan is to define the University of Arkansas for Medical Science (UAMS) responsibilities under federal and state regulations governing hazardous waste disposal and to outline a program for compliance with those regulations. This plan is intended to provide instructions for UAMS faculty and staff in the management of hazardous waste. Information contained in this manual is applicable to all University divisions, centers, schools, and departments. Since laboratory work frequently produces an unpredictable variety of wastes, much of the information provided within this document specifically addresses laboratory waste disposal.

The United States Environmental Protection Agency has implemented strict rules and regulations pertaining to the handling and disposal of hazardous wastes. The Resource Conservation and Recovery Act (RCRA) establish the cradle-to-grave concept. This concept involves the tracking of a hazardous waste from the point of generation through its final disposition. If UAMS is found to be in violation of RCRA laws, UAMS can be fined up to $32,500 per day per violation. Additionally, criminal charges may be brought against individuals who knowingly violate state, federal, or local regulations. Failure to follow guidelines established within the UAMS Hazardous Waste Management Plan could result in disciplinary action not to exclude termination of employment.

UAMS at times produces more than 100 kilograms of hazardous waste in a month, and thus must meet the requirements regulating a small quantity generator, as established by the Resource Conservation and Recovery Act (RCRA). If at any time the University generates more than 1000 kilograms of hazardous waste or greater than one liter of acutely hazardous waste in one calendar month, the requirements for large quantity generators will be applied to the UAMS HWMP. The applicable Environmental Protection Agency (EPA) regulations (40 CFR 261) are very demanding and require cooperation of all campus generators to meet compliance requirements.

Guidelines established in the plan are intended to create an awareness of chemical wastes that require special disposal and management procedures involved. Specific procedures for continuous operations (longer than one month) generating hazardous waste are to be developed by the overseeing laboratory director or facility manager and approved by the UAMS Occupational Health & Safety Department (OH&S).

The Hazardous Waste Management Plan shall serve as a guidance document for UAMS employees to meet the challenges for providing a safe, environmentally sound, and unified response for chemical waste management. Note that certain laboratory procedures that have been acceptable in the past, including pouring chemicals down the drain and evaporation of solvents in the fume hood, is unacceptable. All UAMS personnel involved in any waste disposal process must read and have a thorough knowledge of the procedures contained within this guidance document. Each individual's participation is critically important in making the UAMS Hazardous Waste Management Plan reliable, safe, and efficient.

2.0 HAZARDOUS WASTE DISPOSAL REGULATIONS

The federal government has aggressively approached the regulation of hazardous wastes. In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), and four years later the Environmental Protection Agency (EPA) issued complex and stringent regulations to implement Subtitle C of RCRA. In 1984 the Hazardous and Solid Waste Amendments became law, substantially revising and extending the scope of RCRA. The federal government has established a comprehensive cradle to grave system of monitoring hazardous wastes from the point of generation through the point of disposal. This system is still undergoing changes, especially with regard to wastes that are classified as hazardous. Sanctions for noncompliance with EPA regulations are severe; they include criminal prosecution and fines of up to $32,500.00 per occurrence per day.

RCRA regulations are worded primarily to effectively control wastes produced by single waste-stream industrial generators, but are applicable to universities as well. UAMS must not store, process, dispose of, transport, or offer for transport any hazardous waste without having received an EPA identification number. Nor can UAMS offer hazardous waste to transporters or Treatment, Storage and Disposal Facilities (TSDFs) which have not received an EPA identification number. Before transporting hazardous waste to an off-site facility, all requirements for packaging, labeling, marking and placarding must be met. In addition, a uniform hazardous waste manifest must be properly executed and accompany each shipment. Any state that the hazardous waste shipment is transported through may also require a hazardous waste manifest specific for the state.

UAMS cannot treat hazardous waste on-site. Only an EPA permitted disposal facility can legally landfill, incinerate, or recycle hazardous waste under the "cradle to grave" system. A waste generator never loses liability for environmental damage. For this reason, transporters and disposal facilities must be carefully chosen. The OH&S determines the TSDF through the bid system. Stringent criteria have been established to minimize environmental risk and University liability.

The EPA and the Arkansas Department of Environmental Quality (ADEQ), who periodically perform inspections of hazardous waste collection procedures, documentation, and storage facilities, jointly enforce the regulations governing hazardous waste storage and disposal at UAMS.

Regulations concerning small quantity generators are applicable to institutions or industries that generate between 100 and 1000 kilograms of hazardous waste per month. Generation at UAMS may occasionally exceed 100 kilograms a month. Therefore ,UAMS must comply fully with the regulations pertaining to small quantity generators. These regulations specify procedures and requirements for: 1) hazardous waste identification, 2) shipping, 3) reporting, 4) accumulation time limits, 5) general sampling and waste analysis, 5) personnel training, 6) emergency contingency planning, and 7) record keeping. UAMS is allowed to accumulate hazardous waste on-site for a maximum of 180 days as long as Small Quantity Generator status (100 - 1000kg/month of hazardous waste or <1kg/month of acutely hazardous waste) is not exceeded. If at any time UAMS produces more than 1000 kilograms per month of hazardous waste, regulations pertaining to Large Quantity Generator status must be implemented to include an accumulation time limit of 90 days. All waste must then be transported to a permitted off-site waste disposal facility for further treatment, disposal, or recycling.

Local, state and federal law forbids the discharge of any hazardous waste into the public sanitary sewer system. In addition, due to recent developments, it is policy of UAMS that no chemical wastes, laboratory or otherwise, be discharged into the sanitary sewer system. Any questions concerning the discharge of materials into the sanitary sewer system must be directed to the Environmental Programs Manager at 686-6958.

In conclusion, by state and federal guidelines, UAMS is required to manage hazardous wastes in a safe and environmentally sound manner. All generators of hazardous waste are held legally responsible for ensuring that the applicable regulations concerning the management and disposal of hazardous waste within your departments, laboratories, shops, or service areas are followed. The following sections are the basis of University policy.

3.0 HAZARDOUS WASTE MANAGEMENT SYSTEM

Chemical waste generated at UAMS must be managed with proper identification, labeling, storage, and disposal of materials that are regulated as hazardous waste. The hazardous chemical waste management system must achieve three goals:

1. Protection of employee health and safety
   Proper evaluation, packing and labeling protects the health and safety of employees handling or potentially exposed to hazardous chemical waste.

2. Reduction of hazardous chemical waste volume in the laboratory
   The volume of hazardous chemical waste generated at the University can be reduced by:
   a. Disposal of non-hazardous wastes separately from hazardous chemical wastes.
   b. Utilizing procedures for chemical waste minimization (Lab Safety Manual).
   c. Recycling of unused and reusable chemicals in teaching and research laboratories.

3. Compliance with regulations
   To ensure that UAMS is in compliance with federal, state, and local regulations regarding packing, labeling, storage, transportation, and disposal of hazardous chemical wastes.

Wastes requiring special consideration that are not hazardous chemical wastes are:

1. Non-hazardous solid waste includes garbage, rubbish, paper, cardboard, aluminum cans, and glass. These items are collected and disposed of by the Grounds Department of Facilities and Operations. Glass from laboratory operations must be thoroughly rinsed and or decontaminated and disposed of in a glass receptacle. Persons responsible for the laboratory must securely seal these containers prior to removal from the laboratory.

2. Bio-hazardous waste includes, but is not limited to, tissue specimens, preserved specimens, and blood or other body fluids (Refer to the Biological Safety Plan for a complete listing). Departments generating bio-hazardous waste must have procedures in place for disposal of these wastes.

3. Low level radioactive waste includes, but is not limited to, radioactive solid lab trash, radioactive aqueous based wastes, radioactive flammable solvent based wastes, and liquid scintillation solutions. Disposal of radioactive waste is managed under the guidelines established in the UAMS Radiation Safety Program. For more information contact the Occupational Health & Safety, RSO 686-7803 or 686-5550.

Compounds identified in the Non-hazardous Chemical Registry, Appendix B, should also be disposed of via the hazardous waste program. If they are components of a mixture with hazardous materials, the mixture is considered hazardous waste.

4.0 IDENTIFICATION AND DISPOSAL OF WASTES

The Occupational Health & Safety is available to provide advice and guidance concerning the regulatory considerations of any proposed disposal. This office is also responsible for record keeping and arranging for the ultimate disposal of University generated hazardous wastes.

5.0 HAZARDOUS WASTE DETERMINATION

The question of primary importance to most generators is "What wastes require special consideration?" On the basis of EPA criteria and the Arkansas Department of Environmental Quality Regulation 23, chemical waste is considered hazardous if it is a Listed Hazardous Waste as described in Regulation 23 261 (see Appendix A). A waste is also considered hazardous if it exhibits any of the following characteristics: 1) ignitability, 2) corrosiveness, 3) reactivity, or 4) toxicity; as described in Sections 5.1.1 through 5.1.4.

5.1 Characteristic Wastes

Certain wastes are regulated under the Resource and Conservation Recovery Act (RCRA) based on characteristics of ignitability, reactivity, corrosiveness, and/or toxicity. If a waste meets one or more of these criteria and is not specifically excluded, it is regulated and must be disposed of through OH&S. Each of these categories is briefly summarized below.

5.1.1 Ignitable Waste

Any waste having a flash point of less than 60°C (140°F) is classified as an ignitable waste. The only exception is an aqueous solution containing less than 24% alcohol where alcohol is the only ignitable constituent. This exception is made because alcohol solutions at this concentration exhibit low flash points and are not capable of supporting combustion.

Conservative estimates of flash points should be made based on information found on the label of the container and on the Safety Data Sheets (SDS).

Any chemical designated as a flammable liquid for shipping purposes will exhibit the characteristics of ignitability. Chemicals shipped as combustible liquids have flash points between 60.5°C (141°F) and 93°C (200°F), and therefore may be classified as an ignitable waste depending on the material's actual flash point. Please note that there are different requirements for flammability classifications from EPA and the Department of Transportation (DOT).

Solids are regulated as ignitable waste if the material is capable of ignition through friction, moisture absorption, or spontaneous chemical changes and, when ignited burns so vigorously and persistently that it creates a hazard. Any solid material identified as flammable on the container, shipping paper, or SDS, should be disposed of as a regulated ignitable waste.

RCRA also regulates oxidizers as ignitable wastes. The following common chemicals are
characterized as oxidizers at certain concentrations:

- ✓ Chlorates
- ✓ Chromates
- ✓ Chromium Trioxide

- ✓ Dichromates
- ✓ Hydrogen Peroxide[1]
- ✓ Perchlorates
- ✓ Peroxides
- ✓ Permanganates
- ✓ Persulfates

5.1.2 Corrosive Waste

Any waste that exhibits the characteristic of corrosiveness is regulated as a hazardous waste. The regulations define this as any material with a pH of less than 2 or greater than 12.5, or any material which will corrode steel at a rate greater than 6 mm (0.25 in.) per year. Wastes included in this category are solutions of strong acids and bases in concentrations greater than 0.01N. RCRA regulations permit spent corrosives to be neutralized by the generator. Neutralization must occur in a container compatible with the chemical(s) to be neutralized and must take place at the site where the wastes are generated. Note: Any precipitated material produced during neutralization must be collected and properly characterized prior to disposal.

5.1.3 Reactive Waste

Disposal of waste that is shock sensitive, unstable, reacts violently with air or water, or generates H_2S or HCN in pH conditions between 2 and 12.5 are regulated as a reactive waste. With the exception of cyanide and sulfide solutions most reactive waste should only be disposed of with the assistance of explosives experts. The generation of these wastes must be avoided whenever possible. Some common chemicals that are classified as explosives include:

- ✓ Picric acid and other polynitroaromatics, in dry form
- ✓ Old ethers and other peroxide forming organics
- ✓ Peroxides, transition-metal salts
- ✓ Perchlorate salts
- ✓ Diazonium slats, when dry
- ✓ Chlorite salts of metals, such as $AgClO_2$
- ✓ Azides, metal, nonmetal, and organic

5.1.4 Toxic Waste

A waste exhibits the characteristic of toxicity if, using the EPA's Toxicity Characteristic Leachate Procedure (TCLP), a representative sample of the waste contains any of the contaminants listed in Table 5-1 at the concentration equal to or greater than the regulatory limit.

Identification of materials regulated as hazardous waste is complicated by discrepancies in definitional guidelines used by the Environmental Protection Agency (EPA), Department of Transportation (DOT), and state agencies. The process of identification of hazardous chemical waste, therefore, must incorporate an understanding of the framework of EPA, DOT, and ADEQ.

5.2 Acutely Hazardous Waste

Stock reagents and stock reagent containers of certain chemical compounds are strictly regulated as acutely hazardous waste. Rinsate and dilute spill cleanup material contaminated with these compounds are regulated.

Appendix A provides a list of compounds regulated under this category. The regulations regarding acutely hazardous waste are much more stringent than those for other hazardous wastes are. For example, accumulation at the point of generation is limited to only one quart or 1kg of an acutely hazardous waste.

5.3 Organic Solvents

RCRA identifies certain chemicals used as organic solvents under a specific set of regulatory requirements. At UAMS, all organic solvents should be collected for disposal as hazardous waste.

Table 5-1 Toxicity Characteristic Contaminants

D004	Arsenic	5.0
D005	Barium	100.0
D018	Benzene	0.5
D006	Cadmium	1.0
D019	Carbon Tetrachloride	0.5
D020	Chlordane	0.03
D021	Chlorobenzene	100.0
D022	Chloroform	6.0
D007	Chromium	5.0
D023	o-Cresol	200.0[2]
D024	m-Cresol	200.0[2]
D025	p-Cresol	200.0[2]
D026	Cresol	200.0[2]
D016	2,4-D	10.0
D027	1,4-Dichlorobenzene	7.5
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethylene	0.7
D030	2,4-Dinitrotoluene	0.13[3]
D012	Endrin	0.02
D031	Heptachlor	0.008
D032	Hexachlorobenzene	0.13[3]
D033	Hexachlorobutadiene	0.5
D034	Hexachloroethane	3.0
D008	Lead	5.0
D013	Lindane	0.4
D009	Mercury	0.2
D014	Methoxychlor	10.0
D035	Methyl ethyl ketone	200.0
D036	Nitrobenzene	2.0
D037	Pentachlorophenol	100.0
D038	Pyridine	5.0
D010	Selenium	1.0
D011	Silver	5.0
D039	Tetrachloroethylene	0.7
D015	Toxaphene	0.5
D040	Trichloroethylene	0.5
D041	2,4,5-Trichlorophenol	400.0
D042	2,4,6-Trichlorophenol	2.0
DO17	2.4.5-TP Silvex	1.0
D043	Vinyl Chloride	0.2

[1] EPA hazardous waste number. [2] Cannot be differentiated; Total Cresol is used. [3] Quantitation limit is higher than the regulatory limit. Quantitation number therefore becomes the regulatory limit.

6.0 WASTE MINIMIZATION

To attain the UAMS chemical waste management goals, the University strongly encourages its employees to utilize chemical waste minimization (waste reduction) techniques to reduce the volume and toxicity of chemical wastes produced at the University. An important benefit from waste minimization is that it reduces pollution that is directly related to quality of life indices. Even the best managed hazardous waste management programs produce quantities of pollution. Waste minimization decreases the expenses of ever-increasing chemical disposal costs. Generators should therefore modify procedures to eliminate or minimize the generation of hazardous waste by following common waste minimization techniques.

6.1 Minimizing Reactive Waste

Materials that are considered reactive require special handling; hence the disposal of these materials is difficult and costly. Chemicals that are allowed to become shock or temperature sensitive present significant explosion hazards and cannot be landfilled or incinerated. Disposal of these chemicals can only be accomplished by detonation by explosives experts. The generation of reactive waste should be avoided.

Laboratory safety can be enhanced by the elimination of generating reactive waste by purchasing peroxide forming organics in quantities that are assured of being used within a short period of time. Containers of the following chemicals should be labeled with the date they are opened and discarded and disposed of within three months of the open date.

Diisopropyl Ether (isopropyl ether)
Divinylacetylene
Potassium metal
Potassium Amide
Sodium Amide
Vinylidine Chloride

The chemicals listed below should be dated when opened and discarded within six months of that date:

Acetyaldehyde Diethyl Acetal (acetal)
Chloroprene (2-chloro-1,3-butadiene)
Cumene (isopropyl benzene)
Cyclohexane
Cyclopentene
Decalin (decahydronaphthalene)
Diacetylene (butadiene)
Diethyl ether (ether)
Diethylene Glycol Dimethyl Ether (diglyme)
Dioxane
Ethylene Glycol Dimethylether (glyme)
Ethylene Glycol Ether Acetates
Ethylene Glycol Monoethers (cellusolve)
Furan
Methylacetylene
Methylcyclopentane
Methylisobutyl Ketone
Styrene

Tetrahydrofuran (THF)
Tertalin (tetrahydronapthalene)
Vinyl Ethers

In addition, containers of picric acid and similar compounds should be labeled with a checklist for monthly addition of water sufficient to form a paste equivalent to 10% moisture by weight. **Reactive wastes should not be moved.** Contact the OH&S 686-6958 to arrange for pick-up.

6.2 Minimizing Quantities

It is common practice to order larger quantities of stock chemicals than necessary to take advantage of volume discounts. As a result, aging reagents or solvents are often left for disposal. This may result in disposal costs that are greater than the original savings. It is estimated that as much as 40% of laboratory waste may result from unused stock chemicals. Besides reducing disposal costs, smaller inventories reduce potential chemical exposure to personnel, thus minimizing the risks and severity of accidents.

6.3 Recycling

Many materials treated as chemical waste are actually surplus chemicals that are reusable. To assist waste reduction it is recommended that unopened or unwanted chemicals are transferred to laboratories where they may be used. OH&S has begun the recycling of unopened or unwanted chemicals. Recycled chemicals are provided free of charge to any interested University department or research laboratory that may have a need for these chemicals.

Laboratories are required to develop schedules for routine inventory, cleaning, and removal of chemicals that are no longer needed. These chemicals are a liability and represent a future expense as waste. OH&S can determine if these chemicals are suitable for recycling or if they should be disposed of as hazardous waste.

Note: Certain chemicals are particularly desirable for recycling and include the following:

Solvents
Acetone
Chloroform
Dichloromethane (Methylene Chloride)
Ethyl Acetate
Hexanes
Isopropyl Alcohol
Methanol
Petroleum Ether

Acids
Acetic Acid (glacial)
Hydrochloric Acid
Sulfuric Acid

Oxidizers
Bromine
Potassium Chlorate
Potassium Dichromate
Silver Nitrate

6.4 Substitution

Substitution of a non-hazardous or less hazardous chemical in place of a hazardous chemical is a commonly used method of reducing waste. A simple example of this is to change a cleaning agent from a toxic, flammable solvent to an appropriate soap or detergent solution. Other examples of substitution are: 1) the use of detergent instead of chromic acid in the cleaning of glassware; 2) the use of water based paints and cements over solvent based; 3) substituting non-halogenated, non-aromatic solvents for solvents such as benzene, methylene chloride, or carbon tetrachloride; and 4) avoiding the use of potentially explosive chemicals such as ethers or picric acid whenever possible.

6.5 Reduction of Scale

Experimental laboratory procedures should be set up on as small a scale as possible. The use of methods requiring micro-quantities and equipment to handle these small volumes allow chemical reactions to be carried out on a much smaller scale than previously possible. For example, chromatographic techniques enable separation/purification of microgram quantities. Significant savings in chemicals, apparatus, and disposal costs can result.

6.6 Donations, Free Samples, and Government Surplus of Chemical Items

UAMS personnel must not accept chemical donations, free samples or purchase large quantities of government surplus of chemical items that will later become a disposal problem. These items should not be accepted unless there is an immediate need and adequate storage space available. No chemical should be accepted which has a limited shelf life unless for immediate use and in exact quantities. No University representative shall accept any chemical item: 1) without an accompanying Safety Data Sheet, and 2) in an original labeled container, that includes a shelf life date.

6.7 Unknowns

Unknowns are a special problem in laboratories, especially with regard to a change in management and/or personnel. Therefore, it is important to incorporate maintenance schedules for routine laboratory inventories and cleanup and closeout in departmental procedures. Outdated and unwanted chemicals must be disposed of prior to personnel changes that would result in the new management of a laboratory, shop, storage facility, etc. Guidelines for characterizing unknowns are available in the Laboratory Safety Manual. Laboratory closeout procedures are also available in the Laboratory Safety Manual.

When responsible parties are leaving the University or changing laboratories, lack of laboratory closeout is a primary source of unknown chemicals. When an unknown is discovered, an intensive attempt at identification must be made. Usually consulting individuals who may have worked in the laboratory where the unknown was found can help to identify the contents. If this fails, the compound must be analyzed. Generation of unknowns should be avoided by performing periodic inspections of chemicals in the laboratory to ensure that each is properly labeled. All waste containers must be labeled with 1) the chemical name, 2) the concentration(s), 3) the volume, and 4) the date a chemical was added to a mixture. In addition, waste containers must meet all labeling requirements as found in the Laboratory Safety Manual.

7.0 HAZARDOUS WASTE COLLECTION PROCEDURES

The following information applies to wastes that have been identified as hazardous, either appearing on the EPA's regulatory lists or displaying one or more characteristics including ignitability, corrosiveness, reactivity, or toxicity. All University chemical waste ready for shipment is currently stored in a secured hazardous materials storage building. All wastes are classified and sorted by OH&S personnel prior to final disposal. By regulation, UAMS may store hazardous wastes at a single facility-wide storage area. However, each laboratory generating hazardous waste on campus is considered a Satellite Hazardous Waste Accumulation Area. Accumulation within these areas must: 1) be under the control of the person in charge of the waste generating process, and 2) the volume of hazardous waste may not exceed 55 gallons or one quart of acutely hazardous waste. It is important that you contact OH&S for a waste pickup prior to accumulating this amount of waste in your laboratory. Proper controls must be in place in all hazardous waste accumulation areas as described below.

8.0 CHEMICAL SPILL PLAN

CHEMICAL SPILL PLAN

A department experiencing a chemical spill can often perform clean up procedures with little or no outside help. If additional assistance is needed, the Department of Occupational Health and Safety will be contacted. Spill response will vary widely depending on circumstances. For purposes of preplanning, most spill scenarios can be characterized as to whether a known or unknown chemical is involved and if the spill is or is not confined to a laboratory hood.

Known Chemical Spilled in Laboratory Hood.

The first consideration is the safety of building occupants. If there appears to be immediate danger of fire, explosion or extensive vapor migration from the spill area, close the hood sash, initiate area evacuation and notify Occupational Health and Safety (686-5536), 7:30-4:30, Monday-Friday or Campus Operations Call Center (526-0000) after hours. If there is no immediate danger apparent, close the hood sash and locate a Safety Data Sheet (SDS) for the chemical. The SDS will include spill clean-up procedures. In many cases this will require a spill kit and protective equipment. Usually, the SDS will not provide detailed guidance for disposal, other than "comply with existing laws." The Department of Occupational Health and Safety can provide technical assistance or equipment, if needed during any step of the response. If employee injury/exposure is known or suspected, send the individuals to Student Employee Health Services (SEHS) or the Emergency Department. Notify OH&S that the spill occurred, even if their assistance was not required. This will insure notification to outside agencies, if necessary. Complete a UAMS Incident & Injury report form.

a. Unknown Chemical Spilled in Laboratory Hood

The first consideration is the safety of building occupants. If there appears to be immediate danger of fire, explosion, or extensive vapor migration from the spill area, close the hood sash, initiate area evacuation, and notify Occupational Health and Safety (686-5536), 7:30-4:30, Monday-Friday or Campus Operations Call Center (526-0000) after hours. If there is no immediate danger apparent, close the hood sash and contact other lab personnel who would possibly know the identity of the spilled substance. If the identity is established, follow the procedures for known chemical spill. If the identity cannot be established, contact the Department of Occupational Health and Safety for assistance in identification, neutralization and cleanup. If employee injury/exposure is known or suspected, send the individuals to Student Employee Health Services or the Emergency Department. Complete a UAMS Incident & Injury Report form.

Known Chemical Spilled (Not in Lab Hood)

The first consideration is the safety of individuals in the area. If there appears to be immediate danger of fire, explosion, or extensive vapor migration from the spill area, initiate evacuation and notify Occupational Health and Safety (686-5536), 7:30-4:30, Monday-Friday or Campus Operations Call Center (526-0000) after hours. If there is no immediate danger apparent, control the area and obtain an SDS for the chemical. The SDS will contain spill clean-up procedures. A spill kit and protective equipment will often be required. The SDS will often provide non-specific guidance for disposal such as “comply with existing laws.” Consult OH&S if technical assistance or equipment is needed during any step of the response. If employee injury/exposure is known or suspected, send the individuals to Student Employee Health Services or the Emergency Department. Notify the Department of Occupational Health and Safety (686-5536) that the spill occurred, even if their assistance was not required. This will insure notification to outside agencies, if necessary. Complete a UAMS Incident & Injury Report form.

Unknown Chemical Spilled (Not in Lab Hood)

The first consideration is the safety of individuals in the area. If there appears to be immediate danger of fire, explosion, or extensive vapor migration from the spill area, initiate evacuation and notify Occupational Health and Safety (686-5536), 7:30-4:30, Monday-Friday or Campus Operations Call Center (526-0000) after hours. If there is no immediate danger apparent, control access to the area and contact others who work in the vicinity who could possibly know the identity of the spilled substance. If the identity is established, follow the procedures for known chemical spill. If the identity cannot be established, contact the Department of Occupational Health and Safety for assistance in identification and follow on actions. If employee injury/exposure is known or suspected, send the individuals to Student Employee Health Services or the Emergency Department. Complete a UAMS Incident & Injury Report form.

CHEMOTHERAPY DRUG SPILLS IN CLINICAL AND RESEARCH APPLICATIONS

To provide direction in protecting students, employees, patients, visitors and the environment from the potential hazards in managing chemotherapy drug spills.

Equipment: Chemotherapy Drug Spill Kit

There should be one spill kit available on each nursing unit that administers chemotherapy agents, research laboratories or other areas where chemotherapy agents are used. In addition, the in-patient pharmacy and the Department of Occupational Health and Safety will maintain an inventory of several kits for re-supplying these areas.

Procedure :

The immediate cleanup of any amount of chemotherapy agent spilled shall be performed by the individual who initiated or was primarily involved with the incident. If problems develop or questions arise during normal working hours, contact either the Pharmacy (686-6221) or the Department of Occupational Health and Safety (686-5536). After hours, contact the Pharmacy (686-6221), and Campus Operations Call Center (526-0000). Material Safety Data Sheets are available for chemotherapy agents in the SDS Manual located in the Nursing Office and the In-Patient Pharmacy if needed.

Actions for spills should be as follows:

1. Direct contact with chemotherapy agents.
   The following action should be taken for overt contamination of gloves or gowns or direct skin or eye contact with chemotherapy agent:
   aa. Immediately remove the involved gloves or gown.
   bb. Immediately wash the affected skin area with soap and water. The affected area should be examined by a physician as soon as possible.
   cc. For eye exposure, immediately flood the affected eye with water or eyewash designated for that purpose. Medical attention should be obtained immediately.

2. Spills in hood.

Spills involving chemotherapy material that occur inside a hood should be handled as follows:

- aa. Leave blower on.
- bb. Put on double gloves, gown, and eye protection.
- cc. If liquid, clean up with absorbent gauze pads or an absorbent pillow provided in the spill kit. The absorbent should be gently placed on the spill so that liquid is not splashed about the hood.
- dd. If solid, cover and wipe with wet (with water) absorbent gauze.
- ee. Place the pad(s) with the absorbed chemotherapy material in a yellow bag.
- ff. All contaminated surfaces should be thoroughly cleaned with detergent solution and wiped with clean water.
- gg. Any broken glass fragments should be placed in a sharps container.
- hh. If it is necessary to raise the hood's sash to clean up the spill, a NIOSH-certified respirator (N-95 or equivalent) and splash goggles must be worn during the cleanup.
- ii. If a chemotherapy agent is spilled into the intake perforations of the hood, remove the work surface according to the manufacturer's directions and thoroughly clean the drain pan in the proper manner, discarding all cloths and other materials used in the cleaning process.
- jj. If, for some reason, the HEPA filter of a hood is contaminated with chemotherapy agents, the unit must be turned off. A sign "Do Not Use-Contaminated" should be placed on the unit. The filter must be changed as soon as possible according to the manufacturer's instructions by personnel wearing protective double gloves, goggles, NIOSH-certified respirator (N-95 or equivalent), and gown. Whoever is changing the filter must be informed that it is a chemotherapy contaminate. The filter must be placed in a yellow bag.

3. Spills not in hood.

   Spills involving chemotherapy material on counter tops, floors, or other areas outside the hood should be handled as follows:

   - aa. Isolate the area of the spill so that it is not disturbed by other personnel.
   - bb. Put on double gloves, gown, and eye protection.
   - cc. A NIOSH-certified respirator (N-95 or equivalent) must be used when there is any danger of airborne powder or an aerosol being generated.
   - dd. If liquid, clean up with disposable absorbent toweling or absorbent pillow provided in the spill kit. The absorbent should be gently placed on the spill so that liquid is not splashed.
   - ee. If solid, cover and wipe with wet (with water) absorbent gauze.
   - ff. Place the pad(s) with the absorbed chemotherapy material in a yellow bag.
   - gg. All contaminated surfaces should be thoroughly cleaned with detergent solution and wiped with clean water.
   - hh. Any broken glass fragments should be placed in a sharps container.
   - ii. Non-cleanable items, including any other drugs or supplies that may have been contaminated, will be put in a yellow bag.
   - jj. Glassware or other contaminated items should be placed in a plastic bag so that they do not spread the spill, transferred to the sink, and then carefully washed with an appropriate detergent. Avoid splashing while washing.
   - kk. Upon completion of the cleanup, notify the Housekeeping Department to remove the bagged waste and to perform any final cleanup of the area.

4. Documentation of Spills:
   - a. In the event of a spill, the individual primarily involved in the spill will document the incident by the following means:
     1. Patient Involved - Complete the UAMS Patient Visitor Incident Report and the UAMS Chemotherapy Drug Spill Checklist.
     2. Employee Involved - Complete the UAMS Chemotherapy Drug Spill Checklist and Employee/Student Incident Report. (Incident forms may be filled out by ER or Student Employee Health.)
   - b. Upon completion, all documentation regarding the spill will be distributed to the following:

    1. Clinical patient care - Department of Occupational Health and Safety, Nursing Administration, Hospital Administration and Student/Employee Health.
    2. Research - Laboratory department head, Department of Occupational Health and Safety and Student/Employee Health.
5. Medical Surveillance:
   Any individual having direct contact with a chemotherapy agent as a result of a spill should contact Student/Employee Health at the Department of Family and Community Medicine/or ER on evenings, weekends, and holidays. The employee should take a copy of the "UAMS Chemotherapy Drug Spill Checklist." If determined necessary by Student/Employee Health, the examining physician will be responsible for the following:
   a. Hemogram and a panel of four liver function tests.
   b. Complete health questionnaire if no previous records on the employee are available.
   c. Above lab study redrawn in two weeks.

9.0 INFECTIOUS /BIOHAZARDOUS WASTE

INFECTIOUS/BIOHAZARDOUS AGENT SPILL PLAN

To provide direction in protecting students, employees, patients and visitors, and the environment from the potential hazards by managing spills involving infectious/ biohazardous agents. These types of agents can be categorized into the following groups:

- Isolation Wastes
- Cultures and stocks of infectious agents and associated biologicals, specimens from medical and pathology labs, cultures and stocks of infectious agents from clinical and research labs and disposable culture dishes, wastes from production of biological and discarded live and attenuated vaccines.
- Human blood and blood products - waste blood, serum, plasma, and blood products, or items contaminated with blood or blood products.
- Human body fluids - including cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid, amniotic fluid, semen and vaginal secretions and items contaminated with regulated body fluids.
- Pathological waste - tissues, organs, body parts, blood, and body fluids removed during surgery, autopsy, and biopsy.
- Contaminated sharps - contaminated hypodermic needles, syringes, scalpel blades, pasteur pipettes, broken glass and IV catheters.
- Contaminated animal carcasses, body parts and bedding - contaminated animal carcasses, body parts, and bedding of animals that were intentionally exposed to pathogens.

Cleanup of spills involving small volumes of infectious agents shall be performed by the individual who initiated or was primarily involved with the incident.

. A wash bottle of disinfectant should be kept at hand to carry out decontamination of such spills. Phenolics are most useful in laboratories that do not culture for viruses, while a hypochlorite (bleach) is recommended when contamination by viruses is expected.

For larger spills, during normal working hours, the Department of Occupational Health and Safety, extension 686-5536, shall be contacted immediately and will respond to the area. After hours, notify the appropriate housekeeping department and Campus Operations Call Center (526-0000).

Major Spills Outside a Biological Safety Cabinet

- Any spill or accident involving all class III organisms such as; M. tuberculosis, C. immitis, F. tularensis, or Brucella, species should be considered a major hazard.

- Accidents with cultures of moderate - risk agents that have the potential for generating large quantities of aerosol, such as breakage in a centrifuge, should also be handled with precautions designed to minimize inhalation of airborne infectious agents and the following actions should be taken:
  1. In the event of a major aerosol producing spill, i.e., breakage in a centrifuge, the following should be initiated: Hold your breath, leave the room immediately, and close the door.
  2. For a smaller spill - immediately cover with an amphyl soaked paper towel.
  3. Warn others not to enter the contaminated area.
  4. Remove contaminated garments and place them in a container for autoclaving; thoroughly wash hands and face.
  5. Wait at least 30 minutes to allow reduction of aerosols created by the spill.
  6. Obtain a “spill kit” as provided by the Department of Occupational Health and Safety or the In-patient Pharmacy.
  7. Before reentering the room, don the protective clothing provided in the “spill kit.”
  8. Use disinfectants that are two to three times more concentrated than those routinely employed in the laboratory, because the volume of the spill may reduce their concentration.
  9. Pour the disinfectant around the spill and allow it to flow into the spill. Paper towels soaked with disinfectant may be used to cover the area. To minimize aerosolization, avoid pouring disinfectant directly on the spill.
  10. Allow 20 minutes contact time, leave area and shut the door.
  11. Use paper towels to wipe up disinfectant and spill, working toward the center of the spill. Discard towels into an autoclavable container as they are used.
  12. Using an autoclavable dustpan and squeegee, transfer broken glass and other debris to an autoclave pan.
  13. Wipe the outside of the discard container, especially the bottom, with disinfectant.
  14. Place protective clothing, dust pan, and squeegee in container and autoclave them.

Major Spills in a Biological Safety Cabinet

If a spill is confined to the interior of the cabinet it should not be hazardous; however, the following disinfection procedures should be initiated at once while the cabinet continues to operate to prevent escape of contaminants:

1. Wear gloves and gown for the cleanup.
2. Spray or wipe walls, work surfaces, and equipment with a disinfectant.
3. Use sufficient disinfectant to flood the top work surface tray and, if a class II cabinet, the drain pans and catch basins below the surface. Allow to stand 15 minutes.
4. See your biological safety cabinet manual for procedures to disinfect drain pans and catch basins.
5. Autoclave disinfectant, gloves, towels, and sponges before discarding.

Documentation:

1. In the event of a spill, the individual primarily involved in the spill will document the incident by completing a UAMS Injury & Incident Report.
2. Upon completion, all documentation regarding the spill should be distributed to the following:
   aa. Department of Occupational Health and Safety
   bb. Student/Employee Health
   cc. Department Head

Medical Surveillance:

Any individual involved in a spill cleanup of the above organisms should contact Student/Employee Health at the Department of Family and Community Medicine. The examining physician will use his or her discretion in performing the appropriate health examination and lab studies.

10.0 MISCELLANEOUS WASTE RULES

Volatilization - Volatile toxic substances should never be disposed of by evaporation in a fume hood. Such substances should be collected in suitable containers and properly labeled.

Glassware - Glassware and other expendable items contaminated by hazardous chemicals must be rinsed with a suitable solvent. The rinsate must be labeled as Hazardous Waste and disposal protocols as previously described must be followed. The glassware must then be collected in individual laboratories in a receptacle used for glass only.

Sharps - All needles from syringes must be removed before disposal and placed in a sharps container.

Infectious - Infectious waste must be collected by approved procedures and autoclaved at 15 psig (121°C) for at least 30 minutes prior to disposal. The bags must be labeled indicating they have been autoclaved. After autoclaving the biohazardous waste place in a trash bag for disposal. Quality control/assurance procedures must be followed for documentation purposes.

11.0 EMERGENCY PROCEDURES

Emergency procedures for spills and injuries are provided in the Laboratory Safety and Biosafety Manuals. All spills must be reported immediately to the OH&S 686-6958 or 686-5536 or by calling the Campus Operations Call Center at 526-0000.

Due to the seriousness of non-compliance and/or complacency with existing Federal, State and local regulations, which may result in civil and/or criminal liabilities, the policies and guidelines presented in this document must be followed as a minimum. Failure to comply, blatant disregard, or multiple infractions may result in disciplinary action not excluding termination of employment.

HWMP - APPENDIX A

Lists of Hazardous Wastes

(1) General.

A solid waste is a hazardous waste if it is listed below, unless it has been excluded from this list under Regulation 23 or types of wastes by employing one or more of the following Hazard Codes:

Ignitable Waste	(I)
Corrosive Waste	(C)
Reactive Waste	(R)
Toxicity Characteristic Waste	(E)
Acute Hazardous Waste	(H)
Toxic Waste	(T)

Each hazardous waste listed in this appendix is assigned an EPA or Arkansas Hazardous Waste Number which precedes the name of the waste. This number must be used in complying with the notification requirements of Section 3010 of the RCRA and certain recordkeeping and reporting requirements.

Hazardous Waste Number	Hazardous Waste	Hazard Code
Generic:		
F001	The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; all spent solvent mixtures/blends used in degreasing containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.	(T)
F002	The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane, and 1,1,2-trichloroethane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those listed in F001, F004, or F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.	(T)
F003	The following spent non-halogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol,	(I)*

Hazardous Waste Number	Hazardous Waste	Hazard Code
	cyclohexanone, and methanol; all spent solvent mixtures/blends containing, before use, only the above spent non-halogenated solvents; and all spent solvent mixtures/blends containing, before use, one or more of the above non-halogenated solvents, and a total of ten percent or more (by volume) of one or more of those solvents listed in F001, F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.	
F004	The following spent non-halogenated solvents: cresols and cresylic acid, and nitrobenzene; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.	(T)
F005	The following spent non-halogenated solvents: toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, or F004; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.	(I,T)
F007	Spent cyanide plating bath solutions from electroplating operations.	(R,T)
F008	Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process.	(R,T)
F009	Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process.	(R,T)
F010	Quenching bath residues from oil baths from metal heat treating operations where cyanides are used in the process.	(R,T)
F011	Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations.	(R,T)

* (I,T) should be used to specify mixtures containing ignitable and toxic constituents.

Listing Specific Definitions:

1. For the purposes of the F037 and F038 listings, oil/ water/solids is defined as oil and/or water and/or solids.

2. For the purposes of the F037 and F038 listings, aggressive biological treatment units are defined as units which employ one of the following four treatment methods: activated sludge; trickling filter; rotating biological contactor for the continuous accelerated biological oxidation of wastewaters; or high-rate aeration. High-rate aeration is a system of surface impoundments or tanks, in which intense mechanical aeration is used to completely mix the wastes, enhance biological activity, and the units employs a minimum of 6 hp per million gallons of treatment volume; and either the hydraulic retention time of the unit is no longer than 5 days; or the hydraulic retention time is no longer than 30 days and the unit does not generate a sludge that is a hazardous waste by the Toxicity Characteristic.

3. Generators and treatment, storage and disposal facilities have the burden of proving that their sludges are exempt from listing as F037 and F038 wastes under this definition. Generators and treatment, storage and disposal facilities must maintain, in their operating or other on-site records, documents and data sufficient to prove that:

   - the unit is an aggressive biological treatment unit as defined in this subparagraph; and
   - the sludge's sought to be exempted from the definitions of F037 and/or F038 were actually generated in the aggressive biological treatment unit.

4. For the purposes of the F037 listing, sledges' are considered to be generated at the moment of deposition in the unit, where deposition is defined as at least a temporary cessation of lateral particle movement.

5. For the purposes of the F038 listing, sledges' are considered to be generated at the moment of deposition in the unit, where deposition is defined as at least a temporary cessation of lateral particle movement, and floats are considered to be generated at the moment they are formed in the top of the unit.

(2) Hazardous wastes from specific sources.

Solid wastes that are listed hazardous wastes from specific sources have not been listed in this reference document because at the time of printing none applied to UAMS research and learning activities.

(3) Commercial Chemical Products

Commercial chemical products that are in their pure state, are out of date or off specification are hazardous wastes if listed below. Those wastes that have an EPA identification number beginning with the letter P are considered acutely hazardous. No more than 1 liter of acutely hazardous waste can be generated at UAMS per month. In the event that more than 1 liter of acutely hazardous waste is generated in a one month period UAMS will become a large quantity generator and must abide by the rules and regulations set forth by local, state and federal governmental authorities.

Hazardous Waste No.	Chemical Abstracts No.	Substance
P023	107-20-0	Acetaldehyde, chloro-
P002	591-08-2	Acetamide, N-(aminothioxomethyl)-
P057	640-19-7	Acetamide, 2-fluoro-
P058	62-74-8	Acetic acid, fluoro-, sodium salt
P002	591-08-2	1-Acetyl-2-thiourea
P003	107-02-8	Acrolein
P070	116-06-3	Aldicarb
P203	1646-88-4	Aldicarb sulfone
P004	309-00-2	Aldrin
P005	107-18-6	Allyl alcohol
P006	20859-73-8	Aluminum phosphide (R,T)
P008	504-24-5	5-(Aminomethyl)-3-isoxazolol
P007	2763-96-4	4-Aminopyridine
P009	131-74-8	Ammonium picrate (R)
P119	7803-55-6	Ammonium vanadate
P099	506-61-6	Argentate(1-), bis(cyano-C)-, potassium
P010	7778-39-4	Arsenic acid H_3AsO_4
P012	1327-53-3	Arsenic oxide As_2O_3
P011	1303-28-2	Arsenic oxide As_2O_5
P011	1303-28-2	Arsenic pentoxide
P012	1327-53-3	Arsenic trioxide
P038	692-42-2	Arsine, diethyl-
P036	696-28-6	Arsonous dichloride, phenyl-
P054	151-56-4	Aziridine
P067	75-55-8	Aziridine, 2-methyl-
P013	542-62-1	Barium cyanide
P024	106-47-8	Benzenamine, 4-chloro-
P077	100-01-6	Benzenamine, 4-nitro-
P028	100-44-7	Benzene, (chloromethyl)-
P042	51-43-4	1,2-Benzenediol, 4-[1-hydroxy-2-(methyl-amino)ethyl]-, (R)-
P046	122-09-8	Benzeneethanamine, alpha, alpha-dimethyl-
P014	108-98-5	Benzenethiol
P127	1563-66-2	7-Benzofuranol, 2,3-dihydro-2,2-dimethyl-, methylcarbamate
P188	57-64-7	Benzoic acid, 2-hydroxy-,compd. With (3aS-cis)-1,2,3,3a,8,8a-hexahydro-1,3a,8-trimethylpyrrolo [2,3-b]indol-5-yl methylcarbamate ester (1:1)
P001	[1] 81-81-2	2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenylbutyl)-, & salts, when present at concentrations greater than 0.3%
P028	100-44-7	Benzyl chloride
P015	7440-41-7	Beryllium powder
P017	598-31-2	Bromoacetone
P018	357-57-3	Brucine

Hazardous Waste No.	Chemical Abstracts No.	Substance
P045	39196-18-4	2-Butanone, 3,3-dimethyl-1-(methylthio)-, O-[methylamino)carbonyl] oxime
P021	592-01-8	Calcium cyanide
P021	592-01-8	Calcium cyanide $Ca(CN)_2$
P189	55282-14-8	Carbamic acid, [(dibutylamino)-thio]methyl-2,3-dihydro-2,2-dimethyl-7-benzofuranyl ester
P191	644-64-4	Carbamic acid, dimethyl-, 1-[(dimethyl-amino) carbonyl]-5-methyl-1H-pyrozol-3-yl ester
P192	119-38-0	Carbamic acid, dimethyl-, 3-methyl-1-(1-methylethyl)-1H-pyrazol-5-yl ester
P190	1129-41-5	Carbamic acid, methyl-, 3-methylphenyl ester
P127	1563-66-2	Carbofuran
P022	75-15-0	Carbon disulfide
P095	75-44-5	Carbonic dichloride
P189	55285-14-8	Carbosulfan
P023	107-20-0	Chloroacetaldehyde
P024	106-47-8	p-Chloroaniline
P026	5344-82-1	1-(o-Chlorophenyl)thiourea
P027	542-76-7	3-Chloropropionitrile
P029	544-92-3	Copper cyanide
P029	544-92-3	Copper cyanide Cu(CN)
P202	64-00-6	m-Cumenyl methylcarbamate
P030		Cyanides (soluble cyanide salts), not otherwise specified
P031	460-19-5	Cyanogen
P033	506-77-4	Cyanogen chloride
P033	506-77-4	Cyanogen chloride (CN)Cl
P034	131-89-5	2-Cyclohexyl-4,6-dinitrophenol
P016	542-88-1	Dichloromethyl ether
P036	696-28-6	Dichlorophenylarsine
P037	60-57-1	Dieldrin
P038	692-42-2	Diethylarsine
P041	311-45-5	Diethyl-p-nitrophenyl phosphate
P040	297-97-2	O,O-Diethyl O-pyrazinyl phosphorothioate
P191	644-64-4	Dimetilan
P043	55-91-4	Diisopropylfluorophosphate (DFP)
P004	309-00-2	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-, (1alpha,4alpha,4abeta,5alpha,8alpha,8abeta)-
P060	465-73-6	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-

Hazardous Waste No.	Chemical Abstracts No.	Substance
		hexahydro-, (1alpha,4alpha, 4abeta,5beta,8beta,8abeta)-
P037	60-57-1	2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1alpha,2beta, 2alpha,3beta,6beta,6alpha,7beta, 7alpha)-
P051	[1]72-20-8	2,7:3,6-Dimethanonaphth [2,3-b]oxirene,3,4,5,6,9, 9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1alpha,2beta, 2beta,3alpha,6alpha,6beta,7beta, 7alpha)-, & metabolites
P044	60-51-5	Dimethoate
P046	122-09-8	alpha, alpha-Dimethylphenethylamine
P047	[1]534-52-1	4,6-Dinitro-o-cresol, & salts
P048	51-28-5	2,4-Dinitrophenol
P020	88-85-7	Dinoseb
P085	152-16-9	Diphosphoramide, octamethyl-
P111	107-49-3	Diphosphoric acid, tetraethyl ester
P039	298-04-4	Disulfoton
P049	541-53-7	Dithiobiuret
P185	26419-73-8	1,3-Dithiolane-2-carboxaldehyde, 2,4-dimethyl-, o-[(methylamino)-carbonyl]oxime
P050	115-29-7	Endosulfan
P088	145-73-3	Endothall
P051	72-20-8	Endrin
P051	72-20-8	Endrin, & metabolites
P042	51-43-4	Epinephrine
P031	460-19-5	Ethanedinitrile
P066	16752-77-5	Ethanimidothioic acid, N-[[(methylamino)carbonyl] oxy]-, methyl ester
P194	23135-22-0	Ethanimidothioc acid, 2-(dimethylamino)-N-[[(methylamino) carbonyl]-2-oxo]-, methyl ester
P101	107-12-0	Ethyl cyanide
P054	151-56-4	Ethyleneimine
P097	52-85-7	Famphur
P056	7782-41-4	Fluorine
P057	640-19-7	Fluoroacetamide
P058	62-74-8	Fluoroacetic acid, sodium salt
P198	23422-53-9	Formetanate hydrochloride
P197	17702-57-7	Formparanate
P065	628-86-4	Fulminic acid, mercury(2+) salt (R,T)
P059	76-44-8	Heptachlor
P062	757-58-4	Hexaethyl tetraphosphate

Hazardous Waste No.	Chemical Abstracts No.	Substance
P116	79-19-6	Hydrazinecarbothioamide
P068	60-34-4	Hydrazine, methyl-
P063	74-90-8	Hydrocyanic acid
P063	74-90-8	Hydrogen cyanide
P096	7803-51-2	Hydrogen phosphide
P060	465-73-6	Isodrin
P192	119-38-0	Isolan
P202	64-00-6	3-Isopropylphenyl N-methylcarbamate
P007	2763-96-4	3(2H)-Isoxazolone, 5-(aminomethyl)-
P196	15339-36-3	Manganese, bis(dimethylcarbamodithioato-S,S')-,
P196	15339-36-3	Manganese dimethyldithiocarbamate
P092	62-38-4	Mercury, (acetato-O)phenyl-
P065	628-86-4	Mercury fulminate (R,T)
P198	23422-53-9	Methanimidamide, N,N-dimethyl-N'-[3-[[(methylamino)-carbonyl]oxy]phenyl]-, monohydrochloride
P197	17702-57-7	Methanimidamide, N,N-dimethyl-N'-[2-methyl-4-[[(methylamino)carbonyl]oxl]phenyl]-
P199	2032-65-7	Methiocarb
P082	62-75-9	Methanamine, N-methyl-N-nitroso-
P064	624-83-9	Methane, isocyanato-
P016	542-88-1	Methane, oxybis[chloro-
P112	509-14-8	Methane, tetranitro-(R)
P118	75-70-7	Methanethiol, trichloro-
P050	115-29-7	6,9-Methano-2,4,3-benzodioxathiepin,6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide
P059	76-44-8	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-
P190	1129-41-5	Metolcarb
P066	16752-77-5	Methomyl
P068	60-34-4	Methyl hydrazine
P064	624-83-9	Methyl isocyanate
P069	75-86-5	2-Methyllactonitrile
P071	298-00-0	Methyl parathion
P128	315-8-4	Mexacarbate
P072	86-88-4	alpha-Naphthylthiourea
P073	13463-39-3	Nickel carbonyl
P073	13463-39-3	Nickel carbonyl $Ni(CO)_4$, (T-4)-
P074	557-19-7	Nickel cyanide
P074	557-19-7	Nickel cyanide $Ni(CN)_2$
P075	[1] 54-11-5	Nicotine, & salts
P076	10102-43-9	Nitric oxide
P077	100-01-6	p-Nitroaniline

Hazardous Waste No.	Chemical Abstracts No.	Substance
P078	10102-44-0	Nitrogen dioxide
P076	10102-43-9	Nitrogen oxide NO
P078	10102-44-0	Nitrogen oxide NO_2
P081	55-63-0	Nitroglycerine (R)
P082	62-75-9	N-Nitrosodimethylamine
P084	4549-40-0	N-Nitrosomethylvinylamine
P085	152-16-9	Octamethylpyrophosphoramide
P087	20816-12-0	Osmium oxide OsO_4, (T-4)-
P087	20816-12-0	Osmium tetroxide
P088	145-73-3	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
P194	2315-22-0	Oxamyl
P089	56-38-2	Parathion
P034	131-89-5	Phenol, 2-cyclohexyl-4,6-dinitro-
P128	315-18-4	Phenol, 4-(dimethylamino)-3,5-dimethyl-, methylcarbamate (ester)
P199	2032-65-7	Phenol, (3,5-dimethyl-4-(methylthio)-, methylcarbamate
P048	51-28-5	Phenol, 2,4-dinitro-
P047	[1]534-52-1	Phenol, 2-methyl-4,6-dinitro, & salts
P202	64-00-6	Phenol, 3-(1-methylethyl)-, methyl carbamate
P201	2631-37-0	Phenol, 3-methyl-5-(1-methylethyl)-, methyl carbamate
P020	88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro-
P009	131-74-8	Phenol, 2,4,6-trinitro-, ammonium salt (R)
P092	62-38-4	Phenylmercury acetate
P093	103-85-5	Phenylthiourea
P094	298-02-2	Phorate
P095	75-44-5	Phosgene
P096	7803-51-2	Phosphine
P041	311-45-5	Phosphoric acid, diethyl 4-nitrophenyl ester
P039	298-04-4	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester
P094	298-02-2	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester
P044	60-51-5	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester
P043	55-91-4	Phosphorofluoridic acid, bis(1-methylethyl) ester
P089	56-38-2	Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester
P040	297-97-2	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester

Hazardous Waste No.	Chemical Abstracts No.	Substance
P097	52-85-7	Phosphorothioic acid, O-[4-[(dimethylamino)sulfonyl] phenyl] O,O-dimethyl ester
P071	298-00-0	Phosphorothioic acid, O,O,-dimethyl O-(4-nitrophenyl) ester
P204	57-47-6	Physostigmine
P188	57-64-7	Physostigmine salicylate
P110	78-00-2	Plumbane, tetraethyl-
P098	151-50-8	Potassium cyanide
P098	151-50-8	Potassium cyanide K(CN)
P099	506-61-6	Potassium silver cyanide
P070	116-06-3	Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino) carbonyl]oxime
P201	2631-37-0	Promecarb
P203	1646-88-4	Propanal, 2-, methyl-2-(methyl-sulfonyl)-, O-[(methylamino)carbonyl] oxime
P101	107-12-0	Propanenitrile
P027	542-76-7	Propanenitrile, 3-chloro-
P069	75-86-5	Propanenitrile, 2-hydroxy-2-methyl-
P081	55-63-0	1,2,3-Propanetriol, trinitrate (R)
P017	598-31-2	2-Propanone, 1-bromo-
P102	107-19-7	Propargyl alcohol
P003	107-02-8	2-Propenal
P005	107-18-6	2-Propen-1-ol
P067	75-55-8	1,2-Propylenimine
P102	107-19-7	2-Propyn-1-ol
P008	504-24-5	4-Pyridinamine
P075	[1]54-11-5	Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-, and salts
P204	57-47-6	Pyrrolo[2,3-b]indol-5-ol, 1,2,3,3a,8,8a-hexahydro- 1,3a,8-trimethyl-, methylcarbamate (ester), (3aS-cis)-
P114	12039-52-0	Selenious acid, dithallium(1+) salt
P103	630-10-4	Selenourea
P104	506-64-9	Silver cyanide
P104	506-64-9	Silver cyanide (Ag(CN)
P105	26628-22-8	Sodium azide
P106	143-33-9	Sodium cyanide
P106	143-33-9	Sodium cyanide Na(CN)
P108	[1]57-24-9	Strychnidin-10-one, and salts
P018	357-57-3	Strychnidin-10-one, 2,3-dimethoxy-
P108	[1]57-24-9	Strychnine, & salts
P115	7446-18-6	Sulfuric acid, dithallium(1+) salt
P109	3689-24-5	Tetraethyldithiopyrophosphate
P110	78-00-2	Tetraethyl lead
P111	107-49-3	Tetraethyl pyrophosphate

Hazardous Waste No.	Chemical Abstracts No.	Substance
P112	509-14-8	Tetranitromethane (R)
P062	757-58-4	Tetraphosphoric acid, hexaethyl ester
P113	1314-32-5	Thallic oxide
P113	1314-32-5	Thallium oxide Tl_2O_3
P114	12039-52-0	Thallium(1) selenite
P115	7446-18-6	Thallium(l) sulfate
P109	3689-24-5	Thiodiphosphoric acid, tetraethyl ester
P045	39196-18-4	Thiofanox
P049	541-53-7	Thioimidodicarbonic diamide$[(H_2N)C(S)]_2NH$
P014	108-98-5	Thiophenol
P116	79-19-6	Thiosemicarbazide
P026	5344-82-1	Thiourea, (2-chlorophenyl)-
P072	86-88-4	Thiourea, 1-naphthalenyl-
P093	103-85-5	Thiourea, phenyl-
P185	26419-73-8	Tirpate
P123	8001-35-2	Toxaphene
P118	75-70-7	Trichloromethanethiol
P119	7803-55-6	Vanadic acid, ammonium salt
P120	1314-62-1	Vanadium oxide V_2O_5
P120	1314-62-1	Vanadium pentoxide
P084	4549-40-0	Vinylamine, N-methyl-N-nitroso-
P001	[1]81-81-2	Warfarin, & salts, when present at concentrations greater than 0.3%
P205	137-30-4	Zinc, bis(dimethylcarbamodithioato-S,S')-,
P121	557-21-1	Zinc cyanide
P121	557-21-1	Zinc cyanide $Zn(CN)_2$
P122	1314-84-7	Zinc phosphide Zn_3P_2, when present at concentrations greater than 10% (R,T)
P205	137-30-4	Ziram

[1] CAS Number given for parent compound only.

The commercial chemical products, manufacturing chemical intermediates, or off-specification commercial chemical products referred to in Regulation 23 are identified as toxic wastes (T) unless otherwise designated. There is a small quantity exclusion that applies to these wastes. Contact the OH&S for more information.

These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous Waste No.	Chemical Abstracts No.	Substance
U394	30558-43-1	A2213
U001	75-07-0	Acetaldehyde (I)
U034	75-87-6	Acetaldehyde, trichloro-

Hazardous Waste No.	Chemical Abstracts No.	Substance
U187	62-44-2	Acetamide, N-(4-ethoxyphenyl)-
U005	53-96-3	Acetamide, N-9H-fluoren-2-yl-
U240	[1] 94-75-7	Acetic acid, (2,4-dichlorophenoxy)-, salts & esters
U112	141-78-6	Acetic acid ethyl ester (I)
U144	301-04-2	Acetic acid, lead(2+) salt
U214	563-68-8	Acetic acid, thallium(1+) salt
See F027	93-76-5	Acetic acid, (2,4,5-trichloro phenoxy)-
U002	67-64-1	Acetone (I)
U003	75-05-8	Acetonitrile (I,T)
U004	98-86-2	Acetophenone
U005	53-96-3	2-Acetylaminofluorene
U006	75-36-5	Acetyl chloride (C,R,T)
U007	79-06-1	Acrylamide
U008	79-10-7	Acrylic acid (I)
U009	107-13-1	Acrylonitrile
U011	61-82-5	Amitrole
U012	62-53-3	Aniline (I,T)
U136	75-60-5	Arsinic acid, dimethyl-
U014	492-80-8	Auramine
U015	115-02-6	Azaserine
U010	50-07-7	Azirino[2',3':3,4]pyrrolo[1,2-a] indole-4,7-dione, 6-amino-8-[[(aminocarbonyl)oxy]methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl-, [1aS-(1alpha, 8beta,8aalpha,8balpha)]-
U280	101-27-9	Barban
U278	22781-23-3	Bendiocarb
U364	22961-82-6	Bendiocarb phenol
U271	17804-35-2	Benomyl
U157	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-
U016	225-51-4	Benz[c]acridine
U017	98-87-3	Benzal chloride
U192	23950-58-5	Benzamide, 3,5-dichloro-N- (1,1-dimethyl-2-propynyl)-
U018	56-55-3	Benz[a]anthracene
U094	57-97-6	Benz[a]anthracene, 7,12-dimethyl-
U012	62-53-3	Benzenamine (I,T)
U014	492-80-8	Benzenamine, 4,4'-carbonimidoylbis[N,N-dimethyl-
U049	3165-93-3	Benzenamine, 4-chloro-2-methyl-,hydrochloride
U093	60-11-7	Benzenamine, N,N-dimethyl-4-(phenylazo)-
U328	95-53-4	Benzenamine, 2-methyl-
U353	106-49-0	Benzenamine, 4-methyl-
U158	101-14-4	Benzenamine, 4,4'-methylenebis[2-chloro-
U222	636-21-5	Benzenamine, 2-methyl-,hydrochloride

Hazardous Waste No.	Chemical Abstracts No.	Substance
U181	99-55-8	Benzenamine, 2-methyl-5-nitro-
U019	71-43-2	Benzene (I,T)
U038	510-15-6	Benzeneacetic acid, 4-chloro-alpha- (4-chlorophenyl)-alpha-hydroxy-,ethyl ester
U030	101-55-3	Benzene, 1-bromo-4-phenoxy-
U035	305-03-3	Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]-
U037	108-90-7	Benzene, chloro-
U221	25376-45-8	Benzenediamine, ar-methyl-
U028	117-81-7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester
U069	84-74-2	1,2-Benzenedicarboxylic acid, dibutyl ester
U088	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester
U102	131-11-3	1,2-Benzenedicarboxylic acid, dimethyl ester
U107	117-84-0	1,2-Benzenedicarboxylic acid, dioctyl ester
U070	95-50-1	Benzene, 1,2-dichloro-
U071	541-73-1	Benzene, 1,3-dichloro-
U072	106-46-7	Benzene, 1,4-dichloro-
U060	72-54-8	Benzene, 1,1'-(2,2-dichloroethyli-dene)bis[4-chloro-
U017	98-87-3	Benzene, (dichloromethyl)-
U223	26471-62-5	Benzene, 1,3-diisocyanatomethyl- (R,T)
U239	1330-20-7	Benzene, dimethyl-(I,T)
U201	108-46-3	1,3-Benzenediol
U127	118-74-1	Benzene, hexachloro-
U056	110-82-7	Benzene, hexahydro- (I)
U220	108-88-3	Benzene, methyl-
U105	121-14-2	Benzene, 1-methyl-2,4-dinitro-
U106	606-20-2	Benzene, 2-methyl-1,3-dinitro-
U055	98-82-8	Benzene, (1-methylethyl)- (I)
U169	98-95-3	Benzene, nitro-
U183	608-93-5	Benzene, pentachloro-
U185	82-68-8	Benzene, pentachloronitro-
U020	98-09-9	Benzenesulfonic acid chloride (C,R)
U020	98-09-9	Benzenesulfonyl chloride (C,R)
U207	95-94-3	Benzene, 1,2,4,5-tetrachloro-
U061	50-29-3	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-
U247	72-43-5	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-methoxy-
U023	98-07-7	Benzene, (trichloromethyl)-
U234	99-35-4	Benzene, 1,3,5-trinitro-
U021	92-87-5	Benzidine
U202	[1] 81-07-2	1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide, & salts
U203	94-59-7	1,3-Benzodioxole, 5-(2-propenyl)-

Hazardous Waste No.	Chemical Abstracts No.	Substance
U141	120-58-1	1,3-Benzodioxole, 5-(1-propenyl)-
U090	94-58-6	1,3-Benzodioxole, 5-propyl-
U278	22781-23-3	1,3-Benzodioxol-4-ol,2,2-dimethyl-, methyl carbamate
U364	22961-82-6	1,3,Benzodioxol-4-ol,2,2-dimethyl-,
U367	1563-38-8	7-Benzofuranol, 2,3-dihydro-2,2-dimethyl-
U064	189-55-9	Benzo[rst]pentaphene
U248	[1]81-81-2	2H-1-Benzopyran-2-one, 4-hydroxy-3- (3-oxo-1-phenyl-butyl)-, & salts, when present at concentrations of 0.3% or less
U022	50-32-8	Benzo[a]pyrene
U197	106-51-4	p-Benzoquinone
U023	98-07-7	Benzotrichloride (C,R,T)
U085	1464-53-5	2,2'-Bioxirane
U021	92-87-5	[1,1'-Biphenyl]-4,4'-diamine
U073	91-94-1	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-
U091	119-90-4	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethoxy-
U095	119-93-7	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-
U225	75-25-2	Bromoform
U030	101-55-3	4-Bromophenyl phenyl ether
U128	87-68-3	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-
U172	924-16-3	1-Butanamine, N-butyl-N-nitroso-
U031	71-36-3	1-Butanol (I)
U159	78-93-3	2-Butanone (I,T)
U160	1338-23-4	2-Butanone, peroxide (R,T)
U053	4170-30-3	2-Butenal
U074	764-41-0	2-Butene, 1,4-dichloro- (I,T)
U143	303-34-4	2-Butenoic acid, 2-methyl-,7-[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy]methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl ester, [1S-[1alpha(Z),7(2S*,3R*),7aalpha]]-
U031	71-36-3	n-Butyl alcohol (I)
U136	75-60-5	Cacodylic acid
U032	13765-19-0	Calcium chromate
U238	51-79-6	Carbamic acid, ethyl ester
U178	615-53-2	Carbamic acid, methylnitroso-, ethyl ester
U372	10605-21-7	Carbamic acid, 1H-benzimidazol-2-yl, methyl ester
U271	17804-35-2	Carbamic acid, [1-[(butylamino)carbonyl]-1H-benzimidazol-2-yl], methyl ester
U280	101-27-9	Carbamic acid, (3-chlorophenyl)-, 4-chloro-2-butynyl ester
U373	122-42-9	Carbamic acid, phenyl-, 1-methylethyl ester
U409	23564-05-8	Carbamic acid, [1,2-phenylene bis(iminocarbonothiol)]bis-, dimethyl ester

Hazardous Waste No.	Chemical Abstracts No.	Substance
U097	79-44-7	Carbamic chloride, dimethyl-
U114	[1]111-54-6	Carbamodithioic acid, 1,2-ethane-diylbis-, salts & esters
U062	2303-16-4	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro- 2-propenyl) ester
U389	2303-17-5	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3,3-trichloro-2-propenyl) ester
U387	52888-80-9	Carbamothioic acid, dipropyl-, S-(phenylmethyl) ester
U279	63-25-2	Carbaryl
U372	10605-21-7	Carbendazim
U367	1563-38-8	Carbofuran phenol
U215	6533-73-9	Carbonic acid, dithallium(1+) salt
U033	353-50-4	Carbonic difluoride
U156	79-22-1	Carbonochloridic acid, methyl ester(I,T)
U033	353-50-4	Carbon oxyfluoride (R,T)
U211	56-23-5	Carbon tetrachloride
U034	75-87-6	Chloral
U035	305-03-3	Chlorambucil
U036	57-74-9	Chlordane, alpha & gamma isomers
U026	494-03-1	Chlornaphazine
U037	108-90-7	Chlorobenzene
U038	510-15-6	Chlorobenzilate
U039	59-50-7	p-Chloro-m-cresol
U042	110-75-8	2-Chloroethyl vinyl ether
U044	67-66-3	Chloroform
U046	107-30-2	Chloromethyl methyl ether
U047	91-58-7	beta-Chloronaphthalene
U048	95-57-8	o-Chlorophenol
U049	3165-93-3	4-Chloro-o-toluidine, hydrochloride
U032	13765-19-0	Chromic acid H_2CrO_4, calcium salt
U050	218-01-9	Chrysene
U051		Creosote
U052	1319-77-3	Cresol (Cresylic acid)
U053	4170-30-3	Crotonaldehyde
U055	98-82-8	Cumene (I)
U246	506-68-3	Cyanogen bromide (CN)Br
U197	106-51-4	2,5-Cyclohexadiene-1,4-dione
U056	110-82-7	Cyclohexane (I)
U129	58-89-9	Cyclohexane, 1,2,3,4,5,6-hexa-chloro-, (1alpha, 2alpha,3beta,4alpha,5alpha,6beta)-
U057	108-94-1	Cyclohexanone (I)
U130	77-47-4	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-
U058	50-18-0	Cyclophosphamide
U240	[1] 94-75-7	2,4-D, salts and esters
U059	20830-81-3	Daunomycin

Hazardous Waste No.	Chemical Abstracts No.	Substance
U060	72-54-8	DDD
U061	50-29-3	DDT
U062	2303-16-4	Diallate
U063	53-70-3	Dibenz[a,h]anthracene
U064	189-55-9	Dibenzo[a,i]pyrene
U066	96-12-8	1,2-Dibromo-3-chloropropane
U069	84-74-2	Dibutyl phthalate
U070	95-50-1	o-Dichlorobenzene
U071	541-73-1	m-Dichlorobenzene
U072	106-46-7	p-Dichlorobenzene
U073	91-94-1	3,3'-Dichlorobenzidine
U074	764-41-0	1,4-Dichloro-2-butene (I,T)
U075	75-71-8	Dichlorodifluoromethane
U078	75-35-4	1,1-Dichloroethylene
U079	156-60-5	1,2-Dichloroethylene
U025	111-44-4	Dichloroethyl ether
U027	108-60-1	Dichloroisopropyl ether
U024	111-91-1	Dichloromethoxy ethane
U081	120-83-2	2,4-Dichlorophenol
U082	87-65-0	2,6-Dichlorophenol
U084	542-75-6	1,3-Dichloropropene
U085	1464-53-5	1,2:3,4-Diepoxybutane (I,T)
U395	5952-26-1	Diethylene glycol, dicarbamate
U108	123-91-1	1,4-Diethyleneoxide
U028	117-81-7	Diethylhexyl phthalate
U086	1615-80-1	N,N'-Diethylhydrazine
U087	3288-58-2	O,O-Diethyl S-methyl dithiophosphate
U088	84-66-2	Diethyl phthalate
U089	56-53-1	Diethylstilbesterol
U090	94-58-6	Dihydrosafrole
U091	119-90-4	3,3'-Dimethoxybenzidine
U092	124-40-3	Dimethylamine (I)
U093	60-11-7	p-Dimethylaminoazobenzene
U094	57-97-6	7,12-Dimethylbenz[a]anthracene
U095	119-93-7	3,3'-Dimethylbenzidine
U096	80-15-9	alpha,alpha-Dimethylbenzylhydro-peroxide (R)
U097	79-44-7	Dimethylcarbamoyl chloride
U098	57-14-7	1,1-Dimethylhydrazine
U099	540-73-8	1,2-Dimethylhydrazine
U101	105-67-9	2,4-Dimethylphenol
U102	131-11-3	Dimethyl phthalate
U103	77-78-1	Dimethyl sulfate
U105	121-14-2	2,4-Dinitrotoluene
U106	606-20-2	2,6-Dinitrotoluene
U107	117-84-0	Di-n-octyl phthalate
U108	123-91-1	1,4-Dioxane

Hazardous Waste No.	Chemical Abstracts No.	Substance
U109	122-66-7	1,2-Diphenylhydrazine
U110	142-84-7	Dipropylamine (I)
U111	621-64-7	Di-n-propylnitrosamine
U041	106-89-8	Epichlorohydrin
U001	75-07-0	Ethanal (I)
U174	55-18-5	Ethanamine, N-ethyl-N-nitroso-
U404	121-44-8	Ethanamine, N,N-diethyl-
U155	91-80-5	1,2,Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienyl-methyl)-
U067	106-93-4	Ethane, 1,2-dibromo-
U076	75-34-3	Ethane, 1,1-dichloro-
U077	107-06-2	Ethane, 1,2-dichloro-
U131	67-72-1	Ethane, hexachloro-
U024	111-91-1	Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-
U117	60-29-7	Ethane, 1,1'-oxybis- (I)
U025	111-44-4	Ethane, 1,1'-oxybis[2-chloro-
U184	76-01-7	Ethane, pentachloro-
U208	630-20-6	Ethane, 1,1,1,2-tetrachloro-
U209	79-34-5	Ethane, 1,1,2,2-tetrachloro-
U218	62-55-5	Ethanethioamide
U226	71-55-6	Ethane, 1,1,1-trichloro-
U227	79-00-5	Ethane, 1,1,2-trichloro-
U410	59669-26-0	Ethaninidothioic acid, N,N’-[thiobis[(methylimino) carbonyloxy]]bis-, dimethyl ester
U394	30558-43-1	Ethanimidothioic acid, 2-(dimethylamino)-N-hydroxy-2-oxo-, methyl ester
U359	110-80-5	Ethanol, 2-ethoxy-
U173	1116-54-7	Ethanol, 2,2'-(nitrosoimino)bis-
U004	98-86-2	Ethanone, 1-phenyl-
U395	5952-26-1	Ethanol, 2,2’-oxybis-, dicarbamate
U043	75-01-4	Ethene, chloro-
U042	110-75-8	Ethene, (2-chloroethoxy)-
U078	75-35-4	Ethene, 1,1-dichloro-
U079	156-60-5	Ethene, 1,2-dichloro-, (E)-
U210	127-18-4	Ethene, tetrachloro-
U228	79-01-6	Ethene, trichloro-
U112	141-78-6	Ethyl acetate (I)
U113	140-88-5	Ethyl acrylate (I)
U238	51-79-6	Ethyl carbamate (urethane)
U117	60-29-7	Ethyl ether (I)
U114	[1] 111-54-6	Ethylenebisdithiocarbamic acid, salts & esters
U067	106-93-4	Ethylene dibromide
U077	107-06-2	Ethylene dichloride
U359	110-80-5	Ethylene glycol monoethyl ether

Hazardous Waste No.	Chemical Abstracts No.	Substance
U115	75-21-8	Ethylene oxide (I,T)
U116	96-45-7	Ethylenethiourea
U076	75-34-3	Ethylidene dichloride
U118	97-63-2	Ethyl methacrylate
U119	62-50-0	Ethyl methanesulfonate
U120	206-44-0	Fluoranthene
U122	50-00-0	Formaldehyde
U123	64-18-6	Formic acid (C,T)
U124	110-00-9	Furan (I)
U125	98-01-1	2-Furancarboxaldehyde (I)
U147	108-31-6	2,5-Furandione
U213	109-99-9	Furan, tetrahydro- (I)
U125	98-01-1	Furfural (I)
U124	110-00-9	Furfuran (I)
U206	18883-66-4	Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-, D-
U206	18883-66-4	D-Glucose, 2-deoxy-2-[[(methyl-nitrosoamino)-carbonyl]amino]-
U126	765-34-4	Glycidylaldehyde
U163	70-25-7	Guanidine, N-methyl-N'-nitro-N-nitroso
U127	118-74-1	Hexachlorobenzene
U128	87-68-3	Hexachlorobutadiene
U130	77-47-4	Hexachlorocyclopentadiene
U131	67-72-1	Hexachloroethane
U132	70-30-4	Hexachlorophene
U243	1888-71-7	Hexachloropropene
U133	302-01-2	Hydrazine (R,T)
U086	1615-80-1	Hydrazine, 1,2-diethyl-
U098	57-14-7	Hydrazine, 1,1-dimethyl-
U099	540-73-8	Hydrazine, 1,2-dimethyl-
U109	122-66-7	Hydrazine, 1,2-diphenyl-
U134	7664-39-3	Hydrofluoric acid (C,T)
U134	7664-39-3	Hydrogen fluoride (C,T)
U135	7783-06-4	Hydrogen sulfide
U135	7783-06-4	Hydrogen sulfide H2S
U096	80-15-9	Hydroperoxide, 1-methyl-1-phenylethyl- (R)
U116	96-45-7	2-Imidazolidinethione
U137	193-39-5	Indeno[1,2,3-cd]pyrene
U190	85-44-9	1,3-Isobenzofurandione
U140	78-83-1	Isobutyl alcohol (I,T)
U141	120-58-1	Isosafrole
U142	143-50-0	Kepone
U143	303-34-4	Lasiocarpine
U144	301-04-2	Lead acetate
U146	1335-32-6	Lead, bis(acetato-O)tetrahydroxytri-
U145	7446-27-7	Lead phosphate

Hazardous Waste No.	Chemical Abstracts No.	Substance
U146	1335-32-6	Lead subacetate
U129	58-89-9	Lindane
U163	70-25-7	MNNG
U147	108-31-6	Maleic anhydride
U148	123-33-1	Maleic hydrazide
U149	109-77-3	Malononitrile
U150	148-82-3	Melphalan
U151	7439-97-6	Mercury
U152	126-98-7	Methacrylonitrile (I,T)
U092	124-40-3	Methanamine, N-methyl- (I)
U029	74-83-9	Methane, bromo-
U045	74-87-3	Methane, chloro- (I,T)
U046	107-30-2	Methane, chloromethoxy-
U068	74-95-3	Methane, dibromo-
U080	75-09-2	Methane, dichloro-
U075	75-71-8	Methane, dichlorodifluoro-
U138	74-88-4	Methane, iodo-
U119	62-50-0	Methanesulfonic acid, ethyl ester
U211	56-23-5	Methane, tetrachloro-
U153	74-93-1	Methanethiol (I,T)
U225	75-25-2	Methane, tribromo-
U044	67-66-3	Methane, trichloro-
U121	75-69-4	Methane, trichlorofluoro-
U036	57-74-9	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-
U154	67-56-1	Methanol (I)
U155	91-80-5	Methapyrilene
U142	143-50-0	1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-
U247	72-43-5	Methoxychlor
U154	67-56-1	Methyl alcohol (I)
U029	74-83-9	Methyl bromide
U186	504-60-9	1-Methylbutadiene (I)
U045	74-87-3	Methyl chloride (I,T)
U156	79-22-1	Methyl chlorocarbonate (I,T)
U226	71-55-6	Methyl chloroform
U157	56-49-5	3-Methylcholanthrene
U158	101-14-4	4,4'-Methylenebis(2-chloroaniline)
U068	74-95-3	Methylene bromide
U080	75-09-2	Methylene chloride
U159	78-93-3	Methyl ethyl ketone (MEK)(I,T)
U160	1338-23-4	Methyl ethyl ketone peroxide (R,T)
U138	74-88-4	Methyl iodide
U161	108-10-1	Methyl isobutyl ketone (I)
U162	80-62-6	Methyl methacrylate (I,T)
U161	108-10-1	4-Methyl-2-pentanone (I)

Hazardous Waste No.	Chemical Abstracts No.	Substance
U164	56-04-2	Methylthiouracil
U010	50-07-7	Mitomycin C
U059	20830-81-3	5,12-Naphthacenedione, 8-acetyl-10[(3-amino-2,3,6-trideoxy)-alpha-L-lyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-, (8S-cis)-
U167	134-32-7	1-Naphthalenamine
U168	91-59-8	2-Naphthalenamine
U026	494-03-1	Naphthalenamine, N,N'-bis(2-chloroethyl)-
U165	91-20-3	Naphthalene
U047	91-58-7	Naphthalene, 2-chloro-
U166	130-15-4	1,4-Naphthalenedione
U236	72-57-1	2,7-Naphthalenedisulfonic acid, 3,3'-[(3,3'-dimethyl [1,1'-biphenyl]-4,4'-diyl)bis(azo)bis[5-amino-4-hydroxy]-, tetrasodium salt
U279	63-25-2	1-Naphthalenol, methylcarbamate
U166	130-15-4	1,4,Naphthaquinone
U167	134-32-7	alpha-Naphthylamine
U168	91-59-8	beta-Naphthylamine
U217	10102-45-1	Nitric acid, thallium(1+) salt
U169	98-95-3	Nitrobenzene (I,T)
U170	100-02-7	p-Nitrophenol
U171	79-46-9	2-Nitropropane (I,T)
U172	924-16-3	N-Nitrosodi-n-butylamine
U173	1116-54-7	N-Nitrosodiethanolamine
U174	55-18-5	N-Nitrosodiethylamine
U176	759-73-9	N-Nitroso-N-ethylurea
U177	684-93-5	N-Nitroso-N-methylurea
U178	615-53-2	N-Nitroso-N-methylurethane
U179	100-75-4	N-Nitrosopiperidine
U180	930-55-2	N-Nitrosopyrrolidine
U181	99-55-8	5-Nitro-o-toluidine
U193	1120-71-4	1,2-Oxathiolane, 2,2-dioxide
U058	50-18-0	2H-1,3,2-Oxazaphosphorin-2-amine,N,N-bis(2-chloroethyl)tetrahydro-, 2-oxide
U115	75-21-8	Oxirane (I,T)
U126	765-34-4	Oxiranecarboxyaldehyde
U041	106-89-8	Oxirane, (chloromethyl)-
U182	123-63-7	Paraldehyde
U183	608-93-5	Pentachlorobenzene
U184	76-01-7	Pentachloroethane
U185	82-68-8	Pentachloronitrobenzene (PCNB)
See F027	87-86-5	Pentachlorophenol
U161	108-10-1	Pentanol, 4-methyl-
U186	504-60-9	1,3-Pentadiene (I)
U187	62-44-2	Phenacetin

Hazardous Waste No.	Chemical Abstracts No.	Substance
U188	108-95-2	Phenol
U048	95-57-8	Phenol, 2-chloro-
U411	114-26-1	Phenol, 2-(1-methylethoxy)-, methylcarbamate
U039	59-50-7	Phenol, 4-chloro-3-methyl-
U081	120-83-2	Phenol, 2,4-dichloro-
U082	87-65-0	Phenol, 2,6-dichloro-
U089	56-53-1	Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E)-
U101	105-67-9	Phenol, 2,4-dimethyl-
U052	1319-77-3	Phenol, methyl-
U132	70-30-4	Phenol, 2,2'-methylenebis[3,4,6-trichloro-
U170	100-02-7	Phenol, 4-nitro-
See F027	87-86-5	Phenol, pentachloro-
See F027	58-90-2	Phenol, 2,3,4,6-tetrachloro-
See F027	95-95-4	Phenol, 2,4,5-trichloro-
See F027	88-06-2	Phenol, 2,4,6-trichloro-
U150	148-82-3	L-Phenylalanine, 4-[bis(2-chloroethyl)amino]-
U145	7446-27-7	Phosphoric acid, lead(2+) salt (2:3)
U087	3288-58-2	Phosphorodithioic acid, O,O-diethyl S-methyl ester
U189	1314-80-3	Phosphorous sulfide (R)
U190	85-44-9	Phthalic anhydride
U191	109-06-8	2-Picoline
U179	100-75-4	Piperidine, 1-nitroso-
U192	23950-58-5	Pronamide
U194	107-10-8	1-Propanamine (I,T)
U111	621-64-7	1-Propanamine, N-nitroso-N-propyl-
U110	142-84-7	1-Propanamine, N-propyl- (I)
U066	96-12-8	Propane, 1,2-dibromo-3-chloro-
U083	78-87-5	Propane, 1,2-dichloro-
U149	109-77-3	Propanedinitrile
U171	79-46-9	Propane, 2-nitro- (I,T)
U027	108-60-1	Propane, 2,2'-oxybis[2-chloro-
U193	1120-71-4	1,3-Propane sultone
See F027	93-72-1	Propanoic acid, 2-(2,4,5-trichloro-phenoxy)-
U235	126-72-7	1-Propanol, 2,3-dibromo-, phosphate (3:1)
U140	78-83-1	1-Propanol, 2-methyl-(I,T)
U002	67-64-1	2-Propanone (I)
U007	79-06-1	2-Propenamide
U084	542-75-6	1-Propene, 1,3-dichloro-
U243	1888-71-7	1-Propene, 1,1,2,3,3,3-hexachloro-
U009	107-13-1	2-Propenenitrile
U152	126-98-7	2-Propenenitrile, 2-methyl-(I,T)
U008	79-10-7	2-Propenoic acid (I)
U113	140-88-5	2-Propenoic acid, ethyl ester (I)
U118	97-63-2	2-Propenoic acid, 2-methyl-, ethyl ester
U162	80-62-6	2-Propenoic acid, 2-methyl-, methyl ester (I,T)

Hazardous Waste No.	Chemical Abstracts No.	Substance
U373	122-42-9	Propham
U411	114-26-1	Propoxur
U194	107-10-8	n-Propylamine (I,T)
U083	78-87-5	Propylene dichloride
U387	52888-80-9	Prosulfocarb
U148	123-33-1	3,6-Pyridazinedione, 1,2-dihydro-
U196	110-86-1	Pyridine
U191	109-06-8	Pyridine, 2-methyl-
U237	66-75-1	2,4-(1H,3H)-Pyrimidinedione, 5-[bis (2-chloroethyl) amino]-
U164	56-04-2	4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-
U180	930-55-2	Pyrrolidine, 1-nitroso-
U200	50-55-5	Reserpine
U201	108-46-3	Resorcinol
U202	[1] 81-07-2	Saccharin, & salts
U203	94-59-7	Safrole
U204	7783-00-8	Selenious acid
U204	7783-00-8	Selenium dioxide
U205	7488-56-4	Selenium sulfide
U205	7488-56-4	Selenium sulfide SeS_2 (R,T)
U015	79-34-5	L-Serine, diazoacetate (ester)
See F027	115-02-6	Silvex (2,4,5-TP)
U206	93-72-1	Streptozotocin
U103	18883-66-4	Sulfuric acid, dimethyl ester
U189	77-78-1	Sulfur phosphide (R)
See F027	1314-80-3	2,4,5-T
U207	93-76-5	1,2,4,5-Tetrachlorobenzene
U208	95-94-3	1,1,1,2-Tetrachloroethane
U209	630-20-6	1,1,2,2-Tetrachloroethane
U210	127-18-4	Tetrachloroethylene
See F027	58-90-2	2,3,4,6-Tetrachlorophenol
U213	109-99-9	Tetrahydrofuran (I)
U214	563-68-8	Thallium(I) acetate
U215	6533-73-9	Thallium(I) carbonate
U216	7791-12-0	Thallium(I) chloride
U216	7791-12-0	Thallium chloride TlCl
U217	10102-45-1	Thallium(I) nitrate
U218	62-55-5	Thioacetamide
U410	59669-26-0	Thiodicarb
U153	74-93-1	Thiomethanol (I,T)
U244	137-26-8	Thioperoxydicarbonic diamide$[(H_2N)C(S)]_2S_2$, tetramethyl-
U409	23564-05-8	Thiophanate-methyl
U219	62-56-6	Thiourea
U244	137-26-8	Thiram

Hazardous Waste No.	Chemical Abstracts No.	Substance
U220	108-88-3	Toluene
U221	25376-45-8	Toluenediamine
U223	26471-62-5	Toluene diisocyanate (R,T)
U328	95-53-4	o-Toluidine
U353	106-49-0	p-Toluidine
U222	636-21-5	o-Toluidine hydrochloride
U389	2303-17-5	Triallate
U011	61-82-5	1H-1,2,4-Triazol-3-amine
U227	79-00-5	1,1,2-Trichloroethane
U228	79-01-6	Trichloroethylene
U121	75-69-4	Trichloromonofluoromethane
See F027	95-95-4	2,4,5-Trichlorophenol
See F027	88-06-2	2,4,6-Trichlorophenol
U404	121-44-8	Triethylamine
U234	99-35-4	1,3,5-Trinitrobenzene (R,T)
U182	123-63-7	1,3,5-Trioxane, 2,4,6-trimethyl-
U235	126-72-7	Tris(2,3-dibromopropyl) phosphate
U236	72-57-1	Trypan blue
U237	66-75-1	Uracil mustard
U176	59-73-9	Urea, N-ethyl-N-nitroso-
U177	684-93-5	Urea, N-methyl-N-nitroso-
U043	75-01-4	Vinyl chloride
U248	[1] 81-81-2	Warfarin, & salts, when present at concentrations of 0.3% or less
U239	1330-20-7	Xylene (I)
U200	50-55-5	Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxy-benzoyl)oxy]-, methyl ester, (3beta,16beta,17alpha,18beta, 20alpha)-
U249	1314-84-7	Zinc phosphide, Zn_3P_2, when present at concentrations of 10% or less

CAS Number given for parent compound only.

HWMP - APPENDIX B
NON-REGULATED CHEMICAL WASTE

CAS#	Chemical/Compound Name
50817B	ASCORBIC ACID
7440440A	ACTIVATED CARBON
58617A	ADENOSINE, (-)-
9002180A	AGAR
9012366A	AGAROSE
302727A	ALANINE, DL-
56417A	ALANINE, L-
338692A	ALANINE-D
UOFM1485A	ALCONOX
9005327A	ALGINIC ACID
9005383A	ALGINIC ACID, SODIUM SALT
12141467B	ALUMINUM SILICATE
10102713A	ALUMINUM SODIUM SULFATE
10043013S	ALUMINUM SULFATE, Anhydrous solid
9000026A	AMBER
9002260A	AMBERLITE IRA-410CP
56406B	AMINOACETIC ACID
9037223A	AMIOCA
7722761A	AMMONIUM PHOSPHATE MONOBASIC
7783280A	AMMONIUM PHOSPHATE, DIBASIC
528949A	AMMONIUM SALICYLATE
1002897A	AMMONIUM STEARATE
7783202A	AMMONIUM SULFATE
42739388A	AMMONIUM VALERATE
7631869C	AMORPHOUS FUMED SILICA
9037223B	AMYLOPECTIN
31566311B	ARLACEL
50817A	ASCORBIC ACID, L-
5794138A	ASPARAGINE HYDRATE, (L)-
617458A	ASPARTIC ACID, DL-
UOFM1252A	ASPHALT
112856A	BEHENIC ACID
12141467A	BENTONITE
2447576B	BENEZENESULFONAMIDE, 4-AMINO N-(5,6-DIMETHOXY-4-PYRIMIDINYL)
121346C	BENZOIC ACID, 4-HYDROXY-3-METHOXY
9012366B	BIO-GEL A
UOFM235A	BIO-LYTE AMPHOLXLES AND GELS
813934A	BISMUTH CITRATE
UOFM1252B	BITUMEN
7758874B	BONE FLOUR
507700a	BORNEOL
12069328A	BORON CARBIDE
7631869B	CAB-O-SIL
62544A	CALCIUM ACETATE
12007566A	CALCIUM BORATE

4714341A	CALCIUM CARBONATE
10043524A	CALCIUM CHLORIDE
10035048A	CALCIUM CHLORIDE DIHYDRATE
62339B	CALCIUM DISODIUM EDTA
62339A	CALCIUM DISODIU VERSENATE
299285A	CALCIUM GLYCEROPHOSPHATE
10102688A	CALCIUM IODIDE
814802A	CALCIUM LACTATE
142176A	CALCIUM OLEATE
137086A	CALCIUM PANTOTHENATE
7789777A	CALCIUM PHOSPHATE, DIBASIC
7758238A	CALCIUM PHOSPHATE, MONOBASIC
7758874A	CALCIUM PHOSPHATE, TRIBASIC
7778189A	CALCIUM SULFATE
10101414A	CALCIUM SULFATE DIHYDATE
1333864A	CARBON DIOXIDE
409212A	CARBORUNDUM
37225266A	CARBOWAX
9004324C	CARBOXYMETHYL CELLULOSE
9004324A	CARBOXYMETHYL CELLULOSE, (Sodium Salt)
461052A	CARNITINE HYDROCHLORIDE
7235407	CAROTENE, TRANS-BETA-
UOFM1274A	CASEIN HYDROLYSATE
9005463A	CASEIN, SODIUM COMPLEX
68855549A	CELITE
9004324B	CELLEX
9004357A	CELLULOSE ACETATE
9004368A	CELLULOSE ACETATE BUTYRATE
UOFM1278A	CELLULOSE PHOSPHATE
9004346A	CELLULOSE POWDER
1306383A	CERIUM (IV) OXIDE
7647178A	CESIUM CHLORIDE
7440440C	CHARCOAL OR
16291966A	CHARCOAL, ANIMAL BONE
UOFM1146A	CHELATING AGENT
1406651A	CHLOROPHYL
604353A	CHOLESTERYL ACETATE
5808140A	CHOLIC ACID
62497A	CHOLINE
77929A	CITRIC ACID
68042B	CITRIC ACID TRISODIUM SALT DIHYDRATE
68647869A	COCOANUT CHARCOAL
8029434A	CORN SYRUP
9002602A	CORTICOTROPIN
60275A	CREATININE
68199A	CYANOCOBALAMINE
10016203A	CYCLODEXTRIN HYDRATE, ALPHA-
10016203B	CYCLOHEXAAMYLOSE
923320B	CYSTINE

923320A	CYSTINE, DL-
84526B	CYTIDINE-3-MONOPHOSPHATE
84526A	CYTIDYLIC ACID, 3-
71307A	CYTOSINE
UOFM1277A	DEAE CELLULOSE
9003989A	DEOXYRIBONUCLEASE
9011181A	DEXTRAN SULFATE
9004540A	DEXTRAN T 70
9004539A	DEXTRIN
492626B	DEXTROSE
68855549B	DIATOMACEOUS EARTH
7758794A	DISODIUM PHOSPHATE
3325006A	DL-ALPHA-GLYCEROPHOSPHATE
59927B	DOPA, L-
10034998B	EPSOM SALT
2338058A	FERRIC CITRATE
10045860A	FERRIC PHOSPHATE
9007732A	FERRITIN
299296A	FERROUS GLUCONATE
1345251A	FERROUS OXIDE
9001905A	FIBRINOLYSIN
9001336A	FICIN
61790532A	FILTER AGENT, CELITE
1343880A	FLORISIL
3385033A	FLUNISOLIDE HEMIHYDRATE
2321075A	FLUOROSCEIN
UOFM233A	FOOD FLAVORINGS AND OILS
26177855A	FRUCTOSE 1,6-DIPHOSPHATE DS SALT
57487A	FRUCTOSE, D-
643130A	FRUCTOSE-6-PHOSPHATE
8031183A	FULLER'S EARTH
59234A	GALACTOSE, D-(+)
526998B	GALACTRIC ACID
9000708A	GELATIN
77065A	GIBBERELIC ACID
9007834A	GLOBULIN, GAMMA-
299274B	GLUCONIC ACID, POTASSIUM SALT
604682A	GLUCOSE PENTAACETATE, ALPHA-D-
604693A	GLUCOSE PENTAACETATE, BETA-D-
492626A	GLUCOSE, ALPHA-D
50997A	GLUCOSE, D-(+)-
5996145A	GLUCOSE-1-PHOSPHATE, ALPHA
56860A	GLUTAMIC ACID, L-
56859A	GLUTAMINE, L-
110941A	GLUTARIC ACID
50812378A	GLUTATHIONE S-TRANSFERASE
819830A	GLYCEROL 2-PHOSPHATE, DISODIUM SALT HYDRATE
31566311A	GLYCERYL MONOSTEARATE

56406A	GLYCINE
9005792A	GLUCOGEN
556503A	GLYCYLGLYCINE
7782425A	GRAPHITE POWDER
73405A	GUANINE
118003A	GUANOSINE
9000015A	GUM ARABIC
9000059A	GUM BENZOIN
90000286A	GUM GHATTI
90000297A	GUM GUAIC
90000651A	GUM TRAGACANTH
10101414B	GYPSUM
9008020A	HEMOGLOBIN
9005496A	HEPARIN
51456A	HISTAMINE
56928A	HISTAMINE DIHYDROCHLORIDE
6341248A	HISTIDINE MONOHYDROCHLORIDE MONOHYDRATE
121346A	HYDROXY-3-METHOXYBENZOIC ACID
618279A	HYDROXY-L-PROLINE, CIS-4-
51354A	HYDROXY-L-PROLINE, TRANS-4-
9004620A	HYDROXYETHYL CELLULOSE
58639A	INOSINE, (-)-
87898A	INOSITOL
9005805A	INULIN
1637736A	ISOCITRIC ACID, TRISODIUM SALT HYDRATE, DL
73325A	ISOLEUCINE, L-
1332587A	KAOLIN
9008188A	KERATIN
UOFM160A	KODALITH DEVELOPER PART A
63423A	LACTOSE, BETA-D-
8006540A	LANOLIN, WOOL FAT
UOFM91A	LECITHIN
8002435A	LECITHIN
61905A	LEUCINE, L-
7447418A	LITHIUM CHLORIDE
1393926A	LITMUS BLUE
1393926 B	LITMUS, INDICATOR
9001632A	LUSOZYME
657272A	LYSINE MONOHYDRACHLORIDE, L-
56871A	LYSINE, L-
12650883A	LYSOZYME
142723A	MAGNESIUM ACETATE
546930B	MAGNESIUM CARBONATE BASIC
3409820A	MAGNESIUM CARBONATE, BASIC
7786303A	MAGNESIUM CHLORIDE
7757860A	MAGNESIUM PHOSPHATE TRIBASE
7487889A	MAGNESIUM SULFATE
10034998A	MAGNESIUM SULFATE HEPTAHYDRATE

9050366A	MALTODEXTRIN
6363537A	MALTOSE MONOHYDRATE, D-
69658A	MANNITOL, D-
59518A	METHIONINE, DL-
63683A	METHIONINE, L-
9004675A	METHYL CELLULOSE
15507763A	METHYL HISTIDINE, L-1-
111820A	METHYL LAURATE
368161A	METHYL-L-HISTIDINE
555306A	METHYLDOPA
617049A	METHYMANNOSIDE, ALPHA
526998A	MUCIC ACID
42200339A	NADOLOL
604591A	NAPHTHOFLAVONE, ALPHA
98920B	NIACINAMIDE
98920A	NICOTINAMIDE
53598A	NICOTINAMIDE ADENINE DINUCLEOTIDE PHOSPHATE
59676A	NICOTINIC ACID
744044B	NORIT A, ACTIVATED CARBON
63428831A	NYLON
8049476A	PANCREATIN
9001734A	PAPAIN
9002646A	PARTHYROID HORMONE
9001756A	PEPSIN POWDER
UOFM77A	PETROLATUM
150301A	PHENYLALANINE, DL-
8002435B	PHOSPHATIDYL CHOLINE, L-ALPHA
9001905B	PLASMIN
9003490A	POLY(BUTYL ACRYLATE), LIQUID
25322683A	POLY(ETHYLENE GLYCOL), SOLID
9002884A	POLY(ETHYLENE), SOLID
9003274A	POLY(ISOBUTYLENE), SOLID
9003310A	POLY(ISOPRENE), SOLID
9011147A	POLY(METHYL METHACRYLATE)
25704181A	POLY(SODIUM 4-STYRENESULFONATE
9002895A	POLY(VINYL ALCOHOL), SOLID
9003332A	POLY(VINYL FORMAL), SOLID
9003398A	POLY(VINYL PYRROLIDONE), SOLID
9002817A	POLYACETYL, SOLID
9003014A	POLYACRYLIC ACID, SOLID
9003172A	POLYBUTADIENE, CIS-, SOLID
UOFM15A	POLYOLS AND POLYURETHANES
9003207A	POLYVINYL ACETATE, SOLID
127082A	POTASSIUM ACETATE
298146A	POTASSIUM BICARBONATE
1310618A	POTASSIUM BISULFITE
868144A	POTASSIUM BITARTRATE
584087A	POTASSIUM CARBONATE

7447407A	POTASSIUM CHLORIDE
866842A	POTASSIUM CITRATE
299274A	POTASSIUM FORMATE
868144B	POTASSIUM HYDROGEN TARTRATE
7681110A	POTASSIUM IODIDE
16788571A	POTASSIUM PHOSPHATE DIBASIC TRIHYDRATE
7778770A	POTASSIUM PHOSPHATE MONOBASIC, ANHYDROUS
7758114A	POTASSIUM PHOSPHATE, DIBASIC, ANHYDROUS
7778532A	POTASSIUM PHOSPHATE, TRIBASIC
7320345A	POTASSIUM PYROPHOSPHATE, TETRA
304596A	POTASSIUM SODIUM TARTRATE
7778805A	POTASSIUM SULFATE
12045782A	POTASSIUM TETRABORATE, TETRAHYDRATE
50865015A	PROTOPORPHYRIN IX, SODIUM SALT
83885B	RIBOFLAVIN
146178A	RIBOFLAVIN-5-PHOSPHATE
8050097A	ROSIN, POWDER
69727A	SALICYLIC ACID
11081406A	SEPHADEX G-15, FOR GEL FILTRATION
302841A	SERINE, DL-
56451A	SERINE, L-
7631869D	SILICA GEL
7699414A	SILICIC ACID
409212B	SILICON CARBIDE
7631869A	SILICON DIOXIDE
9016006A	SILICONE RUBBER, SOLID
127093A	SODIUM ACETATE
134032A	SODIUM ASCORBATE
144558A	SODIUM BICARBONATE
497198A	SODIUM CARBONATE
9038419A	SODIUM CELLULOSE PHOSPHATE
7647145A	SODIUM CHLORIDE
361091A	SODIUM CHOLATE
68042A	SODIUM CITRATE
7681825A	SODIUM IODIDE
13517061A	SODIUM IODIDE DIHYDRATE
10361032A	SODIUM METAPHOPHATE
143191A	SODIUM OLEATE
7558794A	SODIUM PHOSPHATE, DIBASIC, ANHYDROUS
10039324B	SODIUM PHOSPHATE DIBASIC DODECAHYDRATE
10049215A	SODIUM PHOSPHATE MONOBASIC MONOHYDRATE
10101890A	SODIUM PHOSPHATE TRIBASIC DODECAHYDRATE
10039324A	SODIUM PHOSPHATE, DIBASIC
7782856A	SODIUM PHOSPHATE, DIBASIC, HEPTAHYDRATE
7558807A	SODIUM PHOSPHATE, MONOBASIC, ANHYDROUS
50813166A	SODIUM POLYMETAPHOSPHATE
9080799A	SODIUM POLYSTYRENE SULFONATE
7782696A	SODIUM POTASSIUM PHOSPHATE
304596B	SODIUM POTASSIUM TARTRATE

7722885A	SODIUM PYROPHOSPHATE
1344098A	SODIUM SILICATE
868188A	SODIUM TARTRATE
14986846A	SODIUM TETRAPHOSPHATE
12034343A	SODIUM TITANATE
7785844A	SODIUM TRIMETAPHOSPHATE
13472452A	SODIUM TUNGSTATE
50704A	SORBITOL, D-
87796A	SORBOSE, L-(-)-
UOFM1123A	STAPHYLOCOCCAL ENTEROTOXIN
9005258A	STARCH, ELECTROPHORESIS
9005849A	STARCH, SOLUBLE
9001621A	STEAPSIN
1633052A	STRONTIUM CARBONATE
57501A	SUCROSE
2447576A	SULFADOXINE
12070063A	TANTALUM CARBIDE
87694A	TARTARIC ACID, L(+)-
67038A	THIAMINE HYDROCHLORIDE
80682A	THREONINE, DL-
72195A	THREONINE, L-
9005849B	THYODENE
13463677A	TITANIUM DIOXIDE
7758874C	TRICALCIUM PHOSPHATE
7601549A	TRISODIUM PHOSPHATE, INDICATOR
9002077A	TRYPSIN
51672C	TYROSINE, D-
556025A	TYROSINE, DL-
60184A	TYROSINE, L-
9002124A	URICASE
58968A	URIDINE
72184A	VALINE, L-
121346B	VANILLIC ACID
121335A	VANILLIN
68199B	VITAMIN B12
83885A	VITAMIN B2
7695912B	VITAMIN E
59029B	VITAMIN E
83705A	VITAMIN K-5
69896A	XANTHINE
9010666A	ZEIN
7779900A	ZINC PHOSPHATE

APPENDIX C.

UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES
CHEMOTHERAPY DRUG SPILL CHECKLIST

Patient Room or Lab # _____________________________ Date of Spill
Patient Name (if applicable) _________________________Time of Spill

Staff exposure

Patient exposure (if applicable)

Name of Chemotherapy Agent
Amount of agent in amount of solution
Estimated amount of solution lost
Signature of employee preparing checklist
Chemotherapy agent spill kits are available through the Department of Occupational Health and Safety and the In-Patient Pharmacy.

_____1. Remove involved clothing immediately.
_____2. Flush eye(s) involved.
_____3. Wash skin involved with copious amounts of soap and water.
_____4. Move patient to another bed if the bed is contaminated; transfer patient to another room if large areas of the carpet is involved.

_____5. Isolate the area of the spill.
_____6. The individual involved in the cleanup should notify the Department of Occupational Health and Safety (during normal work hours) or the in house pharmacy (weekends and holidays).
_____7. An incident report and chemotherapy drug spill checklist should be completed with copies to Department heads and the Department of Occupational Health and Safety.