



The University of Texas Health Science Center at Houston

Chemical Hygiene Plan

Chemical Safety Program
September 2018

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<i>Chemical Hygiene Plan</i>	CSP-001	William Bryan	
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PREFACE

The University of Texas Health Science Center at Houston (UTHealth) is committed to providing a safe and healthy working and learning environment for all faculty, students, employees, visitors and contract employees. Environmental Health & Safety's mission is to work in conjunction with the UTHealth community and ensure that education, research, and health-care related activities take place in conditions that are optimally safe and healthy for students, faculty, staff, visitors, surrounding community, and general public.

The objective of the UTHealth Chemical Safety Program is to assist personnel at all levels in fulfilling the commitment to furnish a place of employment and learning that is as free as possible from recognized hazards that cause or are likely to cause harm to UTHealth personnel or the surrounding community. It is vital that faculty, staff and students have enough information available to aid them in the safe conduct of their daily work activities relating to hazards throughout their workplace.

The purpose of this manual is to provide employees with general guidelines for implementing a quality and proactive safety program regarding the use of chemical agents. The information contained herein satisfies the requirements for the university to provide a written Chemical Hygiene Plan and Hazard Communication Program. It is not intended to be an exhaustive reference, rather a guide for all UTHealth personnel to become familiar with and conduct their operations accordingly. Further advice concerning chemical hazards associated with specific processes and the development of new or unfamiliar activities should be obtained through consultation with your supervisor, the Chemical Safety Committee, or UTHealth Chemical Safety Program.

All users of chemicals must be familiar with the requirements set forth in this manual and applicable state and federal regulations and must conduct their operations in accordance with them.

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1. INTRODUCTION

The purpose of this Chemical Hygiene Plan is to define work practices and procedures to help protect students, laboratory workers, researchers, and supervisors at The University of Texas Health Science Center at Houston (UTHealth) from health hazards associated with the use of hazardous chemicals. The Chemical Hygiene Plan is consistent with the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standard entitled "Occupational Exposure to Hazardous Chemicals in Laboratories" (Code of Federal Regulations, 29 CFR 1910.1450) and the Texas Hazard Communication Act (Chapter 502 of the Texas Health and Safety Code).

OSHA has defined a hazardous chemical as "a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees." In addition, OSHA defines a laboratory as "a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis." Finally, laboratory workers are defined in the OSHA Lab Standard under the definition of "employee" as "an individual employed in a laboratory workplace that may be exposed to hazardous chemicals in the course of his or her assignments." An example of a laboratory worker would include researchers in laboratories and principal investigators (the students in the academic laboratory would not be considered laboratory workers according to OSHA; however they are covered by this plan). If there is any confusion about whether a particular workplace is considered a laboratory that utilizes hazardous chemicals, or whether someone is considered a laboratory worker, the Chemical Hygiene Officer will, upon request, make this determination.

Laboratory workers, researchers, supervisors and students conducting laboratory procedures should be familiar with this Chemical Hygiene Plan and together share the responsibility for creating a safe and healthy work environment. In addition to the Plan, the laboratory workers shall be cognizant of and adhere to the Handbook of Operating Procedures (HOOP) "Safety and Health" and any other sections of the HOOP relevant to their research. The Chemical Safety Program of UTHealth's Environmental Health & Safety (EH&S) has prepared guidelines, which represent prudent health and safety practices in a number of areas. A list of both the policies and the guidelines are found in Appendix 2. Copies of these documents are available upon request from EH&S at 713-500-8100.

A written record stating that each laboratory worker has reviewed the Chemical Hygiene Plan and related health and safety policies and guides shall be kept by the laboratory supervisor (see Appendix 5).

This Chemical Hygiene Plan (referred to as the Plan throughout this document) will be reviewed annually by the Chemical Hygiene Officer and/or the Chemical Safety Committee.

2. REGULATIONS

A hierarchy of information sources exist when making safety related decisions. The hierarchy is first based on whether the information has the force of law followed by how well-reviewed the information is. Codes/Regulations has the most force, followed by standards, best practices, other sources (i.e. journal articles, books, websites, and expert judgement), and personal knowledge.

1. Codes (regulations), promulgated by regulatory bodies. Codes have the force of law and adherence to codes is non-optional. For general and chemical laboratory safety at UTHealth, the following are some of the key codes:
 - a. TAC Title 25, 31, and 37 regulations
 - b. City of Houston Fire Code
2. Formal standards and official guidelines from generally recognized professional associations, industry bodies, non-profit standards organizations, and government agencies. Standards do not intrinsically have force of law, but some are given force of law by being specifically referenced in codes; however, all standards, whether mandatory or not, represent an accepted source of best practice which should be followed. Some organizations publish safety guidelines, which are also a valuable source of best practice. Relevant standard/guideline-promulgating bodies include:
 - a. OSHA publications, guidelines, and fact sheets National Fire Protection Association (NFPA)
 - i. NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals
 - b. American National Standards Institute (ANSI)
 - c. National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards.
 - d. American Chemical Society (ACS; official ACS publications, not simply journal articles)
 - i. Laboratory hazard identification and evaluation
 - ii. Creating Safety Cultures in Academic Institutions
 - iii. Classroom chemical safety
 - iv. Various resources
 - e. National Research Council (NSF)
 - f. Official safety information from other states
3. If a safety question is not resolved or covered by the authoritative information sources mentioned above, or the question is too specific to be covered by those sources, then recourse can be had to:
 - a. Standard practice, as determined from:
 - i. Peer-reviewed journal articles
 1. Journal of Chemical Education
 2. Current Protocols series of journals

3. Newer experimental procedures, which incorporate safety warnings
 - ii. Other universities' safety information
 - iii. Safety information from US government labs

3. RESPONSIBILITIES

The division of responsibilities regarding general health and safety is outlined in the Handbook of Operating Procedures (HOOP), "Safety and Health" found within different policy numbers in the handbook. These policy numbers and chapters are paired together in Appendix 2. This part of the HOOP discusses the responsibilities of the department of Environmental Health and Safety and its programs: Chemical Safety, Biological Safety, Radiation Safety, Occupational Safety and Fire Prevention, and Environmental Protection. Appropriate sections shall be reviewed by laboratory workers and their supervisors.

Specific to this Chemical Hygiene Plan, the responsibilities of EH&S's Chemical Safety Program includes the following:

- Provide technical assistance to laboratory supervisors and workers concerning appropriate storage, handling and disposal of hazardous chemicals;
- Provide general and specialized laboratory safety training upon request;
- Conduct exposure assessments and laboratory surveillance upon request and on a routine basis;
- Make routine, as well as special, health and risk appraisals;
- Provide technical assistance concerning personal protective equipment and laboratory safety equipment;
- Facilitate access to manufacturer's Safety Data Sheets and other laboratory and chemical safety literature; and,
- Remain current on rules and regulations concerning chemicals used at UTHealth.

Deans, Directors, and Heads of Academic and Administrative Units have the primary responsibility for the health and safety of their staff and students. Specific responsibilities regarding the implementation of the Chemical Hygiene Plan include:

- Collaborate with faculty and staff to adapt this model Chemical Hygiene Plan to include lab-specific guidelines and to develop strategies to implement the Plan; and,
- Make budget arrangements for health and safety improvements.

Faculty and staff in charge of supervising laboratories (referred to as laboratory supervisors or laboratory managers throughout this document) have the following responsibilities for implementing the Chemical Hygiene Plan:

- Inform and train employees concerning chemical safety as required by this Plan and retain training records and all documentation;
- Implement and enforce rules and standards concerning health and safety for

- laboratories under supervisor's jurisdiction;
- Provide emergency procedures for laboratory personnel, including names and telephone numbers of key lab personnel such as the lab manager and safety officer;
 - Ensure compliance of laboratory workers with this Plan;
 - Notify EH&S of accidents involving hazardous materials and any significant changes in lab design or procedures;
 - Prepare Standard Operating Procedures (SOP), including procedures on safe work practices for all routine processes involving hazardous materials, hazardous procedures, or hazardous equipment;
 - Ensure the availability and enforce the use of the following: appropriate personal protective equipment (PPE), Safety Data Sheets (SDSs), and relevant reference materials;
 - Remain cognizant of chemicals stored and used in labs and their associated hazards;
 - Dispose of chemicals no longer needed by calling the Hazardous Waste Hotline at 713-500-5837;
 - Conduct internal inspections of labs for health and safety concerns; and
 - Request assistance from the Chemical Safety Program as needed.

Laboratory Employee and Student responsibilities regarding implementation of the Chemical Hygiene Plan are as follows:

- Attend initial and refresher Basic Laboratory Clinical Safety Training
- Follow all health and safety policies and procedures;
- Know egress routes and assembly locations;
- Know the locations of eye wash and safety shower stations, first aid kits, fire extinguishers, fire alarm pull stations, and gas shut-off valves through all lab and office areas in which they work;
- Report all hazardous conditions and practices to the supervisor;
- Wear or use prescribed personal protective equipment;
- Report any job-related injuries or illnesses to the supervisor and seek treatment immediately;
- Refrain from the operation of any equipment or instrumentation without proper instruction and authorization;
- Remain aware of the hazards of the chemicals in the lab and how to handle hazardous chemicals safely; and,
- Request information and training when unsure how to handle a hazardous chemical or procedure.

4. STANDARD OPERATING PROCEDURES

"Standard operating procedures relevant to safety and health considerations are to be followed when laboratory work involves the use of hazardous chemicals". 29 CFR 1910.1450(e)(3)(I)

The Plan represents a minimum set of guidelines for the handling of toxic chemicals on campus. Individual administrative units, laboratories or research groups are required to develop more detailed procedures as their situations warrant. Acceptable lab safety references such as those listed in Appendix 2 of this document may be adopted in whole or may be useful in developing additional procedures. In all situations, individual faculty or staff will be responsible for enforcing adequate safety and hygiene measures in laboratories they supervise. If necessary, additional assistance from Environmental Health and Safety is available.

Some rules or standard operating procedures, which apply to all laboratories at UTHealth, include the following:

4.1 General Guidelines

Respect and understand the safety and health hazards associated with the chemicals and equipment in your laboratory, and practice the following general safety guidelines at ALL times:

- **No smoking.**
- **Unattended experiments.** Laboratory experiments should be placed in potentially low hazard condition before leaving them unattended.
- **Working alone.** When working with hazardous materials, it is advisable to have a second person present, or at a minimum, maintain surveillance via telephone contact.
- **Housekeeping.** Exits, aisles and safety equipment must be kept clear of any obstructions, such as equipment, furniture, etc. Hazardous liquid chemicals should be stored below eye level. Work areas and floors should be kept clear of excessive storage.
- **Food, drink, cosmetics.** Eating, drinking and the application of cosmetics are not permitted in areas where hazardous chemicals are used and shall be done only in well-defined designated non-chemical areas. Do not store food in the same refrigerator with chemicals, biohazards or radioactive materials.
- **No horseplay.** Practical jokes or other behavior that might confuse, startle, or distract another worker is not permitted.
- **Equipment.** Use proper equipment that is in good condition. For example, never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.
- **Waste Minimization.** A laboratory waste minimization program is coordinated by EH&S. In general, this plan includes:
 1. An up-to-date chemical inventory.
 2. Use of the chemical redistribution program.
 3. Annual review of experimental protocols and research of new techniques that consider the hazards and quantities of waste produced.

4. Destruction procedures as the final step in experiments. For example, neutralization of corrosive wastes that do not contain heavy metals should be a standard operating procedure.
5. Elimination of thermometers and reagents that contain mercury, and chromic acid cleaning solutions. Use of other hazardous materials such as heavy metals and halogenated solvents should also be eliminated or reduced.

For further information, see the directives listed in Appendix 1. Additional technical information on waste minimization is available from the Environmental Protection Program at 713-500-8100.

- **Disposal of chemicals.** In general, to request a pick-up of chemicals, call the Hazardous Waste Line at 713-500-5837, press “2” for chemical waste pick-up, and leave a message. Disposal of all laboratory waste shall follow the procedures outlined in a guide entitled "[Hazardous Waste Disposal Procedures](#)," a copy of which is available from EH&S. Additional resource materials relating to waste disposal are available from EH&S. Refer to Appendix 1.
- **Chemical spills and accident response.** In the event of a chemical spill, please call the Chemical Safety Hotline at 713-500-5832 or the main EH&S number at 713-500-8100. For large spills/leaks, incidents involving injury or after-hour incidents call 911 and evacuate the area.
- **Mouth pipetting.** Mouth pipetting is not permitted.
- **Mercaptans (thiols, sulfhydryl reagents).** Should mercaptans be used in a laboratory in such a manner that persons outside of the laboratory would smell the mercaptan and suspect a natural gas leak in the building, the Chemical Safety Program should be contacted at 713-500-5832 to avoid false reporting of natural gas leaks. Mercaptans should be used in a chemical fume hood.
- **Perchloric acid.** If perchloric acid is heated above ambient temperature it will give off vapors that can condense and form explosive perchlorates. Hence, when heating perchloric acid above ambient temperature, a perchloric acid fume hood with a wash down system or a local scrubbing or trapping system must be used. A perchloric acid fume hood is a specialized type of hood that is currently not present at UTHHealth.

4.2 Personal Protection and Personal Hygiene

Personal protection and personal hygiene are two very basic aspects of laboratory safety. Wearing appropriate personal protection and practicing good personal hygiene, as described below, will minimize exposures to hazardous chemicals during routine use and in the event of an accident.

- **Attire.** Wear a lab coat or apron, cover legs and feet (no sandals, open-toed shoes, or shorts), and confine loose clothing and long hair.
- **Gloves.** Gloves are essential when working with hazardous substances. The proper

gloves will prevent skin absorption, infection or burns. All glove materials are not equally effective in protection from chemical hazards. ***In many cases, latex examination gloves do not provide adequate protection from hazardous chemicals.*** Consult a chemical resistance chart such as the one found in Appendix 4, consult a glove manufacturer or contact EH&S for assistance in appropriate selection.

- **Eye protection.** All personnel including students, staff and visitors in laboratories shall wear safety glasses, goggles, or face shields at all times where potential eye hazards exist. Goggles are recommended when chemical splashes are possible. The wearing of contact lenses in labs is an unsettled issue. *If contact lenses are to be worn, the eyes should be protected by goggles when in the lab.*
- **Face shields.** Full-face shields must be worn when conducting a procedure that may result in a violent reaction. Full-face shields with bottom caps to protect under the chin are preferred due to the tendency to raise the chin when a splash occurs.
- **Glass tubing.** When inserting glass tubing into stoppers, lubricate the tubing and protect hands from being cut in the event the tubing slips and breaks.
- **Personal hygiene.** Hands should be washed frequently throughout the day, before leaving the lab, after contact with any hazardous material, before eating, etc.

4.3 Hazardous Material Handling and Storage

Hazards associated with various chemicals and gases vary widely. Understanding the hazards associated with a compound and minimizing the quantity used and stored in the lab will decrease the chance of injury.

- **Chemical storage (general).** Chemicals must be stored by compatibility, not by alphabetical arrangement. For example, oxidizers should be separated from organics, air/water reactives must be kept dry and cyanides should be stored away from acids. Storage of all laboratory chemicals shall follow the recommendations outlined in Appendix 7, Chemical Segregation and Incompatibilities Guidelines.
- **Storage of volatile chemicals.** Volatile toxic substances shall be stored in storage cabinets adequate to the purpose or alternatively, in hoods when cabinets are unavailable. If volatile substances are stored in a hood, other uses of the hood shall be restricted to activities compatible with the chemical and physical properties of the chemicals being stored or used. When volatiles must be stored in a cooled atmosphere, refrigerators or cold rooms designed for this purpose must be used. Refrigerator/freezer units for the storage of flammables are located throughout UTHealthH. Call the Chemical Safety Program at 713-500-5832 for locations.
- **Chemical handling.** Use secondary containment when transporting chemicals by placing the chemical being transported inside a protective container. For example, use polycoated bottles or bottle carriers for transporting chemicals that are in regular glass containers. Close caps securely and avoid storing chemical containers in hard to reach areas. Pour chemicals carefully, and never add water to concentrated acid or base. Metal containers and non-conductive containers (e.g., glass or plastic) holding more than five gallons must be grounded when transferring

- flammable liquids.
- **Cylinder storage.** Cylinders must be stored in well-ventilated areas with their protective caps screwed on and the cylinder secured (e.g., strapped or chained down) to reduce the chance of the cylinder being knocked over. For assistance in securing gas cylinders, call the Facilities Remodeling Services at (713) 500-4746. Do not store cylinders near heat or high traffic areas. Do not store flammables and oxidizers together. Do not store empty and full cylinders together. Storage of large quantities of cylinders must be done in an approved gas cylinder storage area.
 - **Cylinder handling.** Use appropriate handcarts to move cylinders. Cylinders must be secured to the cart during transport. Highly toxic gases should not be moved through the corridors, particularly during business hours. Always consider cylinders as full and handle them with corresponding care.
 - **Labels.** Make sure all labels are legible. Label all secondary containers with the chemical name (as it appears on the original label or SDS) and appropriate hazards. Health hazard warning information should include the target organs that may be affected and any of the following terms that are appropriate: carcinogen, toxic or highly toxic agent, reproductive toxin, irritant, corrosive, sensitizer, hepatotoxin, nephrotoxin, neurotoxin, agents which act on the hematopoietic system, or agents which damage the lungs, skin, eyes, and mucous membranes. Physical hazard warning information should include any of the following terms that are appropriate: combustible liquid, compressed gas, explosive, flammable, organic peroxide, oxidizer, pyrophoric, unstable (reactive), or water reactive. Date all peroxidizable (i.e. ethyl ether) and other chemicals that may become unstable over time; test and/or dispose of them when appropriate.
 - **Containers.** Check the integrity of containers. Ensure that the container used is compatible with the chemical, for example hydrofluoric acid must not be stored in glass and some oxidizers should not be stored in plastic containers.

5. CONTROLLING CHEMICAL EXPOSURES

"Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous." 29 CFR 1910.1450(e)(ii)

There are three major routes of entry for a chemical to enter the body: inhalation, skin and eye contact, and ingestion. Three types of controls for prevention of these various routes of entry include the following: engineering controls, personal protective equipment and administrative controls. Each route of entry can be controlled in a number of ways, as explained below.

5.1 Inhalation Hazards

Inhalation of chemicals is the most common route of entry a chemical can take to enter the body. To avoid significant inhalation exposures, engineering controls are the best option to eliminate or minimize hazards. For example, substituting a less volatile or a less toxic chemical, or substituting a liquid or solid chemical for a gaseous one are the best means of control. If substitution is not practical, ventilation should be used to lessen the chance of overexposure. The use of well-functioning local exhaust ventilation such as laboratory (fume) hoods, vented glove boxes and other local exhaust systems is often required to minimize exposure to hazardous chemicals. Dilution ventilation may be used to reduce exposure to non-hazardous nuisance odors. For extremely toxic chemicals such as those classified as poison gases by State or Federal Department of Transportation (e.g., arsine, phosgene) the use of closed systems, vented gas cabinets, fail-safe scrubbing, detection or other stricter controls may be required.

Administrative controls can be utilized to reduce the risk of overexposure to hazardous chemicals. Some examples of administrative controls include:

- minimization of exposure time for individual employees;
- restricted access to an area where a hazardous chemical is used;
- allowing a process that emanates nuisance odors to be done only after typical office hours, when most of the staff in the building have gone home; and,
- proper signage on lab doors to indicate special hazards within, a list of lab personnel who should be contacted in the event of an emergency, and appropriate telephone numbers. Door signs are provided by EH&S.

Finally, if engineering and administrative controls are not an option, the use of personal protective equipment may be required to reduce inhalation exposures. If respirators are worn by laboratory employees, requirements of the OSHA Respiratory Protection Standard (29 CFR 1910.134) must be met. This standard requires training on the proper use of respirators, medical surveillance to ensure the user is capable of wearing a respirator, and fit testing to ensure that the respirator fits properly. A lab worker or his/her supervisor should contact EH&S in the event that respiratory protection is needed to control exposures to hazardous chemicals.

5.2 Skin/Eye Contact Hazards

To reduce the risk of a chemical entering the body via skin and eye contact, engineering controls including substitution and appropriate ventilation, should be used as described above in "Inhalation Hazards." The more obvious means of preventing skin and eye contact is the wearing of personal protective equipment such as eye protection, face shields, gloves, appropriate shoes, lab aprons, lab coats, and other protective equipment appropriate to the hazard. Since the chemical resistivity of the different types of protective equipment varies significantly, the lab supervisor should consult Appendix

4 or other references to ascertain that the protective equipment material is resistant to the chemical being protected against.

Administrative controls to reduce skin/eye contact include: enforcement of policies pertaining to skin and eye protection, and discarding or repairing cracked or broken glassware.

5.3 Ingestion

Ingestion of chemicals is the least common route of entry into the body. A laboratory worker can easily ingest chemicals into the body via contaminated hands if they are not washed prior to eating, smoking or sticking part of the hand, or a writing tool that has been in contaminated hands, into the mouth. Use engineering controls, such as isolating the hazardous substance so that minimal contact is required (e.g., use glove box), to help prevent exposures. Administrative controls such as prohibiting mouth pipetting, encouraging good personal hygiene, and designating a well-marked non-chemical area where eating, drinking and the application of cosmetics are permitted, is also beneficial in preventing chemical exposures via ingestion. Personal protective equipment, such as gloves, may also be used.

At the request of faculty, staff or students, exposure evaluations may be conducted by the Chemical Safety Program for any suspected overexposure to substances regulated by OSHA and/or with threshold limit values published by the American Conference of Governmental Industrial Hygienists. Records of exposure evaluations will be kept by EH&S.

6. LABORATORY SURVEILLANCE

Laboratory safety surveys are conducted on a routine basis in all of the biomedical research and clinical laboratories. The focus of the surveys is to ensure compliance with a number of general safety, fire safety, chemical safety, and physical safety compliance issues. The Environmental Health and Safety department takes a proactive approach to compliance problems found in the laboratories and in most cases facilitates the corrective action process. The following outline the criteria in which the laboratory safety surveys are inspected.

- **General Housekeeping**

It is the responsibility of each laboratory worker to ensure that the laboratory is maintained in a clean and orderly fashion. Excessive storage of equipment, supplies, and chemicals can pose various hazards to laboratory employees and other building occupants.

- **Current Emergency Information and Warning Signs Posted**

All laboratories shall have posted near the telephone or door entrance, the telephone numbers of persons to call in the event of an emergency. In addition to numbers for

chemical spill, radiation spill, fire and medical emergency, there should also be included name of responsible person (PI) along with office and home phone.

A list of campus emergency phone numbers can be found on page six of the Environmental Health and Safety Laboratory Safety yellow flip chart. Other important safety information inside the flip chart includes: Texas Department of Health (TDH) Radiation Notice to Employees, TDH Hazard Communication Notice to Employees, obtaining material safety datasheets, hazardous waste disposal procedures, common lab compliance violations and how to correct, infection control, and the UTHealth compliance program.

The NFPA 704 diamond shall also be posted outside each active laboratory for use by firefighters and safety personnel during emergency situations. Radioactivity work areas, laboratories and containers of radioactive materials must be posted with appropriate warning signs [see Radiation safety manual]. Areas where human blood or other potentially infectious materials are stored or used must bear the universal biohazard symbol. Researchers working with or storing biosafety level 2 or higher organisms shall utilize the universal biohazard warning. Appropriate locations for biohazard signs include laboratory entrance, incubator, refrigerator, and waste containers.

Emergency postings shall also be placed on the laboratory electrical panel and emergency gas shut off valve. These two emergency cut-offs are utilized in emergency situations and shall never be obstructed with equipment or storage.

- **No Food or Drink Rule Observed**

Food and drink brought into areas of chemical or radiological use can easily become contaminated by these hazards. Airborne particulates can settle on exposed food, eating surfaces or utensils. Even though work surface contamination may not be readily apparent, it can adhere to hands and then be transferred to food items. Upon ingestion these harmful substances will be carried into the body, increasing the opportunity for toxic effects.

- **Appropriate Personal Protective Equipment Available**

Chemical resistant gloves should be available and worn during procedures. To choose the best glove for a particular operation one must weigh the ability of the glove material to resist permeation and degradation by the chemicals in use against the dexterity needed to conduct the experimental protocol. There is no single glove material universally resistant to all classes of chemicals; glove selection must be individualized for each experimental protocol. Eye protection should be available and worn during procedures. The eyes are particularly sensitive to chemical or physical insult and should be protected at all times against chemical splashes or sprays, flying particles, UV radiation and other hazards. Protective clothing should be available and worn during procedures (lab coat, apron, etc.). Lab coats not only

protect street clothing from being soiled; they also provide an additional layer of splash and burn protection and help protect family members by reducing take-home toxins.

- **All Applicable Safety Binders/Manuals Available**

Safety manuals available include: Chemical Hygiene Plan, Biological Safety Manual, and the Radiation Safety Manual. Every laboratory using hazardous chemicals, radioactive, or biological hazards must have a copy of the respective Laboratory Safety binder/manual in the lab or otherwise readily available. Thoroughly review all applicable safety manuals with laboratory staff. [OSHA 29CFR 1910.1450 (e) (2)]

- **Occupant's Safety Concerns Solicited**

During routine surveys conducted by EH&S, the Safety Specialist is to talk with the laboratory workers and ensure they have no specific safety concerns. If the employee raises concerns, the Safety Specialist will make every effort to address the issue either personally, by way of a Safety Manager, Safety Director, or the University Chemical Safety Committee.

- **Appropriate Records Shall be Maintained**

Laboratory employees and investigators are to keep documentation of all certificates of required training for working in a laboratory. Training requirements can vary depending on the type of research being conducted. For all laboratory employees, including PI's, Basic Laboratory and Clinical Safety training is required annually. Contact EH&S if there are any questions regarding training requirements.

- **Egress Pathways Unobstructed**

Laboratories shall be maintained in such a manner where there is at least 36 inches of clearance between obstructions to exit from the laboratory into the corridor. The corridors must have a minimum of 48 inches of clearance and shall be maintained free of obstructions to ensure clear egress to the nearest stairwell in the event of an emergency. Many times, emergency safety equipment i.e. safety showers and eyewashes are also located in the main corridors and this equipment shall be maintained free of any obstruction. Contact Occupational Safety and Fire Prevention at 713-500-8100 for further guidance.

- **Fire Extinguisher Available and Inspected**

Fire extinguishers shall be located inside all laboratories or, in some instances, a minimum of 75 feet from the laboratory. Extinguishers are inspected on a quarterly basis and maintained by Occupational Safety and Fire Prevention. Laboratory workers should routinely inspect for broken seals, damage, and low gauge pressure (depending on type of extinguisher). If problems are identified, repairs are requested by contacting Occupational Safety and Fire Prevention at 713-500-8100.

- **Heat Sources Separated from Combustibles**

One of the easiest methods of fire risk reduction is to remove ignition sources from a flammable system (fuel + oxygen + ignition source). Ignition sources include electrical outlets, lighting fixtures, switches, exposed machinery components, as well as open flame. Flammable solvents should be used inside a chemical fume hood so vapors will be prevented from reaching flammable proportions. In the special case of a flammable solvent being heated (as in a distillation) it is important that all ignition sources (electrical outlets, Variac controllers, outlet strips) be located outside of the hood.

- **Appropriate Clearance to Ceiling**

It is required that there is an 18 inch clearance to the ceiling to comply with NFPA codes for sprinkler systems. This regulation does not include shelving and storage attached to a wall, as this does not impede the overlap of spray from other sprinkler heads. Minimizing the “stacking” of combustible material will also decrease the fuel package arrangement of the laboratory and help contain the fire to one laboratory unit in the event of a fire.

- **Electrical Circuit Loading and Cords**

Insufficient or overloading of electrical outlets should be avoided. A sufficient number of outlets will eliminate the need for extension cords. Overloading electrical circuits and extension cords can result in a fire.

A cord should not be pulled or dragged over nails, hooks, or other sharp objects that may cause cuts in the insulation. In addition, cords should never be placed on radiators, steam pipes, walls, and windows. Particular attention should be placed on connections behind furniture, since files and bookcases may be pushed tightly against electric outlets, severely bending the cord at the plug.

When the outer jacket of a cord is damaged, the cord may no longer be water-resistant. The insulation can absorb moisture, which may then result in a short circuit or excessive current leakage to ground. If wires are exposed, they may cause a shock to a worker who contacts them. These cords should be replaced. Electric cords should be examined on a routine basis for fraying and exposed wiring.

Household extension cords and multi-use plugs are prohibited. Check that cords on equipment are in good condition with no fraying. Equipment supplied with a grounded plug requires attachment to a ground source. Removal of the grounding prong interferes with this electrical safety feature and can result in shock or electrocution.

- **Minimize Trip Hazards**

Laboratories shall be maintained free of trip hazards. This includes items such as power cords on the floor, excessive equipment in the laboratory, and/or damaged flooring.

- **Compressed Gas Cylinders Secured**

Compressed gas cylinders are under great pressures, often exceeding 2000 pounds per square inch or 136 atmospheres. To prevent the accidental and uncontrolled release of energy it is important to protect cylinders from toppling over and rupturing the valve stem. All compressed gas cylinders, including lecture bottles, “empty” cylinders, and cylinders in transit, must be secured in racks, clamping devices, stands, or other protective structure.

- **Guards for Mechanical Hazards in Place**

Some common pieces of lab equipment present physical hazards due to rotating parts, nip points or other mechanical action. Particularly prevalent in the lab are vacuum pumps that have had their belt guards removed. To prevent injury due to entrapment of hair, clothing or other items it is necessary that these areas remain guarded. Any piece of equipment with a detached, disengaged or inoperable guard must be prominently tagged and removed from service.

- **Electrical Panel Not Obstructed**

Building safety codes prohibit the placement of any items within 30 inches of the electrical panels. In order to maintain accessibility of the electrical panel in case of an emergency, no items should be placed in such a way as to diminish access to the panel.

- **Proper Segregation of Chemicals**

Storage of chemicals as a general group alphabetically is not recommended as it may place incompatible materials together on a shelf. Instead, separate chemicals into organic and inorganic families and then into related and compatible groups. Suggested chemical storage schemes and compatibility lists can be found in a number of lab safety resources available from EH&S. A quick and very general rule of thumb is to separate acids from bases, flammables from oxidizers, and reactives from air or water. Chemicals should never be stored on the floor.

- **Chemicals Properly Labeled**

Manufacturers are required to label every chemical container with hazard information that includes chemical name, physical and health hazard information, and name of manufacturer. These labels relay valuable information that can assist in hazard evaluation and control, and cannot be removed or defaced from the original container unless the contents have been altered or removed. Secondary containers that will remain in use for a period of time (storage vials, squirt bottles) should bear an abbreviated label that includes chemical name and hazard warning such as flammable, caustic, sensitizer, carcinogen, absorbed through the skin etc.

- **Flammables Properly Stored**

A number of common solvents have flash points close to or below the temperature at which most refrigerators operate (around 39°F or 4°C). Flammable solvents evaporate rapidly, even at lowered temperatures, so they can quickly reach equilibrium inside the small, well-sealed space of a refrigerator. When this “off-gassing” reaches the lower explosive limit (LEL), sources of ignition inside a conventional refrigerator such as the thermostat, interior light, defroster, compressor, or fan can set off an explosion. Flammable liquids that must be stored at reduced temperature require a specially designed refrigerator, termed a “flammable material storage refrigerator,” where ignition sources are isolated from the inside space.

- **Controlled Substances Secured**

Controlled substances must be secured in accordance with the Texas Legislature Chapter 481 *Texas Controlled Substances Act* which include the following criteria:

- Establishing adequate security to prevent unauthorized access to controlled substances and dangerous drugs, including a preliminary security inspection (contact UTPD for assistance).
- Not allowing any individual access to controlled substances and dangerous drugs storage areas except those authorized for efficient operations during the course of business activities.
- Storing controlled substances and dangerous drugs listed in schedules I, II, III, IV, and V in a securely-locked substantially-constructed cabinet or security cabinet or safe.

- **Absence of Old or Potentially Explosive Chemicals**

Out-dated, expired, unknown chemicals should be promptly disposed of by the appropriate means. Many materials, as they age, become unstable, possibly forming explosive byproducts or undergoing rapid and violent decompositions. Other materials simply lose purity as contaminants are introduced or residues form. Chemicals that may no longer be used, that are of questionable purity, or that are past their expiration dates should be removed from the lab by placing a request into the Hazardous Waste Line at 713-500-5837, pressing “2” for chemical waste pick-up, and leaving a message.

- **Hazardous Liquid Chemicals Stored below Eye Level**

Every chemical should have assigned to it a definite storage place and should be returned to that place after each use. Do not store materials on top of high cabinets where they will be hard to reach and see.

- **Air Flow in Chemical Fume Hood Adequate**

Hazardous chemicals that are flammable, volatile, or gases should be manipulated inside a properly functioning chemical fume hood. Optimum height is the sash height at which air flow is maximized without creating turbulence, generally between 60 and 150 linear feet per minute (lfpm). A yellow sticker placed on the hood face indicates the most recently recommended sash height. Hoods can malfunction at any time without warning. It is important to confirm hood operation before each work session. Check the air flow gauge if so equipped. In the absence of a gauge one can tape an inch wide strip of tissue to the lower corner of the sash. Air flow can be visually assessed by noting that the tissue is pulled gently into the hood. Laboratories that have been upgraded during the indoor air quality renovation will have a digital display of the hood flow rate. Variable air volume valves have been calibrated to maintain 100 lfpm. If the flow rate is not within the acceptable range, the correction is to be made by Facility Operations by contacting 713-500-3498.

- **Chemical Fume Hood Sash Closed When Not in Use?**

In order to promote safety and conserve energy, the chemical fume hood sash must be closed when not in use. If a reminder sticker is needed, please contact Chemical Safety at 713-500-5832.

- **Ventilation Negative to Hallway**

The primary objective in controlling occupational exposures is to prevent contamination of the work atmosphere. This shall be achieved first by use of a chemical fume hood, or other enclosure. The second way in which this achieved is by making sure the ventilation is such that the air pressure in the laboratory is negative with respect to the hallway, thus assuring airflow into the laboratory.

- **Safety Shower/Eyewash Station Available**

Emergency shower and eyewash equipment shall be maintained in accordance with the American National Standards Institute (ANSI) code Z358.1 – 1998. If there are any questions or concerns with this equipment please contact Occupational Safety and Fire Prevention at 713-500-8100.

- **Previous Deficiencies Adequately Resolved**

Safety Specialists will review past laboratory inspections and compare to the current inspection. If discrepancies remain that were identified on previous surveys, they will be communicated to the principal investigator. If not resolved, disciplinary actions will be followed as outlined in Section VI.

- **Biological Agents / rDNA**

Biohazards are a concern in laboratories in which microorganisms or material contaminated with them is handled. These hazards are usually present in clinical and infectious disease research laboratories, but may also be present in any laboratory in which bodily fluids or tissues of humans or animal origin are handled.

Identify what bioagents are being used, whether the agents are infectious, and whether the research includes the use of recombinant DNA (rDNA). Identify any animals being used in the research. If the research includes the use of rDNA, notify Biological Safety so that they can check their current approval status.

- **Biological Safety Cabinet Certified within Past Year**

Biosafety cabinet should be certified when installed or moved, and annually thereafter. The biosafety cabinet's (BSC) ability to filter out microscopic particles relies on the seals being intact and the HEPA filter free of micro tears or breaks that can easily occur during moving, instillation or careless handling. To ensure continued proper operation, each BSC should be tested and certified at least annually. [CDC/NIH Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets p. 29; NRC Biosafety in the Laboratory p. 26]

- **Chemical Waste**

Ensure that all chemical waste containers are kept closed and marked "Hazardous Waste" or equivalent.

Label all hazardous waste containers with the word "waste" and list the individual waste chemical constituents on the label. Accumulation start dates should be marked on the container and full containers should be dated. Call the Hazardous Waste Line at 713-500-5837, press "2" for chemical waste pick-up, and leave a message for removal and proper disposal.

- **Biological Waste**

All biological waste must be labeled as such. Ensure that waste bags are contained within a separate solid rigid container (secondary containment), such as a trashcan or cardboard box. Metal frames are insufficient and do not constitute secondary containment. Environmental Protection can be contacted for assistance. Contaminated sharps include needles, scalpels, broken capillary tubes, exposed dental wires, and broken glass if contaminated with human blood or other potentially infectious material. These items must be collected in a sharps box or other puncture resistant container that is color coded or labeled with the universal biohazard symbol.

Needles, razors and other sharps should be contained within rigid plastic sharps containers after use. Coffee cans or other metal containers are not allowed due to the incineration process during disposal. If sharps are to be reused, they should be stored between uses in Styrofoam blocks to reduce the possibility of needlesticks. Sharps containers can be obtained free of charge through the Environmental Protections program.

7. RESPONSE TO NON-COMPLIANCE

Discrepancies discovered during routine inspection will be addressed in the following manner:

- **Step One - Verbal Notification**

If, during a routine evaluation or inspection, a problem involving chemical safety procedures is observed, a verbal recommendation will be provided. If upon receipt of a verbal recommendation, the laboratory staff or the Environmental Health and Safety staff takes immediate steps to correct the problem, then no further response regarding the discrepancy will be requested.

- **Step Two - Written Notification**

Following the survey, a written summary of the findings and recommendations including corrections during the survey will be sent to the PI responsible for the laboratory. The PI will then be requested to take corrective action within 30 days. Verbal, e-mail, or written response is requested.

- **Step Three - Documentation**

A list of discrepancies will be maintained by the Environmental Health and Safety Staff and a follow-up will be conducted within 60 days of the inspection to determine if corrective actions had been taken.

- **Step Four - Follow-up**

If the follow-up reveals that the same discrepancy exists, notification of this situation may be sent to both the PI and the Department Chair. A **written response** from the PI shall be sent to EH&S detailing specific steps taken to ensure correction of the discrepancy. Discrepancies may be presented to the Chemical Safety Committee (CSC) at the discretion of the Director of EH&S.

- **Step Five - Chemical Safety Committee Action**

If the problem continues, both the PI and the Department Chair will be given a written account of the situation. The entire case history will also be presented to the CSC. Any operation causing a high or unacceptable risk to employees or personnel exposure to any chemical hazard will be suspended immediately by EH&S without regard to the above procedure. In the event of this action, the situation will be promptly reviewed by the Director of EH&S and the CSC.

8. LABORATORY FUME HOODS AND OTHER ENGINEERING CONTROLS

"A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment." 29 CFR 1910.1450 (e)(3)(iii)

All laboratory (fume) hoods at UTHealth should comply with EH&S guidelines. Laboratory (fume) hoods and other engineering controls such as vented gas cabinets should be surveyed annually by EH&S. Laboratory (fume) hood velocities for all hoods on campus are currently evaluated on an annual basis by EH&S at no charge to laboratory personnel. The face velocity of the hoods should fall between 60 and 150 feet per minute (fpm) with the sash positioned at approximately half-open, unless specified otherwise. (In general, laboratory hoods should not be used with the sash fully open.) If the face velocity is between 60 and 150 fpm on the day of the evaluation, the laboratory hood will bear a yellow sticker on the cabinet with an arrow pointing to the appropriate sash position. If the face velocity is less than or equal to 59 fpm or greater than or equal to 151 fpm, the hood will not have a yellow sticker with an arrow indicating sash position. This indicates that the hood is "Restricted" and should not be used for protection from highly toxic substances. Upon finding a hood out of the specified range, EH&S will contact Facility Operations for adjustment. Once the hood has been adjusted, a yellow sticker will be attached with an arrow indicating the appropriate sash position and the face velocity in fpm. The fume hood may be equipped with a variable airflow valve that keeps the hood face velocity at a constant 100 fpm. The rate is measured constantly and displayed by a digital readout on the fume hood.

Laboratory personnel should be certain that their hood has a sticker on it and that the date on the sticker is less than a year old. Because the status of a hood can change within one year, continuous air flow indicators are recommended for all fume hoods. New laboratory (fume) hoods should be equipped with air flow monitoring devices which will alert the user if there is a problem with air flow. For older hoods without air flow monitoring devices, a simple visible test to ensure flow into hoods and other ventilating devices is to tape a Kimwipe® to the hood and note its movement when the exhaust fan is on.

Air exhausted from chemical fume hoods and other special local exhaust systems shall not be recirculated. Ductless chemical fume hoods that pass air from the hood interior through an adsorption filter and then discharge the air into the laboratory are only applicable for use with nuisance vapors and dusts that do not present a fire or toxicity hazard (See NFPA 45 8.4.1.).

Protective equipment other than laboratory hoods should be checked periodically by the laboratory supervisor to ensure that the equipment is functioning properly. Any questions or requests for assistance in evaluation of hoods and other protective equipment may be directed to Environmental Health & Safety at 713-500-8100 or Facility Operations at 713-500-3498.

9. PRIOR APPROVAL FOR THE ACQUISITION AND USE OF HAZARDOUS CHEMICALS

"The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation." 29 CFR 1910.1450(e)(3)(v)

The principal investigator/laboratory supervisor is responsible for obtaining approval for the acquisition and use of toxic chemical agents. Certain materials including toxic chemical agents, radioactive materials, recombinant DNA and certain biological agents require prior approval from the respective safety committee at various levels. Questions concerning the need for approvals should be directed to EH&S.

The principal investigator/laboratory supervisor is responsible for obtaining approval from the Chemical Safety Committee for the acquisition and use of toxic chemical agents. Forms for Chemical Safety Committee approval for the use of hazardous chemicals may be found in Appendix 6 and online at www.uth.edu/safety. To determine whether a chemical requires approval prior to acquisition and use, consult the "Chemical Safety Committee Review Criteria." For additional assistance, contact the Chemical Safety Program at 713-500-5832.

10. MEDICAL CONSULTATION

"Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section." 29 CFR 1910.1450(e)(3)(vi)

An opportunity to receive medical consultation shall be provided under the following circumstances: if an employee develops any symptoms thought to arise from chemical overexposure; after an event such as a major spill, leak or explosion which may have resulted in an overexposure; or, if an overexposure is identified as the result of an evaluation by the Chemical Hygiene Officer or designee. These suspected or actual exposures requiring medical evaluation can and should be treated as a regular Worker's Compensation claim. A "Supervisor's First Report of Injury" form should be filled out and signed by the supervisor. The injured employee should contact UT Employee Health Services (713-500-3267) for treatment. Following notification of overexposure, arrangements for an appropriate medical examination must be completed before the exposed individual may return to work. Any medical examination required by this Plan shall be provided without cost to the employee, without loss of pay and at a reasonable time and place. Records of any medical examination will be maintained by UT Employee Health Services.

11. CHEMICAL HYGIENE OFFICER AND CHEMICAL HYGIENE COMMITTEE

"Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee." 29 CFR 1910.1450(e)(3)(vii)

The UTHealth Chemical Safety Committee will serve as the UTHealth Chemical Hygiene Committee. The Vice President of Environmental Health & Safety also serves as the Chemical Hygiene Officer for UTHealth.

Academic units are encouraged to have their own Chemical Safety Officers to help implement this Plan in their units.

12. SPECIAL PROVISIONS FOR SELECT CARCINOGENS, PYROPHORIC/EXPLOSIVE SUBSTANCES, ANTINEOPLASTICS, ACUTELY TOXIC CHEMICALS, AND NANOSCALE PARTICLES

"Provisions for additional employee protection for work with particularly hazardous substances: These include "select carcinogens" and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

- (A) Establishment of a designated area;*
- (B) Use of containment devices such as fume hoods or glove boxes;*
- (C) Procedures for safe removal of contaminated waste; and*
- (D) Decontamination procedures." [29 CFR 1910.1450(e)(3)(viii)]*

Carcinogens, acutely toxic chemicals, explosives/pyrophorics, antineoplastics and nanoscale particles may require approval from the Chemical Safety Committee prior to acquisition and use. A listing of required protocol chemicals can be obtained from Chemical Safety by calling 713-500-5832 or online at www.uth.edu/safety/. In addition to the general safety guidelines mentioned in the first section and throughout the Plan, special precautions are needed when handling these types of chemicals. A minimum set of guidelines that should be followed is listed below. The lab supervisor should ensure that these and other precautions designed to minimize risk of exposure to these substances are taken.

- Quantities of these chemicals used and stored in the laboratory should be minimized, as should their concentrations in solutions or mixtures.
- Work with carcinogens, acutely toxic chemicals, explosives/pyrophorics, antineoplastics and nanoscale particles should be performed within a functioning laboratory (fume) hood, ventilated glove box, sealed system, or other system designed to minimize exposure. (The exhaust air from the ventilation systems may require scrubbing before being released into the atmosphere.) In all cases, work with these types of chemicals shall be done in such a manner that the OSHA permissible exposure limits or similar standards are not exceeded.
- Compressed gas cylinders that contain acutely toxic chemicals such as arsine and nitrogen dioxide should (and may be required to) be kept in ventilated gas cabinets.
- The ventilation efficiency of the designated hood, glove box or gas cabinet, and the operational effectiveness of mechanical and electrical equipment used to contain or

manipulate these special substances should be evaluated periodically by laboratory personnel at intervals determined by the laboratory supervisor. The interval of evaluating systems may vary from weekly to biannually depending upon the frequency of usage, quantities employed and level of hazard.

- Each laboratory utilizing these substances must designate an area for this purpose and must sign or mark this area with an appropriate hazard warning. The designated area may be an entire laboratory, an area of the laboratory or a device such as a fume hood or glove box. The designated area should be marked with a DANGER, specific agent, AUTHORIZED PERSONNEL ONLY or comparable warning sign.
- All laboratory workers who work in a laboratory that has an area designated for use with carcinogens, acutely toxic chemicals, explosives/pyrophorics, antineoplastics and nanoscale particles must be trained about the deleterious effects of these substances as well as signs and symptoms regarding exposure to these substances, whether or not they actually work with the substance themselves. Training to ensure the safe handling and storage of these substances is required for those who use these materials. This training is the responsibility of the laboratory supervisor and must be done prior to the use of any of these materials.
- Laboratory workers working with these chemicals must have access to appropriate protective equipment and clothing (available at no expense to the workers) and must be trained on how to properly utilize the safety equipment.
- Detection equipment may be required in laboratories where chemicals (especially poisonous gases) with a high degree of acute toxicity are utilized.
- All wastes contaminated with these substances should be collected and disposed of in a timely manner and appropriately as outlined in the EH&S waste disposal guide (mentioned previously). For special disposal information, call Environmental Protection at 713-500-8100. If possible and as soon as practical, waste products shall be destroyed by a suitable, generally acceptable chemical procedure to lessen or eliminate their toxicity.
- The designated working area shall be thoroughly and appropriately decontaminated and cleaned at regular intervals determined by the laboratory supervisor. The interval may be as short as one day or as long as six months depending upon the frequency of usage and level of hazard.
- Special precautions to avoid release and exposure to highly toxic chemicals, carcinogens, explosives/pyrophorics, antineoplastics and nanoscale particles must be utilized. For instance, volatile substances should be kept cool and contained; gases should have properly functioning valves, check valves, regulators, containment which can withstand pressure buildup, and appropriate piping; and

dispersive solids should be kept in closed containers, used in places with minimum air currents, and appropriate contact materials should be used to avoid static charging. Additionally, the shipment of any highly toxic chemicals, genotoxins, reproductive toxins and/or nanoscale particles (Appendix 9) from UTHHealth to any other location must be coordinated through the EH&S Chemical Safety Program.

- Emergency response planning for releases or spills shall be prepared by the lab supervisor and included in the training of the laboratory workers and others who may be affected in the building. EH&S can be contacted for assistance.
- More information on the use of controlled substances in research can be obtained by referring to the Controlled Substances Research Guide, available on the EH&S website.

APPENDIX 1: CHEMICAL WASTE DISPOSAL PROCEDURES

BACKGROUND

In general, all chemicals and their disposal should be treated with a healthy measure of respect. Because of the tremendous number of chemicals available in today's medical research institutional environment, their deleterious effects to personnel, and the "cradle to grave" responsibility under the Resource Conservation Recovery Act (RCRA) and Superfund Amendments and Reauthorization Act (SARA Title III) regulations, it is essential that an institution conduct a chemical waste disposal program that limits both health and monetary liability.

Generally, a hazardous chemical is one that is highly flammable, toxic, corrosive, carcinogenic, explosive, reactive, or is a solvent. **Because of the complexity of rules that govern the disposal of hazardous waste, all hazardous chemical waste is disposed of through the Environmental Protection Program of EH&S.**

DISPOSAL

When disposing of chemical waste, the following procedures should be followed:

- 1. Place waste in the proper container.**
 - a. The outside of waste containers must be contamination free, the lid should be securely attached, and the container must be in good condition.
 - b. All containers should be maximum one gallon with a minimum two inches of head space on top. Acids, bases, and poisons should be placed in containers no larger than ½ gallon.
 - c. All dry waste should be double-bagged in 2 mil thick bags.
- 2. Label the waste properly with the complete chemical name and of the waste.**
- 3. Have a completed Hazardous Material Tag attached to it.** Hazardous Material Waste Tags are provided to lab personnel free of charge by contacting the Environmental Protection Program at the number listed below. The tag should have the chemical name(s) and the date when accumulation began and when the container was completely full and ready for pickup.
- 4. When ready for collection, lab personnel should leave a message on the waste line (713-500-5837) after pressing option "2".** Chemical waste is picked up throughout the week.

Empty Containers

Empty containers with a volume of less than five gallons can be disposed of in the regular trash provided the **labels are defaced**. Before containers greater than five gallons can be discarded in the regular trash they must be rinsed a minimum three times, making sure the washings are collected and disposed of as chemical waste.

Broken Glassware/Containers

If a broken container is contaminated with a hazardous chemical residue, call 713-500-5837 for a pickup. Otherwise, broken glassware/containers should be disposed of in a broken glass box. These boxes are available free of charge by calling the number listed above. When filled, the container should be closed, taped, labeled "Housekeeping" and placed near the regular trash for pickup.

Controlled Substances/Expired Drugs/Pharmaceuticals

Adhering to the process approved by the Drug Enforcement Agency (DEA), Environmental Health & Safety can now assist researchers in disposing of controlled substances. In short, the process involves mixing the controlled substances with chlorinated hazardous wastes in 55-gallon drums, thereby rendering them "non-recoverable and non-useable." Approval must be obtained prior to disposal of the substances. Assistance in disposal of controlled substances can be obtained by contacting the Environmental Protection Program at 713-500-8100.

Expired drugs or pharmaceuticals that are not considered controlled substances can be disposed of by calling the waste line at 713-500-5837.

Sink Disposal

Under no circumstances, should any hazardous waste be disposed of by pouring it down the drain (through the sanitary sewer). There are some chemicals, however, that can be disposed of by pouring down the sink. They include **salt solutions, sugar solutions, saline, ringers lactate, amino acid solutions, vitamin solutions, glucose solutions, and urine samples**. Call the Environmental Protection Program at 713-500-8100 for questions regarding waste disposal.

APPENDIX 2: ADDITIONAL POLICIES AND GUIDELINES

THE HANDBOOK OF OPERATING PROCEDURES

Safety and Health Policy Numbers

- 141: Emergency Management and Business Continuity Plan
- 085: University Closure for Emergency, Disaster or Severe Weather
- 086: Medical Emergencies, Minor Injuries/Illnesses
- 087: Reporting Criminal Activity on Campus
- 173: Substance Abuse
- 158: Bloodborne Pathogen Infection Control
- 088: Building Pathways Use
- 089: Environmental Management and Hazardous Waste Disposal
- 090: Safe Use of Potentially Hazardous Materials (*Radiation Safety included in this section*)
- 164: Minors in the Workplace
- 157: Tuberculosis Infection Control

Copies of the following guidelines written by Environmental Health & Safety are available by calling 713-500-8100.

INSTITUTIONAL BIOSAFETY MANUAL

- 1.0 Introduction
- 2.0 General Information and Procedures
- 3.0 Engineering and Work Practice Controls
- 4.0 Requirements for Work with Specific Infectious Agents
- 5.0 Laboratory Evaluations
- 6.0 UT Health Services
- 7.0 Occupational Health Services for Agent Categories
- 8.0 Bloodborne Pathogens Exposure Control Plan
- 9.0 Tuberculosis Exposure Control Plan
- 10.0 Nonhuman Primate Exposure Procedures
- Appendices

RADIATION SAFETY MANUAL

- 1.0 Purpose and Scope
- 2.0 Organization and Responsibilities
- 3.0 Licensing Requirements and Conditions
- 4.0 Procurement, Inventory, and Transfer of RAM
- 5.0 Disposal of Radioactive Waste
- 6.0 Limitation and Minimization of Radioactive Exposures
- 7.0 Personnel Dosimetry
- 8.0 Surveys, Postings, and Instrumentation
- 9.0 Laboratory Safety Audits by EH&S
- 10.0 Human Use of Radiation Sources
- 11.0 Sealed Sources of Radioactive Material
- 12.0 Instruction and Training
- 13.0 Incidents and Emergencies
- 14.0 Recordkeeping
- 15.0 Glossary of Terms

EH&S ONLINE TRAINING AT TRAINING RESOURCE CENTER (TRC)

EH&S Basic Laboratory & Clinical Safety Training (BCLS)
Nanoparticles Safety
How to perform a Radiation Wipe Test
EH&S Basic Workstation Ergonomics

APPENDIX 3: REFERENCE MATERIALS

References available from Environmental Health & Safety:

Dangerous Properties of Industrial Materials, 8th ed., Irving Sax and Richard J. Lewis, Sr., Van Nostrand Reinhold Company, 1992.

Handbook of Compressed Gases, 3rd ed., Compressed Gas Association, Arlington, Virginia, 1990.

Handbook of Laboratory Safety, 3rd ed., edited by A. Keith Furr, CRC Press, 1990.

Hawley's Condensed Chemical Dictionary, 11th ed., Irving Sax and Richard J. Lewis, Sr., Van Nostrand Reinhold Company, 1978.

Industrial Ventilation, 20th ed., American Conference of Governmental Industrial Hygienists, 1992.

NIOSH Pocket Guide to Chemical Hazards, DHHS (NIOSH), June 1997, DHHS (NIOSH) Publication No. 97-140.

OSHA Safety and Health Standards, (29 CFR 1910), United States Department of Labor, U.S. Government Printing Office, 1995.

Patty's Industrial Hygiene and Toxicology, 3rd ed., Patty, F.A., Volumes 1,2(A,B,C),and 3(A,B), Wiley-Interscience, 1978.

Prudent Practices for Disposal of Chemicals from Laboratories, National Research Council, National Academy Press, 1983.

Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, National Academy Press, 1981.

Safety in Academic Chemistry Laboratories, 5th ed., Committee on Chemical Safety, American Chemical Society: Washington, D.C., 1990.

Threshold Limit Values for Chemical Substances and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, 1999.

APPENDIX 4: CHEMICAL RESISTANCE CHART

Resistance to Chemicals of Common Glove Materials
 (E=Excellent, G=Good, F=Fair, P=Poor)

CHEMICAL	NATURAL RUBBER	NEOPRENE	NITRILE	VINYL
Acetaldehyde	G	G	E	G
Acetic acid	E	E	E	E
Acetone	G	G	G	F
Acrylonitrile	P	G	-	F
Ammonium hydroxide	G	E	E	E
Aniline	F	G	E	G
Benzaldehyde	F	F	E	G
*Benzene	P	F	G	F
*Benzyl chloride	F	P	G	P
Bromine	G	G	-	G
Butane	P	E	-	P
Butyraldehyde	P	G	-	G
Calcium hypochlorite	P	F	G	F
Carbon disulfide	P	P	G	F
*Carbon tetrachloride	P	F	G	F
Chlorine	G	G	-	G
Chloroacetone	F	E	-	P
*Chloroform	P	F	G	P
Chromic acid	P	F	F	E
Cyclohexane	F	E	-	P
CHEMICAL	NATURAL RUBBER	NEOPRENE	NITRILE	VINYL

	RUBBER			
Dibenzyl ether	F	G	-	P
Dibutyl phthalate	F	G	-	P
Diethanolamine	F	E	-	E
Diethyl ether	F	G	E	P
**Dimethyl sulfoxide	-	-	-	-
Ethyl acetate	F	G	G	F
*Ethylene dichloride	P	F	G	P
Ethylene glycol	G	G	E	E
*Ethylene trichloride	P	P	-	P
Fluorine	G	G	-	G
Formaldehyde	G	E	E	E
Formic acid	G	E	E	E
Glycerol	G	G	E	E
Hexane	P	E	-	P
Hydrobromic acid (40%)	G	E	-	E
Hydrochloric acid (conc)	G	G	G	E
Hydrofluoric acid (30%)	G	G	G	E
Hydrogen peroxide	G	G	G	E
Iodine	G	G	-	G
Methylamine	G	G	E	E
Methyl cellosolve	F	E	-	P
*Methyl chloride	P	E	-	P
Methyl ethyl ketone	F	G	G	P
*Methylene chloride	F	F	G	F
CHEMICAL	NATURAL	NEOPRENE	NITRILE	VINYL

	RUBBER			
Monoethanolamine	F	E	-	E
Morpholine	F	E	-	E
*Naphthalene	G	G	E	G
Nitric acid (conc)	P	P	P	G
Perchloric acid	F	G	F	E
Phenol	G	E	-	E
Phosphoric acid	G	E	-	E
Potassium hydroxide	G	G	G	E
*Propylene dichloride	P	F	-	P
Sodium hydroxide	G	G	G	E
Sodium hypochlorite	G	P	F	G
Sulfuric acid (conc)	G	G	F	G
*Toluene	P	F	G	F
*Trichloroethylene	P	E	G	F
Tricresyl phosphate	P	E	-	F
Triethanolamine	F	E	E	E
Trinitrotoluene	P	E	-	P

* Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. If swelling should occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal.

** No data on the resistance of dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials are available; the manufacturer of the substance recommends the use of butyl rubber gloves.

Appendix 4 taken from the following source: Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, National Academy Press, 1981.

**APPENDIX 5: GENERAL TRAINING CERTIFICATE
FOR UTHHealth CHEMICAL HYGIENE PLAN**

Name: _____ Date: _____

Building/Room: _____ Phone: _____ Department: _____

I certify that I have read the Chemical Hygiene Plan for the University of Texas-Houston HSC and that I have received the general training related to the Chemical Hygiene Plan, which included the following:

1. Location of the potentially hazardous chemicals in the workplace.
2. Recognition of the chemical labeling and its meaning.
3. Location of the SDS's in the workplace.
4. Location of the health hazard, physical hazard, environmental protection, and special protection sections of the SDS and an explanation of their use.
5. Identification of the Chemical Hygiene Officer by name and title.
6. The major components of the laboratory's standard labeling system.
7. The appropriate protective clothing for the area and its proper usage.
8. Emergency procedures in the events of a hazardous chemical spill.
9. The environmental monitoring protocol for the laboratory.
10. Location and safety precautions for potentially hazardous equipment.
11. Physical and health effects of hazardous chemicals associated with task assignments.
12. Methods and observation techniques used to determine the presence or release of hazardous chemicals in the laboratory.
13. How to lessen or prevent exposure to hazardous chemicals through controlled work practices and personal protective equipment.
14. Emergency and first-aid procedures to follow if employees are exposed to hazardous chemicals.

In addition, I understand that I have the responsibility to read the SDS's for any chemical that I will work with in the laboratory.

Laboratory User Signature

APPENDIX 6: CHEMICAL SAFETY COMMITTEE FORMS



Application for the Use of A Highly Toxic Chemical and Exposure Assessment Form

Section 1 - Applicant Data

Date:

CSC Protocol Number:

Project Name:

Principal Investigator:

Department:

Building/Room Number:

Office Phone:

Other Committee Approvals:

Section 2 - Identification of Chemical Agent

Chemical Agents:

Use Quantity:

Number of Procedures:

Storage Quantities and Location:

Location Where Work is to be Conducted (Building/Room Number):

Laboratory Phone Number:

Section 3 - Personnel Involved in Study and Experience Working with Chemical Agents / Experience with the specific agent under review

- | | | |
|----|-------------|---|
| 1. | Experience: | / |
| 2. | Experience: | / |
| 3. | Experience: | / |
-

Section 4 - Experimental Description (Include procedural aspects regarding chemical usage):

Methods:

Section 5 – Chemical / Industrial Hygiene Related Information

Physical Properties:

Classification:

Toxicology:

Routes of Exposure:

Other Precautions:

Exposure Limits:

Monitoring Requirements:

Section 6 - Hazard Controls

Engineering/Administrative Controls:

Personal Protective Equipment:

Section 7 - Hazardous Waste Disposal

Identify method of waste disposal:

Hazardous waste code:

Has source substitution been investigated?

Can chemical be neutralized during experiment?

Section 8 - Fulfillment of UTHHealth Chemical Hygiene Plan Requirements

Hazard Communication Training:

Personnel:

Date/Status:

Last Laboratory Safety Survey Date:

Findings:



Memorandum of Understanding and Agreement for the Use of Chemical Agents

Title of Research:

Number: CSC 00-000

PI Name: **Dept:**

Lab Room No(s): **Phone:**

Chemical Name:

CAS Number:

Usage Amount:

Storage Amount:

The referenced chemical has been determined to require Chemical Safety Committee Protocol Review based on the following: (check one) :

_____ **Chemicals are listed on the “Mandatory Protocol Review Chemical List”**

_____ **Chemical has been found to be potential hazardous because of its toxicological, usage and storage quantities**

Attach completed “Application for the Use of Acutely Toxic Chemicals”

_____ **The referenced chemical has been exempted from full review process, and a Fact Sheet has been provided with information on hazards and safety practices that must be followed**

I agree to comply with current regulations and university policies pertaining to the use, storage, transfer and shipment of chemical agents. I will also abide by all of the provisions of UTHealth Chemical Hygiene Plan, the recommendations of the Chemical Safety Committee, and follow the instructions on the Fact Sheet supplied for a specific chemical that is exempt from the full committee review process.

P.I. signature

Date

The UTHealth Environmental Health and Safety Chemical Safety Program has reviewed the above proposal and has verified the classification indicated by the Principal Investigator.

Chemical Safety Representative

Date

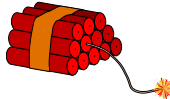
The Chemical Safety Committee has been provided a summary of the described work and approves the described use of chemical(s) listed. The activities described in this protocol will be reviewed annually.

Chair, Chemical Safety Committee

Date



APPENDIX 7: CHEMICAL SEGREGATION & INCOMPATIBILITIES GUIDELINES

Class of Chemical	Examples	Recommended Storage Method	Incompatible Materials	Possible Reaction If Mixed
Corrosive Acids 	Mineral Acids – Chromic Acid Hydrogen Chloride Hydrochloric Acid Nitric Acid Perchloric Acid Phosphoric Acid Sulfuric Acid	Separate cabinet or storage area away from potential water sources, i.e. under sink	Flammable Liquids Flammable Solids Bases Oxidizers Poisons	Heat  Gas Generation  Violent Reaction
Corrosive Bases/Caustics 	Ammonium Hydroxide Sodium Hydroxide Sodium Bicarbonate	Separate cabinet or storage area away from potential water sources, i.e. under sink	Flammable Liquids Flammable Solids Acids Oxidizers Poisons	Heat  Gas Generation  Violent Reaction
Explosives 	Ammonium Nitrate Nitro Urea, Picric Acid Trinitroaniline Trinitrobenzene Trinitrobenzoic Acid Trinitrotoluene Urea Nitrate	Secure location away from other chemicals	Flammable Liquids Oxidizers Poisons Acids Bases	Explosion Hazard 

Class of Chemical	Examples	Recommended Storage Method	Incompatible Materials	Possible Reaction If Mixed
Flammable Liquids 	Acetone Benzene Diethyl Ether Methanol Ethanol Toluene Glacial Acetic Acid	Grounded flammable storage cabinet of flammable storage refrigerator	Acids Bases Oxidizers Poisons	Fire Hazard  Heat  Violent Reaction 
Flammable Solids 	Phosphorus Magnesium	Separate dry cool area	Acids Bases Oxidizers Poisons	Fire Hazard  Heat  Violent Reaction 
Oxidizers 	Sodium Hypochlorite Benzoyl Peroxide Potassium Permanganate Potassium Chlorate Potassium Dichromate Peroxides Perchlorates Chlorates Nitrates	Spill tray that is separate from flammable and combustible materials	Reducing Agents Flammables Combustibles Corrosives	Fire Hazard  Toxic Gas Generation 
Poisons 	Cyanides Cadmium Mercury Osmium Acrylamide DMSO	Vented, cool, dry area in unbreakable chemically resistant secondary containers	Flammable Liquids Acids Bases Oxidizers Corrosives	Generation of Toxic & Flammable Gas  Violent Reaction 

Class of Chemical	Examples	Recommended Storage Method	Incompatible Materials	Possible Reaction If Mixed
Water Reactive Chemicals 	Sodium Metal Potassium Metal Lithium Metal Lithium Aluminum Hydride	Dry, cool location away from potential spray from fire sprinklers and other water sources, i.e. under sink	Aqueous Solutions Oxidizers	Heat   Violent Reaction
Flammable Compressed Gases 	Methane Acetylene Propane Hydrogen	Cool, dry area away from oxidizing gases while securely attached to wall or bench	Oxidizing & Toxic Compressed Gases Oxidizing Solids	Fire Hazard   Explosion Hazard
Oxidizing Compressed Gases 	Oxygen Chlorine Bromine	Cool, dry area away from flammable gases while securely attached to wall or bench	Flammable Gases	Fire Hazard   Explosion Hazard
Poisonous Compressed Gases 	Carbon Monoxide Hydrogen Sulfide	Cool, dry area away from flammable gases or liquids while securely attached to wall or bench	Flammable Gases Oxidizing Gases	Release of Toxic Gas   Violent Reaction

Partial Incompatibility Listing

Compound/Class	Avoid Storage Near or Contact With:
Acids	
Acetic Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene, glycogen, perchloric acid, peroxides, permanganate
Hydrofluoric Acid	Ammonia (aqueous or anhydrous), do not store in glass container
Nitric Acid (conc.)	Acetic acid, aniline, chromic acid, acetone, alcohol, or other flammable liquids, hydrocyanic acid, hydrogen sulfide, or other flammable gases, nitratable substances: copper, brass or any heavy metals (or will generate nitrogen dioxide/nitrous fumes) or organic products such as wood and paper
Sulfuric Acid	Light metals (lithium, sodium, potassium), chlorates, perchlorates, permanganates
Bases	
Ammonia	Mercury, chlorine, bromine, iodine, hydrofluoric acid, calcium hypochlorite
Calcium oxide	Water
Alkaline metals	Sodium, potassium, magnesium, calcium, aluminum, carbon dioxide, carbon tetrachloride or other chlorinated hydrocarbons, halogens, water
Bromine	Ammonia, acetylene, butadiene, methane, propane, butane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Carbon, activated	Calcium hypochlorite, oxidizing agents
Chlorine	Ammonia, acetylene, butadiene, methane, propane, butane, or other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Copper	Acetylene, hydrogen peroxide, nitric acid
Fluorine	Isolate from everything
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, ammonia, fulminic acid (produced in nitric acid ethanol mixtures)
Oxygen	Oils, grease, hydrogen, other flammable gases, liquids, or solids

<i>Bases, continued</i>	
Phosphorous (white)	Air, oxygen, caustic alkalis as reducing agents (or will generate phosphine)
Potassium	Carbon tetrachloride, carbon dioxide, water
Silver	Acetylene, oxalic acid, tartaric acid, fulminic acid (produced in nitric acid-ethanol mixtures), and ammonium compounds
<i>Organics</i>	
Acetone	Concentrated nitric acid and sulfuric acid mixtures
Acetylene	Fluorine, chlorine, bromine, copper, silver, mercury
Aniline	Nitric acid, hydrogen peroxide
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons (propane, butane, etc.)	Fluoride, chlorine, bromine, chromic acid, sodium peroxide
Nitroparaffins	Inorganic bases, amines
Oxalic Acid	Silver, mercury
<i>Oxidizers</i>	
Chlorates	Ammonia salts, acids, metal powders, sulfur, finely divided organics, or combustible materials
Chromic Acid (trioxide)	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol or flammable liquids
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrates, sulfur, finely divided organic or combustible materials
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Cumene Hydroperoxide	Organic or inorganic acids

<i>Oxidizers, continued</i>	
Hydrogen Peroxide	Copper, chromium, iron, most other metals or salts, alcohols, acetone, or other flammable liquids, aniline, nitromethane, or other organic or combustible materials
Hypochlorites	Acids (will generate chlorine or hypochlorous acid)
Nitrates	Sulfuric acid (will generate nitrogen dioxide)
Perchloric Acid	Acetic acid, bismuth and its alloys, alcohol, paper, wood, grease, oils
Peroxides (Organics)	Organic or inorganic acids, also avoid friction and store cold
Potassium Chlorate	Acids, especially sulfuric acid
Potassium Permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Sodium Peroxide	Any oxidizable substance such as methanol, ethanol, glycerol, ethylene glycol, glacial acetic acid, acetic anhydride, benzaldehyde, furfural, methyl acetate, ethyl acetate, carbon disulfide
Alkaline metals	Sodium, potassium, magnesium, calcium, aluminum, carbon dioxide, carbon tetrachloride or other chlorinated hydrocarbons, halogens, water
Calcium oxide	Water
Cyanides	Acids (will generate hydrogen cyanide)
Phosphorous (white)	Air, oxygen, caustic alkalis as reducing agents (will generate phosphine)
Potassium	Carbon tetrachloride, carbon dioxide, water
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium Peroxide	Any oxidizable substance such as methanol, ethanol, glycerol, ethylene glycol, glacial acetic acid, acetic anhydride, benzaldehyde, furfural, methyl acetate, ethyl acetate, carbon disulfide
Sulfides	Acids (will generate hydrogen sulfide)

<i>Reducing Agents</i>	
Hydrazine	Hydrogen peroxide, nitric acid, other oxidants
Nitrites	Acids (will generate nitrous fumes)
Sodium Nitrite	Ammonium nitrate and other ammonium salts
<i>Toxics/Poisons</i>	
Arsenicals	Reducing agents (will generate arsine)
Azides	Acids (will generate hydrogen azide)
Cyanides	Acids (will generate hydrogen cyanide)
Hydrocyanic Acid	Nitric Acid, alkalis
Hydrogen Sulfide	Fuming nitric acid, oxidizing gases
Selenides	Reducing agents (will generate hydrogen selenide)
Sulfides	Acids (will generate hydrogen sulfide)
Tellurides	Reducing agents (will generate hydrogen telluride)

APPENDIX 8: HAZARD COMMUNICATION PROGRAM

At THE UNIVERSITY OF TEXAS HEALTH CENTER AT HOUSTON

Introduction

To ensure that information about the dangers of hazardous chemicals used at the University of Texas Health Science Center at Houston (UTHealth) are known by all affected employees, the following Hazard Communication Program has been established. This purpose of this program is to implement the Texas Hazard Communication Act, Chapter 502 of the Health and Safety Code as well as the Federal Hazard Communication Standard 1910.1200

The Federal OSHA Hazard Communication Standard was recently updated on March 26, 2012 to conform to the United Nations' (UN) Globally Harmonized System of Classification and Labeling of Chemicals (GHS). To incorporate the changes made to the Federal OSHA Hazard Communication Standard, UTH has added these components into this program to establish consistency and safety for the entire university. This program applies to all work operations at UT-H where employees may be exposed to hazardous chemicals under normal working condition and during emergency situations. This written program is available for review on our website or in writing by contacting Environmental Health and Safety.

Under this program, employees are educated on: work place chemical lists; labeling of containers; Safety Data Sheets now known as Safety Data Sheets (SDS); education and training requirements; complaints, investigations, injuries, and reporting procedures; treatment; university policies, as well as any additional state or federal requirements directly related to this program.

APPLICABILITY

The primary function of UTHealth laboratories is research. Chemicals in laboratories are under the direct supervision of faculty members/principal investigators (technically qualified individual), labels on incoming containers of chemical are not to be removed or defaced, UTHealth complies with Sections 502.006 and 502.009 with respect to laboratory employees and no laboratories are used primarily to produce hazardous chemicals in bulk for commercial purposes. Laboratories that want to ship samples of hazardous chemicals must follow the same federal requirements as manufacturers and distributors. Please contact Environmental Health and Safety for chemical shipping guidelines.

Texas Health & Safety Code: Sec. 502.004

(f) This chapter does not apply to:

(1) any hazardous waste, as that term is defined by the federal Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended, when subject to regulation issued under that Act by the Environmental Protection Agency.

(2) a chemical in a laboratory under the direct supervision or guidance of a technically qualified individual if:

(A) labels on incoming containers of chemicals are not removed or defaced;

(B) the employer complies with Sections 502.006 and 502.009 with respect to laboratory employees; and

(C) the laboratory is not used to produce hazardous chemicals in bulk for commercial purposes.

WORKPLACE CHEMICAL LIST

In accordance with the Texas Community Right-To-Know Act, a Texas Tier II Report is completed by Environmental Health & Safety annually by March 1st of each year to report chemicals that meet or exceed excess of 55 gallons at UTHHealth. Copies of this report are sent to the Texas Department of Health's State Emergency Response Commission, the local fire department, and the local emergency planning committee. Copies of this report are kept by Environmental Health and Safety's Environmental Protection Program, and may also be found in section five of this Hazard Communication Program binder. At this time, diesel fuel is the only chemical maintained in single containers in excess of 55 gallons. The Tier II report gives the identity of the diesel fuel used on the SDS and container label and also gives the locations of the underground and above ground diesel storage tanks. This list is updated annually, dated, signed, and copies are kept indefinitely. Employees are made aware of this hazard through training.

Texas Health & Safety Code: Sec. 502.005

(a) For the purpose of worker right-to-know, an employer shall compile and maintain a workplace chemical list that contains the following information for each hazardous chemical normally present in the workplace or temporary workplace in excess of 55 gallons or 500 pounds or in excess of an amount that the board determines by rule for highly toxic or dangerous chemicals:

(1) the identity used on the SDS and container label; and

(2) the work area in which hazardous chemical is normally present.

(b) The employer shall update the workplace chemical list as necessary but at least by December

31st of each year. Each workplace chemical list shall be dated and signed by the person responsible for compiling the information.

(c) The workplace chemical list may be prepared for the workplace as a whole or for each work area or temporary workplace and must be readily available to employees and their representatives. All employees shall be made aware of the workplace chemical list before working with or in a work area containing hazardous chemicals.

(d) An employer shall maintain a workplace chemical list for at least 30 years. The employer shall send complete records to the director if the employer ceases to operate.

ANNUAL CHEMICAL INVENTORY

In order to comply with the EPA's Emergency Planning and Community Right-to-Know regulations and the OSHA Laboratory Standard, principle investigators are required to submit a chemical inventory identifying the exact location (building and room) and quantity of all hazardous chemicals in their laboratories. To facilitate the submission of the inventory, a template and all supporting documentation is available at www.uth.edu/safety/chemical-safety/ . Environmental Health and Safety will verify the annual chemical inventory submission during the lab's annual laboratory safety survey.

SAFETY DATA SHEETS (Formerly known as Safety Data Sheets SDSs)

SDS's for the chemicals are provided by manufacturers and distributors to UTHealth with each initial shipment and with the first shipment after an SDS is updated. Depending on the company, the SDS is included inside the package containing the chemical, which should go directly to the principal investigator's laboratory personnel.

SDS's are readily available for review by all employees at the UTHealth. In addition to the paper copies available as described above, employees may access SDS's via computer 24 hours a day at the institutional website(www.uth.edu/safety/chemical-safety/). In addition, an employee may directly request an SDS 24 hours a day from Chemical Safety by calling 713-500-5832.

This phone number is also linked to a paging system, which contacts a Safety Specialist on-call.

Texas Health & Safety Code: Sec. 502.006

*(e) A chemical manufacturer or distributor shall provide appropriate Safety Data Sheets to employers who acquire hazardous chemicals in this state with each initial shipment and with the first shipment after an SDS is updated. **The SDSs must conform to the most current requirements of the OSHA standard.***

- (f) An employer shall maintain a legible copy of a current SDS for each hazardous chemical purchased. If the employer does not have a current SDS for a hazardous chemical when the chemical is received at the workplace, the employer shall request an SDS in writing from the manufacturer or distributor in a timely manner or shall otherwise obtain a current SDS. The manufacturer or distributor shall respond with an appropriate SDS in a timely manner.*
- (g) Safety Data Sheets shall be readily available, on request, for review by employees or designated representatives at each workplace.*
- (h) A copy of an SDS maintained by an employer under this section shall be provided to the director upon request.*

LABELS

Labels on chemicals received at UTHHealth are not intentionally removed or defaced. Secondary containers are relabeled with the chemical name and appropriate hazard classification. As part of the Environmental Health & Safety's routine surveillance program, principal investigators/laboratory personnel are reminded not to label secondary containers using a chemical symbol in place of the chemical name found on the SDS. In addition, principal investigators/laboratory personnel are encouraged to label all containers with chemicals even if the chemical is intended for immediate use by the employee who performs the transfer.

Texas Health & Safety Code: Sec. 502.007

- (a) A label on an existing container of a hazardous chemical may not be removed or defaced unless it is illegible, inaccurate, or does not conform to the OSHA standard or other applicable labeling requirement. Primary containers must be relabeled with at least the identity appearing on the SDS, the pertinent physical and health hazards, including the organs that would be affected, and the manufacturer's name and address. Except as provided by Subsection (b), secondary containers must be relabeled with at least the identity appearing on the SDS and appropriate hazard warnings.*
- (b) An employee may not be required to work with a hazardous chemical from an unlabeled container except for a portable container intended for the immediate use of the employee who performs the transfer.*

EMPLOYEE EDUCATION PROGRAM

The UTHHealth Chemical Safety Committee has instituted a new annual basic laboratory safety training requirement for all individuals working in laboratories. This training will provide a brief refresher on the critical elements of laboratory safety and also fulfill the annual bloodborne pathogens training requirement. Principle investigators and laboratory personnel working in or overseeing a laboratory are required to complete this convenient on-line training. Principal Investigators will be responsible for verifying that all laboratory personnel have completed the training as required by the UTHHealth Chemical Safety Committee. Environmental Health and Safety will be verifying the training is complete during the lab's annual laboratory safety survey.

All UTHHealth employees are required to attend an employee orientation prior to beginning their first day of work. During employee orientation, the initial Basic Laboratory Safety Class is conducted. Employees attending the Basic Laboratory Safety Class receive information on chemical hazard communication and an introduction to safe use protocols for hazardous chemicals. Those employees that work in a laboratory will be notified by Human Resources and Environmental Health & Safety during orientation that the PIs may need to receive the Chemical Safety Committees approval for some substances as well as attend additional training.

Principal investigators are responsible for any hands on training for specific hazards in their laboratory. Principal investigators are required to work with Environmental Health and Safety to assure training is completed for all laboratory attendants. Environmental Health & Safety can assist with Standard Operational Procedures and advanced training. Environmental Health and Safety can be contacted via phone at 713-500-5832 or the schedule can be found online at: <http://www.uthouston.edu/safety/>.

We appreciate your continued participation in maintaining a safe working environment. Please contact the Office of Environmental Health and Safety for any questions at 713-500-8100 or visit our webpage at www.uth.edu/safety.

The training program emphasizes these items:

Information on interpreting labels and SDSs and the relationship between those two methods of hazard communication; the location by work area, acute and chronic effects, and safe handling of hazardous chemicals known to be present in the employee's work area and to which the employees may be exposed; the proper use of protective equipment and first aid treatment to be used with respect to the hazardous chemicals to which the employees may be exposed; and general safety instructions on handling, cleanup procedures, and disposal of hazardous chemicals.

Training is conducted by chemicals categories for employees. Employees are instructed that information is available on the specific hazards of individual chemicals through their supervisor and on the SDSs.

Employees are also told how they may access chemical safety information 24 hours a day. Protective equipment and first aid treatment information is also classified by categories of hazardous chemicals.

Whenever the potential for exposure to hazardous chemicals in the employee's work area increases significantly or when new information concerning the hazards of a chemical is received, additional training will be provided when Environmental Health & Safety is notified of these changes. Principal investigators are primarily responsible for deciding when additional training is required and whether or not to inform Environmental Health and Safety. The addition of new chemicals does not necessarily require additional training.

Training class/session rosters are maintained for the type of training given to the employees, including the date, employees who attended, the subjects covered, and the names of the instructors. Those records are maintained for at least five years by UTHHealth and have also been used to create a training database. Laboratory and clinic employee training status is assessed annually during routine safety surveys and employees are asked to attend refresher training if necessary.

Environmental Health and Safety's Chemical Safety Program responds to chemical spills and the staff of this program is required to attend an initial 24 hour Hazardous Materials Emergency Response Training in accordance with 29 CFR 1910.120, with an annual 8 hour refresher course.

UTHHealth has developed, implemented, and maintained a written hazard communication program for the workplace that describes how the criteria in the Texas Hazard Communication Act, Chapter 502, of the Health and Safety Code are being met.

Texas Health & Safety Code: Sec.502.009

- (a) An employer shall provide an education and training program for employees who use or handle hazardous chemicals.*
- (b) An employer shall develop, implement, and maintain at the workplace a written hazard communication program for the workplace that describes how the criteria specified in this chapter will be met.*
- (c) An education and training program must include, as appropriate:*
 - (1) information on interpreting labels and SDSs and the relationship between those two methods of hazard communication;*
 - (2) the location by work area, acute and chronic effects, and safe handling of hazardous chemicals known to be present in the employee's work area and to which the employees may be exposed;*

- (3) *the proper use of protective equipment and first aid treatment to be used with respect to the hazardous chemicals to which the employees may be exposed; and*
 - (4) *general safety instructions on the handling, cleanup procedures, and disposal of hazardous chemicals.*
- (d) *Training may be conducted by categories of chemicals. An employer must advise employees that information is available on the specific hazards of individual chemicals through the SDSs. Protective equipment and first aid treatment may be categories of hazardous chemicals.*
- (e) *An employer shall provide additional instruction to an employee when the potential for exposure to hazardous chemicals in the employee's work area increases significantly or when the employer receives new and significant information concerning the hazards of a chemical in the employee's work area. The addition of new chemicals alone does not necessarily require additional training.*
- (f) *An employer shall provide training to a new or newly assigned employee before the employee works with or in a work area containing a hazardous chemical.*
- (g) *An employer shall keep a written hazard communication program and a record of each training session given to employees, including the date, a roster of the employees who attended, the subjects covered in the training session, and the names of the instructors. Those records shall be maintained for at least five years by the employer. The department shall have access to those records and may interview employees during inspections.*
- (h) *Emergency service organizations shall provide, to their members or employees who may encounter hazardous chemicals during an emergency, information on recognizing, evaluating, and controlling exposure to the chemicals.*

REPORTING FATALITIES AND INJURIES

UTHealth will report any accidents described in Sec. 502.012 above within 48 hours to the Texas Department of State Health Services. Additional reports will be submitted if necessary.

Texas Health & Safety Code: Sec.502.012

- (a) *Within 48 hours after the occurrence of an employee accident that directly or indirectly involves*

chemical exposure, or that involves asphyxiation, and that is fatal to one or more employees, or results in the hospitalization of five or more employees, the employer of any of the employees so injured or killed shall report the accident either orally or in writing to the department.

- (b) The report to the department shall relate the circumstances of the accident, the number of fatalities, and the extent of any injuries. If it is necessary to complete the investigation of an incident, the department may require additional reports in writing as necessary.*

EMPLOYEE NOTICE; RIGHTS OF EMPLOYEES

The Texas Department of State Health Service “Notice to Employees” (see section 7 of this Hazard Communication Program binder) is posted in all laboratories at UTHealth and additional locations where it is easily visible to employees. Employees who may be exposed to hazardous chemicals as part of their normal work routine will be informed of the possible exposure and will have access to the workplace chemical list and SDSs. Employees have access to training and 24 hour access to SDSs, as described earlier. Principal investigators are primarily responsible for providing personal protective equipment to their employees according to state and federal regulations. However, in the event they are unable to, Environmental Health & Safety will make arrangements for this equipment to be provided to the employees.

Texas Health & Safety Code: Sec.502.017

- (a) An employer shall post and maintain adequate notice, at locations where notices are normally posted, informing employees of their rights under this chapter. If the director does not prepare the notice under Section 502.008, the employer shall prepare the notice.*
- (b) Employees who may be exposed to hazardous chemicals shall be informed of the exposure and shall have access to the workplace chemical list and SDSs for the hazardous chemicals. Employees, on request, shall be provided a copy of a specific SDS with any trade secret information deleted. In addition, employees shall receive training concerning the hazards of the chemicals and measures they can take to protect themselves from those hazards. Employees shall be provided with appropriate personal protective equipment. These rights are guaranteed.*

APPENDIX 9: NANOPARTICLES SAFETY GUIDE

I. Purpose

This document has been written to offer health and safety guidance to faculty, staff, students, and visitors working with nanotechnology at The University of Texas Health Science Center at Houston. The purpose of the Nanomaterials Safety Program is to provide a framework for anticipating, recognizing, evaluating, and controlling the potential hazards associated with nanotechnology; however, the Program is not intended to provide stand-alone guidance and should be used in conjunction with the UTHealth Chemical Hygiene Plan and in consultation with the office of Safety, Health, Environment, and Risk Management (SHERM). All work involving nanotechnology requires approval from the institutional Chemical Safety Committee before work with nanotechnology is initiated. A site-specific risk assessment will be conducted by SHERM to determine the potential hazards of working with the nanotechnology. In addition, it is the responsibility of each principal investigator to ensure that laboratory-specific safety plans and standard operating procedures are developed for each laboratory where nanomaterials are used and stored.

II. Introduction

Nanotechnology involves the manipulation of matter at nanometer scales to produce new materials, structures, and devices. Nano-objects are materials that have at least one dimension (e.g., length, width, height, and/or diameter) that is between 1 and 100 nanometers. (CDC/NIOSH, 2009) A nanometer, or nm, is 1×10^{-9} meters or one millionth of a millimeter. The term *nanoparticles* typically refer to materials in which all three dimensions are in the nanoscale. In this document, the term *nanoparticles* or *nanomaterials* will refer to purposefully created, engineered particles with at least one dimension between 1 and 100 nanometers. (CDC/NIOSH, 2009) Nanoparticles may be dry particles, suspended in a gas (as a nanoaerosol), suspended in a liquid (as a nanocolloid or nanohydrosol), or embedded in a matrix (as a nanocomposite). Nanoparticles also exist in several structures, such as nanotubes, nanoplates, and nanofibers. (CDC/NIOSH, 2009)

The term *ultrafine particle* has traditionally been used to describe airborne particles smaller than 100 nm in diameter that are byproducts of industry or nature. Ultra-fine particles tend to be generated through processes such as combustion and vaporization. The particles are produced in large quantities from industrial activities such as thermal spraying and welding and from domestic combustion activities like gas cooking. Ultra-fine particles are also found in the atmosphere, where they originate from combustion sources like forest fires and volcanic activity and from atmospheric gas-to-particle conversion processes, such as photo-chemically driven nucleation. (CDC/NIOSH, 2009)

Research with nanomaterials has shown that the physiochemical characteristics of particles can influence their effects in biological systems. Some of these characteristics include:

- Charge;
- Chemical reactivity;
- Degree of agglomeration;
- Shape;
- Size;
- Solubility;
- Surface area; and
- Surface composition.

There are many unknowns as to whether the unique properties of engineered nanomaterials pose health concerns. The potential health risk following exposure to a substance is generally associated with the following (CDC/NIOSH, 2009):

- Magnitude and duration of the exposure;
- Persistence of the material in the body;
- Inherent toxicity of the material; and
- Susceptibility or health status of the person.

Unfortunately, there is limited data regarding the health risks related to nanomaterials. As such, this document is to provide EHS-accepted recommendations for practicing prudent health and safety measures when working with nanomaterials.

III. Regulations

At this time, there are no federal regulations that specifically address the health and safety implications of nanotechnology. There are also no national or international consensus standards on measurement techniques for nanomaterials in the workplace. However, as with conventional chemicals, research with nanomaterials must be conducted in a manner that is safe and responsible. All chemicals, including nanomaterials, must be transported, stored, used, and disposed in accordance with all federal, state, and local requirements.

The Occupational Safety and Health Administration (OSHA) require employers to maintain a safe and healthful workplace, “free from recognized hazards likely to cause death or serious physical harm.” (29 USC 654) According to OSHA, laboratory personnel must be informed of the risks associated with workplace hazards. This is generally accomplished through training programs, Safety Data Sheets, and labeling and signage.

The Resource Conservation and Recovery Act of 1976 (RCRA) regulates the transportation, treatment, disposal, and cleanup of hazardous waste. Nanomaterials that meet the definition of a “hazardous waste” in RCRA are subject to this rule.

Nanomaterials that are defined as “chemical substances” under the Toxic Substances Control Act (TSCA) and which are not on the TSCA Inventory must be reported to U.S. Environmental Protection Agency (EPA). A Pre-manufacture Notice must be submitted to the EPA by anyone intending to manufacture or import a chemical substance that is not on the TSCA Inventory of Chemical Substances.

The Federal Insecticide, Fungicide, and Rodenticide Act requires that the EPA approve all new pesticide products, as well as new uses and changes in the composition of existing pesticide products, before the products may be sold or distributed in commerce. In order to evaluate an application for registration, the EPA requires the applicant to provide a complete characterization of the composition of the product, proposed labeling which describes the intended use of the product, and the results of extensive health and safety testing.

It should be also noted that the U.S. Food and Drug Administration currently regulates a wide range of products including those that utilize nanotechnology or contain nanomaterials (e.g., a drug delivery device).

IV. Hazard Assessments

Prior to beginning work with nanomaterials, a hazard assessment should be performed by safety personnel. The purpose of the assessment will be to identify appropriate work procedures, controls, and personal protective equipment to ensure worker safety. The assessment will evaluate several factors, including but not limited to the physical and chemical properties of the nanomaterial, the process by which the material will be generated and/or used, and existing engineering controls (e.g., fume hood, glove box). In some instances, the safety personnel may recommend collecting occupational exposure measurements (e.g., sampling). This will be performed to further understand potential hazards or to identify specific processes or equipment requiring additional engineering controls. Additionally, any protocol involving the use to nanoparticles is subject to approval by the UTHealth Chemical Safety Committee.

V. Exposure Routes

The most common route of exposure to a nanomaterial is through inhalation (see Table 1). The deposition of discrete nanomaterials in the respiratory tract is determined by the particle's aerodynamic or thermodynamic diameter. Particles that are capable of being deposited in the gas exchange region of the lungs are considered respirable particles.

Discrete nanomaterials are deposited in the lungs to a greater extent than larger respirable particles. Deposition increases with exertion (due to an increase in breathing rate and change from nasal to mouth breathing). It also increases among persons with existing lung diseases or conditions. Based on animal studies, discrete nanomaterials may enter the bloodstream from the lungs and translocate to other organs.

Ingestion is another route whereby nanomaterials may enter the body. Ingestion can occur from unintentional hand-to-mouth transfer of materials. This can occur with traditional materials and it is scientifically reasonable to assume that it could happen during handling of materials that contain nanomaterials. Ingestion may also accompany inhalation exposure because particles that are cleared from the respiratory tract via the mucociliary escalator may be swallowed. A few studies suggest that nanomaterials may enter the body through the skin during exposure. At this time, it is not known if skin penetration of nanomaterials would result in adverse health effects. There is also little information about the health effects of injecting nanomaterials into living organisms.

Potential Sources of Occupational Exposure to Nanomaterials for Various Synthesis Methods			
<i>Process Synthesis</i>	<i>Particle Formation</i>	<i>Exposure Source or Worker Activity</i>	<i>Primary Exposure Route**</i>
Gas Phase	In Air	Direct leakage from reactor, especially if the reactor is operated at positive pressure	Inhalation
		Product recovery from bag filters in reactors.	Inhalation/Dermal
		Processing and packaging of dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance (including reactor evacuation and spent filters).	Dermal (and inhalation during reactor evacuation)
Vapor Deposition	On Substrate	Product recovery from reactor/dry contamination of workplace.	Inhalation

		Processing and packaging of dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance (including reactor evacuation).	Dermal (and inhalation during reactor evacuation)
Colloidal	Liquid Suspension	If liquid suspension is processed into a powder, potential exposure during spray drying to create a powder, and the processing and packaging of the dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance.	Dermal
Attrition	Liquid Suspension	If liquid suspension is processed into a powder, potential exposure during spray drying to create a powder, and the processing and packaging of the dry powder.	Dermal
		Equipment cleaning/maintenance.	Dermal
** Note: Ingestion would be a secondary route of exposure from all sources/activities from deposition of nanomaterials on food or subsequently swallowed (primary exposure route inhalation) and from hand-to-mouth contact (primary exposure route dermal).			

Table 1 – Sources of Exposure to Nanomaterials through Occupational Activities (Aiken et al. 2004)

VI. Factors Affecting Exposure

Every attempt should be made to prevent or minimize exposure to nanomaterials. Factors affecting exposure to nanomaterials include the amount of material being used and whether it can be easily dispersed or form airborne sprays or droplets. The degree of containment and duration of use will also influence exposure. In the case of airborne material, particle or droplet size will determine whether the material can enter the respiratory tract and where it is most likely to deposit. Inhaled particles smaller than 10 micrometers in diameter have some probability of penetrating and being deposited in the gas-exchange (i.e., alveolar) region of the lungs, but there is at least a 50% probability that particles smaller than 4 micrometers in diameter will reach the gas-exchange region.

At present there is insufficient information to predict all of the situations and workplace scenarios that are likely to lead to exposure to nanomaterials. However, there are some workplace factors that will increase the potential for exposure, including (CDC/NIOSH, 2009):

- Working with nanomaterials in liquid media without adequate protection (e.g. gloves) will increase the risk of skin exposure.
- Working with nanomaterials in liquid media during pouring or mixing operations, or where a high degree of agitation is involved, will lead to an increased likelihood of inhalable and respirable droplets being formed.
- Generating nanomaterials in the gas phase in non-enclosed systems will increase the chances of aerosol release to the workplace.
- Handling nanopowders will lead to the possibility of aerosolization.

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- Maintenance on equipment and processes used to produce or fabricate nanomaterials will pose a potential exposure risk to workers performing these tasks.
 - Cleaning of dust collection systems used to capture nanomaterials will pose a potential for both skin and inhalation exposure.

VII. Engineering Controls

In order to provide a safe work environment for faculty, staff, students and visitors, engineering controls must be maintained wherever nanomaterials are used or stored. At a minimum, engineering controls should include local exhaust ventilation, localized filtration, and personal protective equipment. Respiratory protection is required when working with nanomaterials when local exhaust ventilation and filtration is not available.

The following engineering controls should be used in conjunction with the aforementioned policy when handling nanomaterials (CDC/NIOSH, 2009; VCU, 2007):

- Use of a chemical fume hood is recommended for all tasks with potential of aerosolizing nanomaterials in either liquid or powder form.
- A well-designed local exhaust ventilation system with a local high-efficiency particulate air (HEPA) filter should be used to effectively remove nanomaterials.
- Animals should be appropriately restrained and/or sedated prior to administering injections and other dosing methods.
- If heavy usage of aerosolized nanoparticles is in use, a proper decontamination, or buffer, area should be utilized to ensure the nanomaterials are not transported outside of the working area.
- Frequent hand washing, especially before eating, smoking, applying cosmetics, or leaving the work area should be employed.
- Laboratories and other spaces where nanomaterials are used or stored must be equipped with an eyewash station that meets American National Standards Institute (ANSI) and Occupational Safety and Health Administration (OSHA) requirements.

VIII. Administrative Controls

Although traditional permissible exposure limits (PEL) exist for many of the substances that nanomaterials are made from, the PEL for a nanomaterial of these substances is not yet clear. Thus, it is important to incorporate the following administrative controls into all laboratory operations:

- The laboratory's safety plan should be modified to include health and safety considerations of nanomaterials used in the laboratory.
- Principal investigators should develop and implement standard operating procedures (SOPs) in the preparation and administration of nanomaterials (with minimal exposure).
- Protocols involving the *in vivo* use of nanomaterials must be reviewed and approved by the Animal Welfare Committee.
- Laboratory personnel must receive the appropriate training, including specific nanomaterial-related health and safety risks, standard operating procedures, and steps to be taken in event of an exposure incident, prior to working with nanomaterials.
- Laboratory personnel must be instructed to use extreme caution when performing injections involving nanomaterials since accidental needle stick presents an exposure threat.

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- Exposures involving nanomaterials or any other acutely hazardous material must be reported to the office of Safety, Health, Environmental and Risk Management as soon as possible.

IX. Work Practices

The incorporation of good work practices can help to minimize exposure to nanomaterials. Examples of good work practices include the following (CDC/NIOSH, 2009):

- Projects or applications with the potential for producing nanomaterial aerosols must be conducted within an approved chemical fume hood or ducted biological safety cabinet.
- Needles used for nanomaterial injection must be disposed in an approved sharps containers immediately following use. Needles used for nanomaterial injection should never be bent, sheared, or recapped.
- Bench paper utilized during preparation of nanomaterial stock should be lined with an impervious backing to limit potential for contamination of work surfaces in the event of a minor spill.
- Work areas should be cleaned at the end of each work shift (at a minimum) using either a HEPA-filtered vacuum cleaner or wet wiping methods. Dry sweeping or pressurized air should not be used to clean work areas. Bench tops, chemical fume hood interiors, biological safety cabinet interiors, equipment, and laboratory surfaces with potential for nanomaterial contamination should be routinely cleaned. Cleanup should be conducted in a manner that prevents worker contact with wastes. The disposal of all waste material should comply with all applicable federal, state, and local regulations.
- The storage and consumption of food or beverages in workplaces must be prevented where nanomaterials are handled, processed, or stored, since exposure may occur via ingestion. Wash hands carefully before eating, drinking, applying cosmetics, smoking, or using the restroom.
- Facilities for showering and changing clothes should be provided to prevent the inadvertent contamination of other areas (including take-home) caused by the transfer of nanomaterials on clothing and skin.

X. Personal Protective Equipment

Typical chemistry laboratory apparel should be worn when working with nanomaterials in accordance with the University's Chemical Hygiene Plan (UTHealth, 2018). Always wear appropriate clothing (e.g., pants, shirts, shoes) and personal protective equipment, including safety glasses, laboratory coats, and gloves, when working with nanomaterials. Open sandals, shorts, and skirts are prohibited. Laboratory personnel involved in any task with a potential to nanomaterials must wear the following personal protective equipment:

- **Protective gloves:** Glove selection is best determined by a risk assessment and the chemicals used for the procedure. Nitrile or rubber gloves, which cover hands and wrists completely through overlapping sleeve of lab coat when working with nanomaterials, may provide adequate protection. Wearing of two sets of gloves ("double gloving") is advised whenever performing tasks involving nanomaterials and other hazardous substances. Laboratory personnel should thoroughly wash hands with soap and water before and immediately upon removal of gloves.
- **Eye protection:** Safety glasses or goggles are considered to be the appropriate level of eye protection for working with nanomaterials. SHERM recommends wearing a full-face shield when conducting tasks posing potential for any generation of aerosol and/or droplets.

- **Protective clothing:** Laboratory coats or disposable gowns that provide complete coverage of skin must be worn when working with nanomaterials. Clothing contaminated with nanomaterials should be removed immediately. Do not take contaminated work clothes home – contaminated clothing may require disposal as hazardous waste.
- **Respiratory protection:** If engineering controls are not adequate or are not available, and a potential aerosol exposure exists, respiratory protection is required. When working with nanomaterials, one of the following types of respirators must be worn:
 - Filtering face piece (N-95 or greater)
 - Elastomeric half- or full-face piece with N-100, R-100, or P-100 filters; or
 - Powered air-purifying respirator with N-100, R-100, or P-100 filters.

Anyone required to utilize respiratory protection for use with nanoparticle research must contact Chemical Safety at 713-500-5832 to be included in UTHHealth Respiratory Protection Plan.

XI. Nanoparticle Use in Animals

Unless data exists for the use of a specific nanoparticle in an animal, the following Exposure Control methods shall be followed.

Standard PPE for handling of nanoparticles when work is performed outside of chemical fume hood or ducted biological safety cabinets include: double gloves, gown, safety goggles or safety glasses, and N-95 or equivalent respirators (CDC/NIOSH, 2009). Work areas should be cleaned at the end of the procedure using either a HEPA-filtered vacuum cleaner or wet wiping methods, using a fresh cloth that is dampened with soapy water. Cleaning cloths must be disposed of. Drying and reuse of contaminated cloths may result in re-dispersion of particles.

Use of nanoparticles in animals can be broken down into three segments: administration, husbandry and disposal.

Administration:

- Injection: preparation of and actual injection into the animal must take place in a fume hood or Biological Safety Cabinet that does not allow for recirculation of air into the room, i.e. thimble or hard ducted. Dispose of the syringe in an approved Sharps container.
- Oral: if preparation is being administered via a syringe or other feeding device, a fume hood or ducted BSC (as above) must be used. If administration is by food, use of a microisolator cage is recommended.
- Aerosol: fume hood or ducted BSC. Proper PPE for investigators must include an N-95 or equivalent respirator.

Husbandry:

- Exposed animals must be housed under BSL-2 conditions for the first 72 hours post exposure. After 72 hrs, animals can be housed at BSL-1.
- All bedding and waste must be bagged and incinerated.

Disposal:

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- All potentially contaminated carcasses, bedding and other materials must be disposed of through incineration.
 - Any surplus nanoparticle stocks must be disposed of as hazardous waste.

As additional information is discovered concerning nanoparticles, the complexity of evaluating hazards associated with their use will probably follow a bell-curve, increasing before decreasing. Thus the information presented above must be considered subject to change.

XII. Spill Cleanup

Anyone attempting to manage any spill involving hazardous agents must be wearing the appropriate personal protective equipment. OSHA advises typically standard approaches to cleaning nanomaterial powder and liquid spills include the use of HEPA-filtered vacuum cleaners, wetting powders down, using dampened cloths to wipe up powders, and applying absorbent materials or liquid traps. (CDC/NIOSH, 2009) Energetic cleaning methods such as dry sweeping or the use of compressed air should be avoided or only be used with precautions that assure that particles suspended by the cleaning action are trapped by HEPA filters. If vacuum cleaning is employed, care should be taken that HEPA filters are installed properly, and bags and filters changed according to manufacturer's recommendations. At a minimum, the following procedures must be followed when managing an accidental spill of nanomaterials (CDC/NIOSH, 2009):

- Small spills (typically involving less than 5 mg of material) of nanomaterials containing powder should be wet-wiped with cloth/gauze that is dampened with soapy water. Affected surfaces should be thoroughly wet-wiped three times over with appropriate cleaning agent and with a clean, damp cloth used for each wipe down. Following completion, all cloth and other spill clean-up materials with a potential for nanomaterial contamination must be disposed of as hazardous waste.
- Small spills (typically involving less 5 ml of material) of nanomaterial-containing solutions should be covered and absorbed with absorbent material. Areas affected by liquid spills should be triple cleaned with soap and water following removal of absorbent paper.
- For larger spills of nanomaterials, contact the Office of Environmental Health and Safety at 713-500-5832.

As with any spill or clean-up of contaminated surfaces, handling and disposal of the waste material should follow existing Federal, State, or local regulations.

XIII. Waste Disposal

Nanomaterials are potentially hazardous materials. Surplus stocks and other waste materials containing greater than trace contamination must be disposed of through the UTHHealth Environmental Protection Program. Due to the fact that certain nanomaterials may be unaltered during metabolism, all potentially contaminated animal carcasses, bedding, and other materials must be disposed through incineration. In addition, all contaminated sharps waste materials must be placed in proper sharps container and disposed as biohazardous waste.

XIV. Glossary

Agglomerate – A group of particles held together by relatively weak forces, including van der Waals forces, electrostatic forces and surface tension.

Aggregate – A heterogeneous particle in which the various components are held together by relatively strong forces, and thus not easily broken apart.

Buckyballs - Spherical fullerenes composed entirely of carbon (C60).

Fullerenes - Molecules composed entirely of carbon, usually in the form of a hollow sphere, ellipsoid, or tube.

Graphene - A one-atom thick sheet of graphite.

Nanoscience – The study of phenomena and manipulation of materials at atomic, molecular and micromolecular scales, where properties differ significantly from those at a larger scale.

Nanoaerosol – A collection of nanomaterials suspended in a gas.

Nanocolloid – A nanomaterial suspended in a gel or other semi-solid substance.

Nanocomposite – A solid material composed of two or more nanomaterials having different physical characteristics.

Nanoparticle – A substance with dimensions less than 100 nanometers in size.

Nanohydrosol – A nanomaterial suspended in a solution.

Nanotechnology – The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.

Nanotubes - A sheet of graphene rolled up into a seamless cylinder with diameter on the order of a nanometer.

Nanowires - A wire of dimensions on the order of a nanometer.

Nucleation - The first step in the process by which gases are converted to small liquid droplets.

Physiochemical – The underlying molecular organization of life that is manifested as chemical and energy transformations.

Pyrolysis - Chemical change brought about by the action of heat.

Quantum Dots – A nanomaterial that confines the motion of conduction band electrons, valence band holes, or excitons (pairs of conduction band electrons and valence band holes) in all three spatial directions.

Single-Walled Carbon Nanotube – A single sheet graphene wrapped into a tube approximately 1.5 nanometers in diameter.

Thermite – A mixture of aluminum powder and a metal oxide (as iron oxide) that when ignited evolves a great deal of heat and is used in welding and in incendiary bombs.

Translocation – The act, process, or an instance of changing location or position.

Transmission Electron Microscopy (TEM) – A microscopy technique whereby a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through, and produces an image formed from the interaction of the electrons transmitted through the specimen which is then magnified and focused onto an imaging device.

Ultra-Fine Particles - Airborne particles with an aerodynamic diameter of 0.1 μ m (100 nm) or less.

XV. References

Aitken, R.J., Creely, K.S., Tran, C.L. *Nanoparticles: An Occupational Hygiene Review*. Research Report 274. Prepared by the Institute of Occupational Medicine for the Health and Safety Executive, North Riccarton, Edinburgh, England. 2004.

Approaches to Safe Nanotechnology. Department of Health and Human Services, Center for Disease Control, National Institute for Occupational Safety and Health. 2009.

Nanotechnology and Nanoparticles – Safe Working Practices Information. Virginia Commonwealth University. Office of Environmental Health and Safety. 2007

Occupational Safety and Health Act of 1970 (29 U.S.C. 654). Section 5(a) (1).

APPENDIX 10: COMPRESSED GAS AND CRYOGENIC SAFETY

Purpose:

This document provides guidance for University of Texas Health Science Center at Houston personnel who work with and store compressed gases.

REGULATORY STATUTE:

OSHA - 29 CFR 1910.101 - 105

CGA - CGA Pamphlets G-1, 4, 4.1, 5, 6, 8.1, P-1, 2, V-1, SB-2

Compressed Gas Safety Practices Program

1. Written Program.
2. Initial Training.
3. Refresher Training.
4. Safe Handling Procedures for Compressed Gases.
5. General Safety Rules for Specific Types of Gases.
6. Visual Inspection of Compressed Gas Cylinders.
7. General Safety Rules for Use of Compressed Gas.
8. Compressed Gas Storage Locations.
9. Facility/Department Evaluation.
10. Compressed Gas Association Safety Manuals.

Compressed Gas and Liquefied Cryogen Safety Practices Program

1. Written Program.

UTHealth will review and evaluate this standard practice instruction on an annual basis, or when changes occur to regulations that govern this program, that prompt revision of this document, or when facility operational changes occur that require a revision of this document. Effective implementation of this program requires support from all levels of management within UTHealth. This written program will be communicated to all personnel that are affected by it. It encompasses the total workplace, regardless of number of workers employed or the number of work shifts. It is designed to establish clear goals, and objectives.

2. Initial Training.

Initial training should be provided before job assignment. Training shall be provided to ensure that the purpose and function of the compressed gas safety program is understood by employees and that the knowledge and skills required for the safe application, and usage, of compressed gases are acquired by employees. The training shall include the following:

2.1 Applicable hazards. Each authorized employee shall receive training in the recognition of applicable hazards associated with compressed gases, and the methods and means necessary for safe operation.

2.2 Purpose and use. Each affected employee shall be instructed in the purpose and use of the compressed gas they will come in contact

2.3 Awareness level training. All other employees whose work operations are or may be in an area where compressed gas may be utilized, shall be instructed about the emergency procedure, and about the prohibition(s) relating to compressed gases used in their work area.

2.4 Warning labels. All employees whose work operations are or may be in an area where compressed gas may be utilized, shall be instructed in the recognition and use of warning labels.

2.5 Storage requirements. Storing and handling requirements will be covered in accordance with this guidance document.

2.6 Handling requirements. Handling requirements will be covered in accordance with this guidance document.

2.7 Moving requirements. Moving requirements will be covered in accordance with this guidance document.

2.8 Connecting and disconnecting requirements. Connecting and disconnecting requirements will be covered in accordance with this guidance document.

2.9 Health hazards regarding specific gases. Health hazard regarding specific gases will be covered in accordance with this guidance document.

2.10 General safety precautions. General safety precautions will be covered in accordance with this guidance document.

2.11 Certification. This employer shall certify that employee training has been accomplished and is being kept up to date. The certification shall contain each employee's name and dates of training.

3. Refresher Training.

Refresher will be conducted on a(n) annual basis. Retraining shall be provided for all authorized and affected employees whenever there is a change in their job assignments, a change in the type of gas used, equipment or processes that present a new hazard, or when there is a change in operating procedures.

3.1 Additional retraining shall also be conducted whenever a periodic inspection reveals, or whenever this employer has reason to believe, that there are deviations from or inadequacies in the employee's knowledge or use of the compressed gas safety procedures.

3.2 The retraining shall reestablish employee proficiency and introduce new or revised control methods and procedures, as necessary.

3.3 Certification. This employer shall certify that employee training has been accomplished and is being kept up to date. The certification shall contain each employee's name and dates of training.

4. Safe handling procedures for compressed gases.

4.1 Filling. Containers will not be filled except by the supplier of the cylinder or with the supplier's consent. Where filling is authorized it will be accomplished in accordance with DOT, OSHA and CGA regulations.

4.2 Content identification

4.2.1 Warning labels. All employees whose work operations are or may be in an area where compressed gas may be utilized, shall be instructed in the recognition and use of warning labels. Warning labels are essentially warning devices and must be legible at all times. The following will be addressed as a minimum:

4.2.1.1 Removal. When a warning label is attached to a compressed gas cylinder, it is not to be removed without authorization of the person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.

4.2.1.2 Legibility. In order to be effective, warning labels must be legible and understandable by all authorized employees, affected employees, and other employees whose work operations are or may be in the area. Non-legible or missing labels will be reported to Environmental Health and Safety (713-500-8100) immediately.

4.2.1.3 Durability. Labels and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.

4.2.1.4 Labels may evoke a false sense of security, and their meaning needs to be understood as part of the overall compressed gas safety program.

4.2.1.5 Labels must be securely attached to cylinders so that they cannot be inadvertently or accidentally detached during use.

4.2.2 Labeling. Each container will bear the proper label for the compressed gas contained.

4.3 Maintenance.

4.3.1 Authorization. Containers and their appurtenances used by UTHealth will be maintained only by the container supplier or authorized representative. Any employee who is not sure of the type of maintenance allowed on containers used by UTHealth should contact Environmental Health and Safety (713-500-8100) for further information.

4.3.2 Changing prescribed markings. The prescribed markings, supplier/owner markings or symbols stamped into containers will not be removed or changed unless in accordance with pertinent regulations.

4.3.3 Changing content markings. No employee will deface or remove any markings, labels, decals, tags or stencil marks applied by our supplier and used for the identification of content. Like markings may be affixed if the original becomes illegible or detached.

4.3.4 Pressure relief devices. No employee will change, modify, tamper with, obstruct, or repair pressure relief devices in container valves or in containers.

4.4 Painting.

4.4.1 Containers will not be painted. If a container shows signs of corrosion it will be removed from service and returned to the supplier.

4.4.2 Cylinder color. All employees should be aware that containers may only be painted by the supplier for the purpose of recognition and segregation. Should UTHHealth change suppliers' of compressed gas the color codings could also change. Always double-check to ensure you have the correct cylinder for the intended use. Never rely solely on the cylinder color for identification.

4.5 Contamination or improper contents. Any container found suspected to be contaminated or having its contents suspect will be immediately removed from service and reported to Environmental Health and Safety (713-500-8100). The supplier will be immediately notified.

4.6 Leaking or defective containers.

4.6.1 Leaking Containers. Supervisors will ensure all employees under their control understand the following. Any employee discovering a leaking container should attempt to take the following actions:

- Notify workers in the immediate area of the leak.
- If the container could contain hazardous material (or if you're not sure), evacuate personnel in the area to fresh air (preferably up-wind or side-wind relative to the source).
- Report the following as soon as possible to Environmental Health and Safety (713-500-8100).
 - Contents.
 - Location.
 - Number of employees in immediate area.
 - Circumstances of the release.
 - Condition of container.
 - Other pertinent information as required.

4.6.2 Defective Containers. Supervisors will ensure all employees under their control understand the following. Any employee discovering a defective or corroded container should attempt to take the following actions:

- Notify the supervisor of the department where the container was discovered.
- If the container could contain hazardous material (if you're not sure), evacuate personnel in the area to fresh air (preferably up-wind or side-wind relative to the source).
- Supervisor. Report the following as soon as possible to Environmental Health and Safety (713-500-8100).
 - Contents.
 - Location.
 - Number of employees in immediate area.
 - Circumstances.
 - Condition of container.

-- Other pertinent information as required.

4.7 Container usage requirements.

4.7.1 Content Identification. Where UTHHealth employees are responsible to handle and connect the container for use the operation will not proceed unless the contents can be verified by legible markings and labels.

4.7.2 Container caps, valve outlet caps, and plugs.

4.7.2.1 Container caps. Where removable caps are provided by the gas supplier for valve protection, UTHHealth employees shall keep such caps on containers at all times except when containers are connected to dispensing equipment.

4.7.2.2 Valve outlet caps and plugs. Where valve outlet caps and plugs are provided by the supplier, employees will keep such devices on the containers and valve outlets at all times except when containers are connected to dispensing equipment.

4.7.3 Misuse. No container will be used for anything other than it's intended purpose. Containers will not be used as rollers, supports or for any purpose other than to contain the content as received. No employee will allow an unsafe condition such as this to occur without notifying his or her supervisor.

4.7.4 Containers not in use (configuration). When containers are not being used the valves will remain closed at all times except when operational constraints apply.

4.8 Movement of compressed gas containers.

4.8.1 Trucks. Containers will not be rolled, dragged, or slid. A suitable hand truck, fork truck, roll platform, or similar device will be used to move containers.

4.8.2 Rough handling. Containers will not be dropped or permitted to strike violently against each other or other surfaces.

4.8.3 Lifting requirements.

4.8.3.1 Container caps. Container caps will not be used for lifting containers except for the use of hand trucks which grip the container cap for lifting on to the hand truck. In any case the container will not be lifted higher than six inches above the operating surface.

4.8.3.2 Magnetic lifting devices. Magnetic lifting devices are prohibited from use with compressed gas containers.

4.8.3.3 Ropes, chains, or slings. Ropes, chains, or slings are prohibited from use with compressed gas containers unless lugs or lifting attachments are provided by the manufacturer.

4.8.3.4 Cradles or platforms. Where approved lifting attachments have been provided by the manufacturer, cradles or platforms are authorized for use.

4.9 Container storage requirements.

4.9.1 Posting requirements.

4.9.1.1 No Smoking. No Smoking signs will be posted in the storage area.

4.9.1.2 Type gas. Signs designating the type gas stored in the area will be posted.

4.9.2 Grouping requirements. Where different types of gases are stored in the same general area the following apply.

4.9.2.1 Like gases. Gases will be stored with like gases and segregated from dissimilar gases.

4.9.2.2 Full and empty containers. Full and empty containers will not be intermingled. Separate storage areas will be delineated for each.

4.9.3 Stock rotation. Stock will be rotated so that the oldest material will be the first to be used. The storage layout will be such that old stock can be removed first with a minimum handling of other containers.

4.9.4 Storage rooms. Storage rooms used by UTHHealth will be well ventilated and dry. Room temperature will not exceed 125 degrees F. Storage in subsurface location will be avoided.

4.9.5 Separation from combustibles. Containers will not be stored near readily ignitable substances such as gasoline or waste, or near combustibles in bulk, including oil.

4.9.6 External corrosion requirements. Containers will not be exposed to continuous dampness and should not be stored near salt or other corrosive chemicals or fumes. Corrosion may damage the containers and may cause the valve protection caps to stick.

4.9.7 Mechanical damage requirements. Containers shall be protected from any object that will produce a harmful cut or other abrasion in the surface of the metal. Containers will not be stored near elevators, gangways, unprotected platform edges or in locations where heavy moving objects may strike or fall on them.

4.9.8 Storage and use requirements.

4.9.8.1 Store upright. All compressed gas containers in service or in storage will be stored standing upright where they are not likely to be knocked over.

4.9.8.2 Restrain. All compressed gas containers in use will be restrained above the midpoint to prevent accidental fall-over of the container.

4.9.8.3 Gas containers with a water volume up to 305 cu.in. (5.0 L) may be stored in a horizontal position.

4.9.8.4 Container valve end up. Liquefied gas containers except those designed for use in a horizontal position on tow motors, etc., will be stored and used valve end up. Acetylene containers will be stored and used valve end up. Storage of acetylene containers valve end up will minimize the possibility of solvent being discharged. Note: Valve end up includes conditions where the container axis is inclined as much as 45 degrees from the vertical.

4.9.9 Outdoor storage. Containers may be stored in the open, but will be stored on a clean dry surface to prevent corrosion to the bottom of the container.

4.9.9.1 Sunlight. Containers may be stored in direct sunlight, except in localities where extreme temperatures prevail (above 125 degrees F.). If our supplier recommends storage in the shade for a particular gas, this recommendation will be observed.

4.9.10 Public area. Containers used or stored in public areas will be protected to prevent tampering.

4.9.11 Interference with egress. Containers when stored inside will not be located near exits, stairways, or in areas normally used or intended for the safe exit of employees.

4.10 Connecting containers and withdrawing content.

4.10.1 Trained personnel. Compressed gases will be handled and used only by properly trained employees. Employees must have had initial training in order to handle and use compressed gases.

4.10.2 Content identification. Employees will verify that a label exists and review the label before beginning operations with a compressed gas. Unmarked containers will not be used. Such containers will be reported to Environmental Health and Safety (713-500-8100). The container color will never be relied on for identification of a container.

4.10.3 Container caps. Caps will be retained and not removed until the container is placed in service.

4.10.4 Secure containers. UTHHealth will ensure that compressed gases will be secured above the midpoint to prevent them from being knocked over.

4.10.5 Pressure regulator. A suitable pressure regulating device will be used where gas is admitted to a system of lower pressure rating than the supply pressure, and where, due to the gas capacity of the supply source, the system rating may be exceeded.

4.10.6 Pressure relief device. A suitable pressure relief device will be used to protect a system using a compressed gas where the system has a pressure rating less than the compressed gas supply source and where, due to the gas capacity of the supply source, the system pressure rating may be exceeded.

4.10.7 Connection requirements. Connections that do not fit will not be forced. Threads on regulator connections or other auxiliary equipment will match those on container valve outlets.

4.10.8 Manifold. Where compressed gas containers are connected to a manifold, the manifold, and its related equipment will be of proper design for the product(s) they are to contain at the appropriate temperatures, pressures, and flows.

4.10.9 Equipment compatibility. Regulators, gauges, hoses, and other appliances provided for use with a particular gas or group of gases, will not be used on containers containing gases having different chemical properties unless information obtained from the supplier indicates that this can be done safely.

4.10.10 Container valve requirements.

4.10.10.1 Container valves will be opened slowly and pointed away from personnel and sources of ignition.

4.10.10.2 For valves having no handwheel the wrench provided by, or recommended by the supplier will be used.

4.10.10.3 On valve containing a handwheel wrenches will not be used.

4.10.10.4 Valves will never be forced open or closed. If valves become frozen for whatever reason, the supplier will be contacted to provide instructions.

4.10.11 Dusting clothing, cleaning work areas. Compressed gas will not be used to dust off clothing or clean work areas of debris. This may cause serious injury to the eyes or body or create a fire hazard.

4.10.12 Residual empty container pressure. When withdrawing a nonliquefied compressed gas from a container, the internal pressure should not be reduced to below 20 psig so

as to preclude the backflow of atmospheric air or other contaminants into the container. The container valve should be closed tightly to retain this residual pressure.

4.10.13 Check valves. Compressed gases will not be used where the container may be contaminated by the feedback of process materials unless protected by suitable traps or check valves.

4.10.14 Gas tightness. Connections to piping, regulators, and other appliances will be kept tight to prevent leakage. Where hose is used, it shall be kept in good condition.

4.10.15 Removing pressure regulator. Before a regulator is removed from a container, the container valve shall be closed and the regulator drained of gas pressure.

5. General safety rules for specific types of gases.

5.1 Flammable gases.

5.1.1 Adjoining exposures. Provisions will be made to protect flammable gases from hazardous exposure to and against hazardous exposure from adjoining buildings, equipment, property, and concentrations of people.

5.1.2 Heating requirements. Where storage areas are heated, the source will be by steam, hot water, or other indirect means. Heating by flames or fire is prohibited.

5.1.3 Electrical equipment requirements. Will conform to the provisions of NFPA 70, National Electrical Code, article 501, for Class 1 Division 2 locations.

5.1.4 Sources of ignition will be forbidden.

5.1.5 Storage buildings will be well ventilated.

5.1.6 Combustibles and ignition sources. Flammable gas containers stored inside of buildings with other occupancies will be kept at least 20 feet from combustibles or ignitions sources.

5.1.7 Capacity limitations. Flammable gas containers stored inside industrial buildings on UTHealth property except those in use or those attached for use are limited to a total gas capacity of 2500 cubic feet of acetylene or nonliquefied flammable gas, or a total container content water capacity of 735 pounds for liquefied petroleum gas or stabilized methylacetylene-propadiene.

5.1.8 Fire protection requirements.

5.1.8.1 Fire extinguishers. Adequate portable fire extinguishers of carbon dioxide or dry chemical types will be made available for fire emergencies at UTHealth storage locations.

5.1.8.2 No smoking signs. Signs will be posted around the storage area of buildings or at the entrance to storage rooms.

5.1.8.3 Leak testing. A flame or other ignition source will **not** be used for detection of flammable gas leaks. Use either a flammable gas leak detector, soapy water, or other suitable solution.

5.2 Oxygen (Including oxidizing gases)

5.2.1 Cleanliness. Oxygen containers, valves, regulators, hose and other oxygen apparatus will be kept free at all times from oil or grease and will not be handled with oily hands, oily gloves, or with greasy equipment.

5.2.2 Separation of oxygen from combustibles. Oxygen containers in storage will be separated from flammable has containers or combustible materials (especially oil and grease) a minimum distance of 20 feet or by a noncombustible barrier at least 5 feet high having a fire resistance rating of at least one-half hour.

5.2.3 Oxygen-rich atmospheres. The oxygen content in work areas (other than hyperbaric chambers) must not exceed 23 percent by volume.

5.2.4 Compatibility of materials. Any materials used by UTHealth that come into contact with oxygen in valves, piping, fittings, regulators, and utilization equipment must be suitable for use with oxygen, ant at the pressures and conditions involved at the specific use point of material. The handling and use of oxygen above 3000 psi may involve greater fire potential, adequate safety systems analysis need to be made.

5.3 Acid and alkaline gases.

5.3.1 Personal protective equipment. Supervisors will ensure that precautions are taken to avoid contacting skin or eyes with acid or alkaline gases. Chemical goggles or face shields, rubber (or other suitable chemically protective material) gloves and aprons will be worn. Long sleeves and trousers will be worn. Open toed shoes or sneakers are prohibited.

5.3.2 Respiratory equipment. Employees handling and using acid and alkaline gases will have gas masks or self-contained breathing apparatus (SCBA) immediately available for use. SCBA must be used when the concentration of the gas could be higher than the mask canister rating, and or where the oxygen content of the atmosphere could be below 19 percent by volume.

5.3.3 Emergency showers and eyewash fountains. Supervisors will ensure that areas where acid or alkaline gases are used are equipped with an emergency shower and eyewash fountain.

5.3.4 Quantity on site. Because of their hazardous nature, supervisors will limit the quantity of this type of gas to the minimum requirements for the foreseeable future.

5.3.5 Ventilation. Acid and alkaline gases will only be used in well ventilated areas.

5.4 Highly toxic gases.

5.4.1 Respiratory equipment. Employees handling and using highly toxic gases will have gas masks or self-contained breathing apparatus (SCBA) immediately available for use. SCBA must be used when the concentration of the gas could be higher than the mask canister rating, and or where the oxygen content of the atmosphere could be below 19 percent by volume.

5.4.2 Storage locations. Storage of highly toxic gases will be:

5.4.2.1 Outdoors, or in a separate noncombustible building without other occupancy, or in a separate room without other occupancy.

5.4.2.2 Of noncombustible construction with a fire-resistance rating of at least one hour.

5.4.2.3 Well ventilated to preclude development of hazardous concentrations.

5.4.2.4 Protected against tampering.

5.4.3 Ventilation. Highly toxic gases will be used only in forced ventilated areas or in hoods with forced ventilation, or outdoors. Hazard analysis will be conducted on equipment emitting high concentrations. The gas will be discharged into appropriate scrubbing equipment which will remove or neutralize the toxic effects before entering the effluent gas stream.

5.4.4 Toxicity. Supervisors will ensure the following. Before using a highly toxic gas, employees must read and understand all warning labels and material data sheet information. All employees working in the immediate area where these gases are handled will be instructed as to the toxicity of the gases and methods of protection against harmful exposure. Employees will not be exposed to concentrations greater than those determined to be safe levels by OSHA 29 CFR 1910.1000 and the threshold limit values guidance by the ACGIH.

5.4.5 Quantity on site. Because of their hazardous nature, supervisors will limit the quantity of this type of gas to the minimum requirements for the foreseeable future.

5.5 Cryogenic liquefied gases. Cryogenic liquids are gases which are handled in liquid form at relatively low pressure and extremely low temperatures, usually below -238 degrees F. Because of their low temperature, cryogenic liquids are handled in multi-wall, vacuum-insulated containers, tank trucks, tank cars, and storage tanks to minimize evaporation and venting of the gas. Some

cryogenic liquids in small quantities are also handled in open, low pressure thermos type containers in laboratory work.

5.5.1 Personal protective equipment. Cryogenic liquids and cold gases can cause frostbite injury upon contact with the body. When handling cryogenic liquids supervisors will ensure that employees use suitable eye protection, such as a face shield, safety glasses, or safety goggles, hand protection, such as insulated loose fitting gloves, and proper clothing to prevent other bodily exposure.

5.5.2 Ventilation. Cryogenic liquid containers will only be stored and handled in well ventilated areas to prevent excessive concentrations of the gas. Containers are equipped with pressure relief devices which permit venting of gas intentionally.

5.5.3 Container handling. Cryogenic liquid containers will be handled and stored in an upright position. The containers must **not** be dropped, tipped over, or rolled on their sides. A four wheeled handling truck will be used to move cryogenic liquid containers over 20 gallons capacity.

5.5.4 Containers. Containers designed for specific gas storage will not be used for any other type of gas.

5.5.5 Pressure relief devices. Containers entering this facility will be provided with DOT approved devices to prevent excessive buildup of pressure from warming gas. Where cryogenic liquids or cold gas may be trapped between valves, piping will be equipped with appropriate pressure relief devices.

5.5.6 Transfer of cryogenic liquids. Only transfer lines designed for cryogenic liquids will be used. Transfer of cryogenic liquids will be performed slowly enough to minimize excess evaporation and stress due to rapid cooling and contraction of warm containers and equipment.

5.5.7 Liquid oxygen. Liquid oxygen containers, piping and equipment will be kept clean and free of grease, oil, and organic materials. Ignitions sources are **not** permitted in areas where liquid oxygen is stored or transferred.

5.5.8 Liquid hydrogen. Ignitions sources are **not** permitted in areas where liquid hydrogen is stored or transferred. Liquid hydrogen must be stored and transferred under positive pressure to prevent the infiltration and solidification of air or other gases.

5.5.9 Liquid helium and liquid neon. Liquid helium and liquid neon must be stored and transferred under positive pressure to prevent the infiltration and solidification of air or other gases.

5.5.10 Liquefied natural gas. Ignitions sources are **not** permitted in areas where liquefied natural gas is stored or transferred. Liquefied natural gas must be stored and transferred under positive pressure to prevent the infiltration of air or other gases.

5.5.11 Inert gases. In areas where inert gases are used or stored employees will have self-contained breathing apparatus (SCBA) immediately available for use. SCBA must be used in the event the oxygen in the room is displaced by the inert gas creating an oxygen deficient atmosphere where the oxygen content of the atmosphere could be below 19 percent by volume.

6. Visual inspection of compressed gas cylinders.

Employees of UTHHealth will use the following for general inspection of compressed gas cylinders. Our supplier has the first responsibility for inspection of cylinders used by UTHHealth in accordance with CGA and NFPA guidelines. Only the following inspection criteria will be followed by employees of UTHHealth:

General Visual Inspection Criteria For Compressed Gas Cylinders

Inspect for:

- Dents
- Cuts, gouges or digs
- Corrosion
- Pitting
- Crevice corrosion
- Bulges
- Neck defects
- ARC/Torch burns
- Valve ease-of-movement
- Valve thread serviceability

Possible result:

- Weakening of cylinder wall
- Decrease in wall thickness
- Decrease in wall thickness
- Decrease in wall thickness
- Weakening of cylinder wall
- Weakening of cylinder wall
- Leak or cylinder explosion
- Weakening of cylinder wall
- Corrosion leading to leak
- Leak during operation

6.1 Suspect cylinders. Cylinders that are suspected to be deficient in any manner will be removed from service. The supplier will then be notified and a representative of the supplier will be asked to inspect the cylinder. UTHHealth employees discovering a cylinder suspected to be deficient in any manner should notify Environmental Health and Safety (713-500-8100).

7. General safety rules for use of compressed gas.

7.1 Pre-operation safety rules.

- Read the Safety Data Sheet before use.
- Inspect cylinder for damage before use.
- Ensure "In use" label is present.
- Ensure all labels/warnings are readable.
- Place upright on stable dry surface.
- Ensure cylinder is restrained above mid-point.
- Keep heat, flame, and electrical sources from gas.
- Operate in accordance with established procedures.

7.2 Post-operation safety rules.

- Ensure "empty" or like label is present.
- Remove from operation using established procedures.
- Close valve completely and cap cylinder.
- Transport cylinder using handtruck.

7.3 Full cylinder storage rules.

- Read the Safety Data Sheet before use.
- Do not smoke.
- Mark cylinder with date of storage.
- Ensure stock is properly rotated.
- Use oldest stock first.
- Inspect cylinder for damage before storage.
- Store with like kind of gas.
- Ensure all labels are readable.
- Ensure valve assembly is tightly capped.
- Ensure cylinder is restrained above midpoint.
- Store upright on stable dry surface.
- Keep electrical devices away from gas.
- Keep combustible materials away from gas.
- Keep heat and flame away from gas.

7.4 Empty cylinder storage rules.

- Read the Safety Data Sheet before use.
- Do not smoke.
- Label cylinder "empty" before storage.
- Ensure valve assembly closed tightly.
- Ensure valve assembly capped tightly.
- Inspect cylinder for damage before storage.
- Store with like kind of gas cylinders.
- Ensure all labels are readable.
- Ensure cylinder is restrained above midpoint.
- Store upright on stable dry surface.
- Keep electrical devices away from gas.
- Keep combustible materials away from gas.
- Keep heat and flame away from gas.

8. Compressed gas storage locations.

<u>Location</u>	<u>Type Gas</u>	<u>Average Quantity Stored</u>	<u>Last Hazard Eval.</u>
_____	_____	_____	_____

[illegible]