3 SAFE WORK PRACTICES AND GUIDELINES

Carefully read the chemical label before using a chemical. The manufacturer's or supplier's Safety Data Sheets (SDS) may also provide special handling information. Be aware of potential hazards existing in the laboratory and the appropriate safety precautions. Know the location and proper use of emergency equipment, the procedures for responding to emergencies, and the proper methods for storage, transportation and disposal of chemicals within the facility.

3.1 General Work and Laboratory Hygiene Practices

- Laboratory personnel are responsible for regular cleaning and disinfection of laboratory surfaces to maintain good laboratory hygiene. Solid waste (regular trash cans) should be placed outside the lab at the end of each business day for custodial staff to pick for disposal. Custodial staff will have access to labs only for services requested through AU Facilities work management by submitting a work order. Examples of these services include deep cleaning and floor waxing.
- Lab personnel are responsible for transporting autoclaved waste to the trash dumpster located outside of the building. Custodians shall not remove any waste from autoclave rooms.
- Do not work alone in the laboratory during after work hours. If you must work alone in the evening, let someone else know and have them periodically check on you.
- Label all secondary chemical containers with appropriate identification and hazard information.
- Use only those chemicals for which you have appropriate exposure controls (such as a chemical fume hood) and administrative procedures (training, restricted access, etc.). Always use adequate ventilation with chemicals. Operations utilizing volatile or toxic substances should be performed in a chemical fume hood.
- Use hazardous chemicals and all laboratory equipment only as directed for their intended purpose.
- Inspect equipment or apparatus for damage before use, do not use malfunctioning equipment.
- Inspect PPE for integrity or proper functioning before use.
- Do not dispense more of a hazardous chemical than is needed for immediate use.
- Remove contaminated clothing and gloves before leaving the laboratory.
- Avoid direct contact with any chemical. Keep chemicals off your hands, face and clothing, including shoes.
- Never smell, inhale or taste a hazardous chemical. Wash hands thoroughly with soap and water after handling chemicals and removing gloves.
- Smoking, drinking, eating and the application of cosmetics is forbidden in laboratories where hazardous chemicals are used.
- Never pipet by mouth. Use a pipet bulb or other mechanical pipet filling device.
- Keep floors clean and dry. Keep all aisles, hallways, and stairs clear of all chemicals and equipment. Stairways and hallways should not be used as storage areas.
- Keep all work areas, and especially work benches, clear of clutter and obstructions.
- All working surfaces should be cleaned regularly by lab personnel, regular trash should be placed outside the lab at the end of each business day for custodial staff to pick for disposal.
- Access to emergency equipment, utility controls, showers, eyewashes and exits should never be blocked.
- Hazardous waste should be stored in appropriate containers and labeled properly.

3.2 Procedures for Proper Labeling, Storage and Management of Chemicals

3.2.1 Chemical Storage

Carefully read the chemical label before storing a hazardous chemical, chemicals must be stored according to hazard class and compatibility. The manufacturer's SDS will provide any special storage information as well as information on incompatibilities. *Do not store unsegregated liquid chemicals in alphabetical order. Do not store incompatible chemicals in close proximity to each other. See Appendix C-1 for* examples of incompatible chemicals; this list is not a complete list:

Common chemical hazard groups are:

Flammable /combustible liquids
Unstable (shock sensitive/explosive chemicals)
Flammable solids
Water Reactives
Flammable Gases
Air Reactives
Inorganic acids
Corrosive gases
Organic acids
Toxic / Poisons
Caustics (bases)
Toxic gases
Oxidizers
Reproductive Toxins
Oxidizing acids
Carcinogens
Caustics (bases)
Oxidizing gases

Once separated into the above hazard classes, chemicals may be stored alphabetically. Use approved storage containers and safety cans for flammable liquids. Store flammable chemicals in flammable storage cabinets, no greater than 10 gallons of flammable liquids may be kept outside of rated flammable storage cabinets in any laboratory. *Flammable chemicals requiring refrigeration should be stored only in the refrigerators and freezers specifically designed for flammable storage.*

Acids must be separated from bases and from active metals such as sodium, magnesium and potassium. Acids must be kept separate from chemicals that can emit toxic gases on contact, such as sodium cyanide and iron sulfide. Corrosive or hazardous liquids should not be stored above eye level. Acids and bases shall be stored below shoulder height of the shortest person within the laboratory. Organic acids, organic material, flammable and combustible materials must be separated from oxidizing acids such as nitric acid and perchloric acid. Separation of nitric and perchloric acid from other acids may be accomplished by utilizing a plastic pan or tray.

Hazardous chemicals should not be stored on bench tops, on the floor, or in hoods for extended periods of time. Chemicals should not be stored under sinks. If separate cabinets are not feasible, different hazard classes can be segregated by utilizing a plastic pan or tray. Use secondary containers for highly corrosive or toxic chemicals. Avoid exposure of chemicals while in storage to heat sources (especially open flames) and direct sunlight.

3.2.2 Chemical Management

Update chemical inventory information using Chematix Chemical Inventory System. Conduct periodic inventories of chemicals stored in the laboratory and dispose of old or unwanted chemicals promptly in accordance with RMS's Hazardous waste program. Ensure that all secondary containers are properly labeled with the identity of the contents and any appropriate hazard warnings.

Note: Peroxide formers form peroxides on exposure to air and light. The two most serious hazards associated with peroxides are fires and explosions when exposed to heat, shock, or friction. Some common oxidizable functional groups are: Ethers, conjugated dienes, enynes and diynes, hydrocarbons with exposed tertiary hydrogens etc.

Since many of these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have not been opened. All containers of ether or other peroxide formers should be dated upon receipt, when opened, and tested for peroxide formation after storage for 12 months. These chemicals should be discarded when peroxides greater than 100 ppm are present. Peroxide formers are grouped into three categories depending on their tendency to form peroxides and associated hazards. Group A, Group B and Group C (see appendix C-2 for a partial list of chemicals under each of these categories) Group A peroxide formers can form peroxide amounts that may cause an explosion without concentration. They should be tested for peroxides before use and discarded when peroxides are present. It is best practice to discard them after three months of opening and unopened containers should be discarded after 12 months of storage.

See the Standard Operating Guideline for Peroxide-forming Materials (Potentially Explosive Chemicals) document found online at: https://cws.auburn.edu/shared/files?id=227&filename=PEC%20Guidelines%20Updated.pdf .

3.2.3 Chemical Labelling

All chemical containers must be labeled clearly identifying their contents. Labels on purchased chemicals must not be removed or defaced except when empty. All secondary containers must be clearly labelled with full chemical name to identify contents. The label and information must be in English and clearly written to identify the contents.

Many labels may provide you with additional safety information to help you protect yourself while working with the substance. This includes information on toxicity, flammability, instability (reactivity), and physical hazards. Protective measures may also be included on the container such as handling of the material, first aid instructions and storage information.

Read the manufacturer's label each time you use a newly purchased chemical. It is possible the manufacturer may have added new hazard information or reformulated the product since your last purchase, and thus altered the potential hazards you face while working with the product. All employees involved in unpacking chemicals are responsible for inspecting each incoming container to ensure that it is in good condition and labeled properly.

3.2.4 Chemical Waste Disposal Program

Laboratory chemical waste must be handled according to the University's procedures outlined in Auburn University Chemical Waste Management Guide. The University's waste management practices are designed to ensure maintenance of a safe and healthful environment for laboratory personnel and the surrounding community without adversely affecting the environment. This is accomplished through regular removal of chemical waste from University facilities and disposal of these wastes in accordance with local, state, and federal regulations. For additional information on Auburn's chemical waste management program ask your supervisor or contact RMS. Chemical waste pickup must be requested through Chematix chemical management system. All chemical containers utilized in experimental procedures or otherwise treated as waste should be updated (removed) from inventory in Chematix as "used up in experiment" or "treated as waste".

3.3 Chemical Spills and Accidents Procedure

Be prepared for chemical spills that may occur in your laboratory (based on the types of chemicals used in your lab) by obtaining the necessary equipment (spill kits and personal protective equipment) to respond to minor spills. Learn how to safely clean up minor spills of the chemicals you use regularly. An SDS contains special spill clean-up information and should also be consulted. Chemical spills should only be cleaned up by trained, knowledgeable **and experienced personnel.**

If the spill is too large for you to handle, is a threat to laboratory personnel or the public, or involves a highly toxic or reactive chemical, call 911 for immediate assistance.

- Simple (small) chemical spills – Call RMS (844-4870)
- Complex (large) chemical spills – Call 911

3.3.1 Cleaning Up Chemical Spills

If you are cleaning up a small chemical spill yourself, make sure that you are aware of the hazards associated with the materials spilled, have adequate ventilation (open windows, chemical fume hood on) and proper personal protective equipment (minimum - gloves, goggles, and lab coat). Consider all residual chemical and cleanup materials (adsorbent, gloves, etc.) as hazardous waste. Place these materials in sealed containers (plastic bags), label, and store in a satellite accumulation area (SAA), Contact RMS for disposal instructions and pickup.

3.3.2 Simple Chemical Spills

- Alert people in immediate area of spill.
- Increase ventilation in area of spill (open windows, turn on hoods).
- Wear protective equipment, including safety goggles, gloves, long-sleeve lab coat and closed toe shoes.
- Avoid breathing vapors from spill.
- Use appropriate kit to adsorb/contain spill Collect residue, place in container and dispose as hazardous chemical waste. Call RMS for disposal information and waste pick up if necessary.

3.3.3 Complex Chemical Spill

- Attend to injured or contaminated persons and remove them from exposure if safe to do so
- Alert people in the laboratory to evacuate.
- If spilled material is flammable, turn off ignition and heat sources. Place spill cleanup material over spill to keep substance from volatilizing.
- Call 911.
- Close doors to affected area.
- Have a person with knowledge of the incident and laboratory available to answer questions from responding emergency personnel.

3.3.4 Mercury Spills

- Do not use a domestic or commercial vacuum cleaner.
- Use a disposable pipette to pick up mercury droplets.
- Cover small droplets in inaccessible areas with powdered sulfur or zinc.
- Place residue in a labeled container and call RMS for disposal information. For larger spills, call RMS to clean up the mercury.
- Contact RMS if you have a mercury spill that exceeds the quantity found in a normal laboratory thermometer.

3.3.5 Personal Contamination and Injury

- Know the locations of the nearest emergency safety shower and emergency eye wash.
- Report all incidents and injuries to your supervisor.
- If an individual is contaminated or exposed to a hazardous material in your laboratory do what is necessary to protect their life and health as well as your own.
- Determine what the individual was exposed to. The SDS may contain special first aid information.
- Do not move an injured person unless they are in further danger (from inhalation or skin exposure).
- Get medical attention promptly by dialing 911.
- Report exposure incidents or injuries to RMS or to on the job injury program

3.3.6 Chemicals Spills on the Body

- Quickly remove all contaminated clothing and footwear
- Get to an emergency safety shower and immediately flood the affected body area for at least 15 minutes.
- Remove jewelry to facilitate removal of any residual material.
- Yell for assistance as soon as incident occurs.
- Get medical attention promptly by dialing 911. Be sure to indicate specifically what chemical was involved.

It should be noted that some chemicals (e.g. phenol, aniline) are rapidly adsorbed through the skin. If a large enough area of skin is contaminated an adverse health effect (systemic toxicological reaction) may occur immediately to several hours after initial exposure depending on the chemical. In general, if more than 9 square inches of skin area has been exposed to a hazardous chemical, seek medical attention after washing the material off the skin.

3.3.7 Chemicals Spills on the Body – Hydrofluoric Acid (HF)

Calcium gluconate paste is an effective treatment for hydrofluoric acid exposure. Every laboratory and location where HF are used or stored should have a tube of calcium gluconate paste readily available. In the event of an HF spill to the body:

- Immediately flood the affected body area with cool water for a minimum of 15 minutes, gently rub calcium gluconate ointment onto the affected area. Continue applying until emergency medical responders arrive.
- If no calcium gluconate is immediately available, continue rinsing the affected area with copious amounts of water until emergency medical responders arrive. Remove contaminated clothing and footwear while rinsing.
- Call or have a co-worker call 911. Be sure to indicate that you were exposed to hydrofluoric acid.
- Inform responders and/or others that the exposure involved hydrogen fluoride/hydrofluoric acid.

3.3.8 Chemical Splash in the Eye

- Use emergency eyewash to irrigate the eyeball and inner surface of eyelid with plenty of water for at least 15 minutes. Forcibly hold eyelids open to ensure effective wash.
- Check for and remove contact lenses.
- Get medical attention promptly and inform medical attendants of the specific type of chemical you were exposed to.

3.3.9 Ingestion of Hazardous Chemicals

- Identify the chemical ingested.
- Call 911.
- Cover the injured person to prevent shock.
- Provide the ambulance crew and physician with the chemical name and any other relevant information. If possible, send the SDS with the victim.

3.3.10 Inhalation of Smoke, Vapors, and Fumes

Anyone overcome with smoke or chemical vapors or fumes should be removed to uncontaminated air and treated for shock.

- Do not enter the area if you expect that a life-threatening condition still exists -oxygen depletion, explosive vapors or highly toxic gases (cyanide gas, hydrogen sulfide, nitrogen oxides, carbon monoxide).
- If CPR certified, follow standard CPR protocols.
- Get medical attention promptly.

3.3.11 Fire and Fire Related Emergencies

If you discover a fire or fire-related emergency such as abnormal heating of material, a flammable gas leak, a flammable liquid spill, smoke, or odor of burning, immediately follow these procedures:

- Call 911.
- Activate the building alarm (fire pull station). If not available or operational, verbally notify people in the building.
- Isolate the area by closing windows and doors and evacuate the building.
- Shut down equipment in the immediate area, if possible.
- If trained to do so, use a portable fire extinguisher to control a small fire.
- Provide the fire/police teams with the details of the problem upon their arrival. Special hazard information you might know is essential for the safety of the emergency responders.

If the fire alarms are ringing in your building:

- You must evacuate the building and stay out until notified to return.
- Move upwind from the building and stay clear of streets, driveways, sidewalks and other access ways to the building.
- If you are a supervisor, try to account for your employees, keep them together and report any missing persons to the emergency personnel at the scene.

3.4 Flammable and Combustible Liquids

Flammable liquids are among the most common of the hazardous materials found in laboratories. They are usually highly volatile (have high vapor pressures at room temperature) and their vapors, mixed with air at the appropriate ratio, can ignite and burn. By definition, the lowest temperature at which they can form an ignitable vapor/air mixture (the flash point) is less than 37.8°C (100°F) and for many common laboratory solvents (ether, acetone, toluene, acetaldehyde) the flash point is well below room temperature. As with all solvents, their vapor pressure increases with temperature and, therefore, as temperatures increase, they become more hazardous.

For a fire to occur, three distinct conditions must exist simultaneously: (1) the concentration of the vapor must be between the upper and lower flammable limits of the substance (the right fuel/air mix); (2) an oxidizing atmosphere, usually air, must be available; and (3) a source of ignition must be present. Removal of any of these three conditions will prevent the start of a fire. Flammable liquids may form flammable mixtures in either open or closed containers or spaces (such as refrigerators), when leaks or spills occur in the laboratory, and when heated.

Strategies for preventing ignition of flammable vapors include removing all sources of ignition or maintaining the concentration of flammable vapors below the lower flammability limit by using local exhaust ventilation such as a hood. The former strategy is more difficult because of the numerous ignition sources in laboratories. Ignition sources include open flames, hot surfaces, operation of electrical equipment, and static electricity.

The danger of fire and explosion presented by flammable liquids can usually be eliminated or minimized by strict observance of safe handling, dispensing, and storing procedures. These include:

- Wearing PPE such as protective glasses or goggles, long sleeved lab coats and closed toe shoes. Wear goggles if dispensing solvents or performing operations that could result in a splash to the eyes.

- Large quantities of flammable liquids should be handled in a chemical fume hood or under some other type of local exhaust ventilation. Five-gallon containers must be dispensed to smaller containers in a hood or under local exhaust ventilation. When dispensing flammable solvents into small storage containers, use metal or plastic containers or safety cans (avoid glass containers). If splash risk is high wear a face shield in addition to goggles.
- Make sure that metal surfaces or containers through which flammable substances are flowing are properly grounded, discharging static electricity. Free flowing liquids generate static electricity that can produce a spark and ignite the solvent.
- Large quantities (five gallons) of flammable liquids must be handled in areas free of ignition sources (including spark emitting motors and equipment) using non-sparking tools. Remember that vapors are heavier than air and can travel to a distant source of ignition. Heavier than air vapors can flow downhill and gather/ aggregate at the bottom of an enclosure or along the floor of a room and could form explosive mixtures waiting for a spark.
- Never heat flammable substances by using an open flame. Instead use any of the following heat sources: steam baths, water baths, oil baths, heating mantles or hot air baths. Do not distill flammable substances under reduced pressure.
- Store flammable substances away from ignition sources. Flammable liquids should be stored inside rated flammable storage cabinets. If no flammable storage cabinet is available store these substances in a cabinet under the hood or bench. Five-gallon containers should only be stored in a storage cabinet that is rated for flammables. You can store flammable liquids inside the hood for short periods of time. However, storage inside chemical fume hoods is not preferred because it reduces hood performance by obstructing air flow.
- The volume of flammable liquids kept outside of rated flammable cabinets must not exceed 10 gallons at any one time in the laboratory. Never store containers of flammable liquids or other hazardous chemicals on the floor.
- Oxidizing and corrosive materials should not be stored in close proximity to flammable liquids. Flammable liquids should not be stored or chilled in domestic (general purpose) refrigerators and freezers but in units specifically designed for this purpose. It is acceptable to store or chill flammables in ultra-low temperature units.
- If flammable liquids will be placed in ovens make sure they are appropriately designed for flammable liquids (no internal ignition sources and/or vented mechanically). Make sure the auto ignition temperature of the solvent is above the oven temperature or its internal elements.

3.5 Highly Reactive Chemicals and High Energy Oxidizers

Highly reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition as well as chemicals which, under specific conditions, can react alone or with other substances in a violent uncontrolled manner, liberating heat, toxic gases, or leading to an explosion. Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water, and certain catalysts can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction. Examples of shock sensitive materials include acetylides, azides, organic nitrates, nitro compounds, and many peroxides. It is important to keep these chemicals stored in dark, cool, and dry places away from incompatible materials.

3.5.1 Organic peroxides

Organic Peroxides are a special class of compounds that have unusual stability problems, making them among the most hazardous substances normally handled in the laboratories. As a class, organic peroxides are low powered explosives. Organic peroxides are extremely sensitive to light, heat, shock, sparks, and other forms of accidental ignition; as well as to strong oxidizing and reducing materials. All organic peroxides are highly flammable.

3.5.2 Peroxide formers

Peroxide formers can form peroxides during storage and especially after exposure to air (once opened). Peroxide forming substances include aldehydes, ethers (especially cyclic ether), compounds containing benzylic hydrogen atoms, compounds containing the allylic structure (including most alkenes), vinyl and vinylidene compounds.

- Before working with a highly reactive material or high energy oxidizer, review available reference literature to obtain specific safety information. The proposed reactions must be discussed with the principal investigator or your supervisor. Safety considerations must be incorporated in procedures using highly reactive materials. Always minimize the amount of material involved in the experiment; the smallest amount sufficient to achieve the desired result should be used. Scale-ups should be handled with great care, giving consideration to the reaction vessel size and cooling, heating, stirring and equilibration rates.
- Excessive amounts of highly reactive compounds should not be purchased, synthesized, or stored in the laboratories. The key to safely handling reactive chemicals is to keep them isolated from the substances that initiate their violent reactions. Do not work alone when manipulating highly reactive and/or explosive chemicals. Work with these chemicals must not be conducted when adequate facilities are not present, by untrained or sleep deprived laboratory personnel.
- Perform all manipulations of highly reactive or high energy oxidizers in appropriate safety equipment such as chemical fume hoods. Some factors to be considered in judging the adequacy of the hood include its size in relation to the reaction and required equipment, the ability to fully close the sash, and the composition of the sash.
- Make sure that the reaction equipment is properly secured. Reaction vessels should be supported from beneath with tripods or lab jacks. Use shields or guards which are clamped or secured.
- If possible, use remote controls for controlling the reaction (including cooling, heating and stirring controls). These should be located either outside the hood or at least outside the shield.
- Handle shock sensitive substances gently; avoid friction, grinding, and all forms of impact. Glass containers that have screw-cap lids or glass stoppers should not be used. Polyethylene bottles that have screw-cap lids may be used. Make sure containers and equipment are compatible with chemicals used.
- Handle water-sensitive compounds away from water sources. It should also be understood that the water vapor in the air can present problems when handling water-sensitive compounds. Light-sensitive chemicals should be used in light-tight containers. Handle highly reactive chemicals away from the direct light, open flames, and other sources of heat. Oxidizing agents should only be heated with fiberglass heating mantles or sand baths.
- High energy oxidizers, such as perchloric acid, should only be handled in a wash down hood if the oxidizer is used in reactions that may result to volatilization and potential condensation in the ventilation system. Inorganic oxidizers such as perchloric acid can react violently with most organic materials. Work with large volumes of perchloric acid can only be done in a specially designed perchloric acid wash down hoods. SOPs must be established for using perchloric acid fume hoods.
- Store highly reactive chemicals and high-energy oxidizers in closed cabinets segregated from incompatible materials, inside secondary containment. These materials can also be stored in the cabinets under a hood. Do not store these substances above eye level or on open shelves.
- Peroxides and peroxide forming compounds should be stored at the lowest possible temperature. Flammables refrigerators should be used for storage if refrigeration is needed. Light- sensitive compounds should be stored away from light and water-reactive compounds should be stored away from water sources.
- Shock sensitive materials should be discarded after one year if in a sealed container and within six months of opening unless an inhibitor was added by the manufacturer. A list of shock sensitive chemicals is provided in Appendix C-4.

3.6 Compressed Gases

Compressed gases present both a physical and a potential chemical hazard, depending on the particular gas. Gases contained in cylinders may be from any of the hazard classes described in this section (flammable, reactive, corrosive, or toxic). Prior to working with any compressed gases, it is important to read the manufacturers' safety data sheet (SDS). Because of their physical state (gaseous), concentrations in the laboratory can increase instantaneously if leaks develop at the regulator or piping systems, creating the potential for a toxic chemical exposure or a fire/explosion hazard. Even inert gases such as nitrogen or argon can displace room oxygen if accidentally released. Often there is little or no indication that leaks have occurred or are occurring. Finally, the large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a potential rocket or fragmentation bomb if the tank or valve is physically broken.

- When storing compressed gases in your work area it is important to think about the following concerns; is the area a confined space and are there other potential hazards that could damage a gas cylinder. Confined spaces increase the possibility of exposure and asphyxiation from leaking gas systems.
- The contents of any compressed gas cylinder should be clearly identified. No cylinder should be accepted for use that does not legibly identify its contents by name. Color coding is not a reliable means of identification and labels on caps have no value as caps are interchangeable.
- All gas cylinders should be clearly marked with appropriate tags indicating whether they are in use, full, or empty. Empty and full cylinders should not be stored in the same place. Cylinders are considered empty if their pressure is less than 25 psig.
- All gas cylinders must be secured (anchored) to a permanent structure in an upright position. Do not anchor more than two gas cylinders per strap or chain. It is important to use appropriate regulators and piping systems with gas cylinders. Do not use equipment that is incompatible with the gas being used. Gas cylinders that are not in use must have a valve protection cap screwed in place. These caps must also be on cylinders that are being transported or are empty. Keep gas cylinders away from heat sources. Store as few cylinders as possible in your laboratory.
- Carefully read the label before using or storing compressed gas. The SDS will provide any special hazard information.
- Transport gas cylinders on gas cylinders carts one or two at a time only while they are secured and capped. Do not move gas cylinders by rolling them.
- It is important to make sure gas line materials are compatible with the gas being used. Never interchange regulators and gas lines among different types of gases. All gas lines leading from a remote compressed gas supply should be clearly labeled identifying the gas and the laboratory served. Gas lines should be properly tested for leaks using an appropriate testing method for the gas being used.
- Place gas cylinders in such a way that the cylinder valve is accessible at all times. Always turn off gas cylinders from the main stem valve (not the regulator) as soon as the gas flow is no longer needed. Do not store gas cylinders with pressure on the regulator or piping. Use the wrenches or other tools provided by the cylinder supplier to open a valve if necessary. Pliers should not be used to open a cylinder valve or attach a regulator or pigtail.
- Use a leak check solution to detect leaks. Leak test the regulator, pigtail connections, and any piping system after performing maintenance or modifications which could affect the integrity of the system. Always use a leak check solution that is approved for oxygen whenever leak checking oxygen or nitrous oxide cylinders.
- Oil or grease on the high-pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator. Personnel should use caution to make sure their hands do not have oil or grease on them. Many products (i.e. soaps, lotions, etc.) can create the same complications as oil and grease and should be avoided prior to working with compressed oxygen.
- Compressed gases that are toxic, reactive and/or pyrophoric should be purchased in the smallest quantity possible. Compressed gases that are toxic and pyrophoric must be stored/used in a ventilated gas cylinder storage cabinet, fume hood or under local exhaust ventilation. Use the smallest returnable sized cylinder.

- If possible, avoid the purchase of lecture bottles. These cylinders are not returnable, and it is extremely difficult and costly to dispose of them. Small refillable cylinders may be an available alternative. Consult with RMS and cylinder vendor for options.
- Keep regulators safe from damage when not in use. Do not use any regulator that appears damaged, dirty, or in otherwise questionable condition. Regulators greater than 10 years old in storage should not be used unless they have been tested and certified.
- Use only Compressed Gas Association standard combinations of valves and fittings for compressed gas installations. Never use a regulator adaptor. The CGA number should be visible on all regulators. Do not use any regulator that does not have a CGA number marking. Use regulators that are appropriate for the gas being used.

3.6.1 Special Precautions for Hydrogen

Hydrogen gas has several unique properties that make it a potential danger with which to work. It has an extremely wide flammability range (Lower Explosive Limit (LEL) 4%, Upper Explosive Limit (UEL) 74.5%) making it easier to ignite than most other flammable gases. Unlike most other gases, hydrogen's temperature increases during expansion. If a cylinder valve is opened too quickly the static charge generated by the escaping gas may cause it to ignite. Hydrogen burns with an invisible flame. Caution should therefore be exercised when approaching a suspected hydrogen flame. A piece of paper can be used to tell if the hydrogen is burning. Hydrogen embrittlement can weaken carbon steel, therefore cast-iron pipes and fittings must not be used. Seamless tubes should be used. Those precautions associated with other flammable substances identified above also apply to hydrogen.

3.6.2 Special Precautions for Toxic Gases and Pyrophoric Gases

Lecture bottle-sized cylinders of the following gases must be kept in a continuously mechanically ventilated chemical fume hood or other continuously ventilated enclosure approved by RMS:

- All gases that have National Fire Protection Agency (NFPA) Health Hazard Ratings of 3 or 4.
- All gases that have a Health Hazard Ratings of 2 without physiological warning properties (i.e. Carbon Monoxide).
- Pyrophoric gases.

Cylinders of all gases that are greater that lecture bottle following under one of the following conditions must be kept in a continuously mechanically ventilated gas cabinet:

- All gases that have National Fire Protection Agency (NFPA) Health Hazard Ratings of 3 or 4.
- All gases that have a Health Hazard Ratings of 2 without physiological warning properties (i.e. Carbon Monoxide).
- Pyrophoric gases.

Cylinders of pyrophoric gases that are larger than lecture bottle size must be kept in continuously mechanically ventilated, sprinkled gas cabinets. Pyrophoric gas cylinders require additional controls and must comply with requirements listed in NFPA 45, NFPA 55, and Compressed Gas Association CGA P-1- 2008 Safe Handling of Compressed Gases in Containers eleventh edition.

3.7 Corrosive Chemicals

The major classes of corrosive chemicals are strong acids and bases, dehydrating agents, and oxidizing agents. These chemicals can erode the skin and the respiratory epithelium and are particularly damaging to the eyes. Inhalation of vapors or mists of these substances can cause severe bronchial irritation. If your skin is exposed to a corrosive chemical, flush the exposed area with water for at least fifteen minutes. Then seek medical treatment.

Strong acids - All concentrated acids can damage the skin and eyes and their burns are very painful. Nitric, chromic, and hydrofluoric acids are especially damaging because of the types of burns they inflict. Seek immediate medical treatment if you have been contaminated with these materials.

Strong alkalis - The common strong bases used in the labs are potassium hydroxide, sodium hydroxide, and ammonia. Burns from these materials are often less painful than acids. However, damage may be more severe than acid burns because the injured person, feeling little pain, may not take immediate action and allow the material to penetrate into the tissue. Ammonia is a severe bronchial irritant and should always be used in a chemical fume hood.

Dehydrating agents - This group of chemicals include concentrated sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide. Because much heat is evolved on mixing these substances with water, mixing should always be done by adding the agent to water, and not the reverse, to avoid violent reaction and spattering. Because of their affinity for water, these substances cause severe burns on contact with skin. Affected areas should be washed promptly with large volumes of water.

Oxidizing agents - In addition to their corrosive properties, powerful oxidizing agents such as concentrated hydrogen peroxide (>30%), perchloric and chromic acids (sometimes used as cleaning solutions), present fire and explosion hazards on contact with organic compounds and other oxidizable substances. The hazards associated with the use of perchloric acid are especially severe.

- Corrosive chemicals should be used in the chemical fume hood or over plastic trays when handled in bulk quantities (> 1 liter) and when dispensing.
- When working with corrosive chemicals wear gloves, goggles, long sleeved lab coat and closed toe shoes. Handling of bulk quantities of these chemicals requires use of rubber aprons and the combined use of face shields and goggles.
- An eyewash and safety shower should be close by in areas where corrosive chemicals are handled. Spill materials - absorbent pillows, neutral absorbent materials or neutralizing materials should be available in the laboratory.
- Store corrosive chemicals in corrosive cabinets. If these cabinets are not available, store them under fume hoods or on low shelves in impervious trays to separate them physically from other groups of chemicals. Keep containers not in use in storage areas and off bench tops.
- Use a chemical carrier (secondary containers) whenever moving corrosive chemicals from one laboratory to another or from a stockroom.

3.8 Chemicals of High Acute and Chronic Toxicity

Substances that possess the characteristic of high acute toxicity can cause damage after a single or short-term exposure. The immediate toxic effects to human health range from irritation to illness and death. Hydrogen cyanide, phosgene, and nitrogen dioxide are examples of substances with high acute toxicity. The lethal oral dose for an average human adult for highly toxic substances ranges from one ounce to a few drops. The following procedures should be used when the oral LD50 of a substance in the rat or mouse is less than 50 milligrams per kilogram body weight for solid materials or non-volatile liquids and 500 mg/kg body weight for volatile liquids or gases.

- Substances that possess the characteristic of high chronic toxicity cause damage after repeated exposure or exposure over long periods of time. Health effects often do not become evident until after a latency period up to twenty or thirty years. Substances that are of high chronic toxicity may be toxic to specific organ systems - hepatotoxins, nephrotoxins, neurotoxins, toxic agents to the hematopoietic system and pulmonary tissue or carcinogens, reproductive toxins, mutagens, teratogens.
- Avoid or minimize contact with these chemicals by any route of exposure. Protect yourself by wearing gloves, closed toe shoes and long-sleeved laboratory coat. Protect your eyes with safety goggles or glasses. If the procedure involving use of these chemicals has a potential for splashing, consider putting on an impermeable apron or coveralls, and a face shield in addition to goggles.
- Use these chemicals in a chemical fume hood or other appropriate containment device if the material is volatile or the procedure may generate aerosols.
- Store chemicals of high acute or chronic toxicity in a designated storage cabinet in unbreakable primary or secondary containers or placed in chemically resistant trays to contain spills. Do not store toxic chemicals on open shelves or counters. Decontaminate working surfaces after completing procedures.
- All chemicals should be transported between laboratories in durable outer containers or chemical carriers.
- Vacuum pumps used in procedures should be protected from contamination by installing two collection flasks in series along with in-line HEPA-like filter.

3.9 Reproductive Toxins, Mutagens, Teratogens and Embryotoxins

OSHA Laboratory Standard Definitions: Reproductive toxins are defined as substances which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Reproductive toxins are chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring.

Embryo toxins are substances that cause harmful effects on a developing fetus. Auburn University has Reproductive Health Policy and Procedures that can be accessed for more information.

3.10 Electrical Safety

All electrical equipment must be double insulated or grounded. Laboratories should take steps to ensure the safety of Personnel from electrocution. Procedures and Equipment (including personal protective equipment) should be evaluated to ensure appropriate safeguards are in place to protect laboratory personnel and visitors on Auburn University Campus.

3.11 Glassware, Sharps and Needles

Handle and store laboratory glassware with care. Do not use damaged glassware. Borosilicate glassware is recommended for all laboratory glassware except for special experiments that use UV or other light sources. Any glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Glass equipment in pressure or vacuum should be provided with shielding to protect users and other laboratory occupants. Glass vessels at reduced pressure are capable of collapsing violently, either spontaneously (if cracked or weakened) or from an accidental blow. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them with safety netting to contain chemicals or fragments should implosion occur. Use appropriate PPE when working with pressurized glass/plastic vessels or evacuated vessels after evaluating potential hazards. Lab personnel are responsible for broken glass disposal.

All sharps and needles must be treated as medical waste regardless of the type of use. Sharps and needles must be placed in a puncture resistant sharps container. When a sharps container is in need of pickup, a disposal request can be submitted to RMS. These containers must not be overfilled past the full line on the container.

3.12 Lab Close-Out Procedures

Proper transfer or disposal of hazardous materials is required whenever a PI vacates their assigned lab. PIs are responsible for ensuring that graduate students, post-doctoral researchers and visiting researchers leave labs in safe conditions upon graduation or separation from Auburn University.

- Notify RMS (334-844-4870) at least one month (or as soon as possible) prior to closing labs
- Plan the transfer or disposal of hazardous materials carefully; use the laboratory close-out checklist (Appendix B) for guidance. Refer to Laboratory Close-Out Guidelines located on the RMS website for more information.