CAES-010
Revision ID: 1
Effective Date: 10/08/2009

CAES Laboratories
Chemical Hygiene Plan

Center for Advanced
Energy Studies

CENTER FOR ADVANCED ENERGY STUDIES (CAES)

CHEMICAL HYGIENE PLAN

Prepared by

CAES Leadership Team

Revision 1

October 8, 2009

Approved By:

CAES Director	Date: Oct 8 2009
CAES Safety Officer	Date: 10/09/09

This plan was prepared for use within CAES. It is intended for use by and applies to all persons conducting work in CAES to include tenants, employees, staff, visitors, and students. The plan will be maintained in compliance with all ISU chemical hygiene requirements.


Center for
Advanced Energy Studies
CAES

CONTENTS

1. PURPOSE

The Center for Advanced Energy Studies (CAES) strives to provide a safe and healthy place for people working in or visiting CAES. The Chemical Hygiene Plan (CHP) serves as guidance for working safely in CAES laboratories and serves as reference for many federal, state, and local regulatory requirements. It by no means covers all regulatory requirements or CAES or Idaho State University (ISU) policies.

The CHP fulfills the requirements outlined by the Idaho General Safety and Health Standards (IGSHS) 111 – *"Laboratories and Chemical Storage Safety Rule."* which is enforced by the Idaho *Division of Building Safety* (see def.) (DBS). The CHP is also designed to fulfill the requirements of the *Occupational Safety and Health Administration* (see def.) (OSHA) 29 CFR 1910.1450 *"Occupational Exposure to Hazardous Chemicals in Laboratories."*

The purpose of the CHP is to describe proper practices, procedures, equipment, and facilities for laboratory researchers at CAES in order to protect them from potential health hazards presented by chemicals used in the laboratory workplace and to keep exposures below specified limits.

Beyond the safe handling of chemicals within the facility, this plan delineates CAES-specific requirements and roles and responsibilities for the transport of chemicals and associated products to CAES; receipt of chemicals and associated products by CAES; the removal of chemicals and associated products, for continued use or as waste, from CAES.

It is the responsibility of all persons working in CAES laboratories (e.g., administrative personnel, managers, laboratory researchers, and students) to know and adhere to the provisions of this document.

1.1 Scope

The Chemical Hygiene Plan applies to the following CAES laboratories:

- Advanced Materials Laboratory
- Analytical Instrumentation Laboratory
- Analytical Chemistry Laboratory
- Fluids Laboratory
- Radiochemistry Laboratory
- Instrument Repair Laboratory.

1.2 Lab Specific Procedures and Requirements

Laboratories may develop their own supplemental laboratory-specific procedures and requirements. They must comply with all regulatory requirements and CAES and ISU policies.

2. RESPONSIBILITIES, AUTHORITY AND RESOURCES

2.1 CAES Safety Officer (CSO)

The CSO assists the CAES laboratory Leads (LLs), Principal Investigators (PIs), and CAES Director and Associate Directors to provide a safe and healthful workplace and to maintain compliance with environmental health and safety regulations and guidelines and CAES and ISU policies. CSO responsibilities and authority are outlined in CAES-012. In regard to the CHP, CSO:

1. Coordinates the evaluation, annual review and implementation of the CAES CHP.
2. In conjunction with LLs, coordinates the review, as necessary, of new research projects prior to initiation to identify the use of hazardous chemicals and provides assistance to PIs in developing proper measures to inform and protect laboratory workers.
3. Provides advice and consultation on environmental health and safety issues; assistance to CAES residents in complying with the CHP.
4. Performs workplace evaluations which may include air samples, swipes, or other tests to determine the amount and nature of airborne and/or surface contamination, and to extrapolate personnel exposure levels from that data.
5. Coordinates hazardous waste characterization and disposal in accordance with CAES and ISU Technical Safety Office (TSO) policies and written program along with federal, state, and local regulations.
6. Coordinates the review of hazardous substance labeling, handling, storage, use, spill cleanup, decontamination and disposal, including specific standard operating procedures (SOPs) dealing with the safe use and disposal of these substances.
7. Coordinates safety assessments of laboratories and storage areas and recommended follow-up activities.
8. Provides and coordinates safety training.
9. Develops and maintains ES&H related programs.
10. Assists with *personal protective equipment* (see def.) (PPE) selection and its proper use.
11. Through the ISU TSO, acts as a liaison with regulatory agencies on the local, state, and federal levels.
12. Provides assistance to principal investigators in conducting their own routine assessments.
13. Coordinates review of the acquisition, operation, and maintenance.
14. Supports the investigation of all reports of laboratory hazards incidents, chemical spills, and near-misses to prevent repeat occurrences.
15. Leads the investigation of exposure complaints or concerns for referral for medical consultation or performance of exposure monitoring.

The CSO has the authority to stop any activity which is an immediate danger to the life and health of laboratory workers and others, or an immediate danger to the environment as outlined in CAES-001, Stop Work Authority Procedure.

2.2 Safety Committee

The CAES safety committee ensures that research tasks are planned and executed productively and safely in accordance with the principles of excellence in laboratory operations and with the ISU Safety Manual. The committee establishes, maintains and reinforces a strong safety culture for CAES; provides safety leadership for all CAES facility users including residents, laboratory users, and visitors. Safety committee representatives meet on a regular basis to discuss safety issues and provide feedback on policies, programs, and procedures. They ensure that information discussed at the safety committee meetings is communicated to everyone in their labs. Safety committee responsibilities are outlined in CAES-026 CAES Safety Committee. In regard to the CHP, each safety committee member:

1. Provides recommendations and assistance with developing safe work practices, Standard Operating Procedures and job hazard analyses for research activities, which includes personal protective equipment requirements.
2. Assists with compliance activities for the CHP and additional safety programs.
3. Reviews and makes recommendations in response to safety training reports, research protocols for hazard identification and safety requirements (as necessary), exposure evaluation requests and reports, availability of facility safety equipment, and emergency response.
4. Assists in conducting and reviewing accident/injury/illness investigations and provides recommendations.
5. Conducts and reviews operations and facility safety assessments on a regular basis.
6. Maintains communications with CAES residents concerning the quality of the work environment. This includes indoor air quality, ergonomics, thermal comfort, etc.
7. Performs other safety related functions as may be assigned by the CAES Director or recommended by the CSO.

2.3 Laboratory Lead

The Laboratory Lead (LL) has overall responsibility for a laboratory and the research/education equipment, practices, procedures and techniques employed in that laboratory. The LL holds the responsibility of ensuring laboratory workers are working in a safe environment. They may designate some or all of the responsibilities to another individual (e.g., CSO), but the LL is ultimately responsible. The LL must:

1. Assure all work performed in their laboratory is conducted in accordance with the CHP and other applicable CAES and ISU policies and programs.
2. Establish supplemental training and SOPs for their laboratory.
3. Provide oversight that helps ensure that researchers are properly trained and understand procedures applicable to safety in their laboratories and work areas.

4. Provide required personal protective equipment to laboratory workers and ensure its proper use.

2.4 Principal Investigator

The Principal Investigator shall ensure that all safety policies and procedures outlined in the CHP are followed by personnel working under their direction and all personnel under their direction are trained in safe work practices appropriate to their project.

The PI must:

1. Maintain a safe and healthful working environment.
2. Review compliance and discrepancies in safety performance as necessary, and work toward resolution of such issues to insure that safe practices and techniques are continuously being employed.
3. Review accident reports, share lessons learned, and make recommendations for future procedures or practices that shall minimize the repetition of that type of accident.
4. Submit research protocols to the CAES Director and safety committees, as required, for review prior to commencing work.
5. Ensure that chemicals are only used in a manner consistent with the pre-approval provided by CAES administration.
6. Assure that chemicals are obtained are stored in an appropriate fashion.

2.5 Laboratory Worker

A laboratory worker is any person performing or supervising work in a CAES laboratory including PIs. Laboratory workers are subject to the CHP and all its provisions and are responsible for following it. Laboratory workers must:

1. Understand and follow all laboratory safety-related policies, programs, procedures, and training received.
2. Know the physical and health hazards, handling procedures, and emergency response information for the chemicals or tasks they are handling or performing.
3. Understand the function and proper use of all PPE and wear required PPE as necessary.
4. Promptly report all work related incidents, injuries, and illnesses to the ES&H CSO and their supervisor. Near misses, potential serious safety issues, and danger of environmental contamination must also be reported.
5. Contact their PI, LL, manager, CSO, or safety committee for further clarification if any of the above procedures are not clearly understood.
6. As outlined in CAES-001, Stop Work Authority Procedure, initiate a stop work when conditions that are potentially unsafe or adverse to quality are identified.

NOTE: *See Section 9 for CAES policies and roles and responsibilities on bringing chemicals into CAES, removal of chemicals from CAES, chemical transport, and chemical inventory.*

3. TRAINING REQUIREMENTS

All laboratory workers must read and understand the CHP and complete all required safety training. Applicable safety training must be completed prior to beginning any laboratory work.

3.1 Laboratory Safety Training

The core laboratory safety training for all Laboratories covered under this CHP is comprised of training on the CHP, chemical management policy, and hazardous waste disposal. The training provides general knowledge pertaining to laboratory hazards and controls to minimize exposure. Additional, general laboratory training that applies to all people performing work in a specific laboratory is assigned at the discretion of the Laboratory Lead based on the types of hazards present in the work area. This training may include topics such as electrical safety, compressed gases, and glove boxes; laboratory standard operating procedures.

The PI or an appointee must introduce new laboratory workers to operations and safety requirements unique to their project. The new employee is responsible for becoming familiar with the hazards of the chemicals he or she will be handling through material safety data sheets, hazard labeling, and other forms of information prior to using the chemicals.

The PI or their appointee must provide lab workers with chemical safety instruction and information that is specific to the project including project standard operating procedures. This information and instruction must be documented by the PI. Safety instruction for the use of chemicals must satisfy the hazard awareness requirements listed below.

1. The name of the chemical and its hazardous component(s);
2. The health and physical risk(s) associated with the chemical;
3. Signs of release and symptoms of exposure;
4. How and when to use engineering controls and personal protective equipment;
5. Labeling and storage requirements;
6. Disposal procedures;
7. Emergency procedures for spills and exposures; and
8. Laboratory standard operating procedures (SOPs).

TSO can assist laboratories to provide this training.

The core laboratory training, as well as project-specific training is specified in the Laboratory Manual maintained in each Laboratory. Documentation for completion of training is maintained in the Laboratory Manual.

3.1.1 ES&H Training

ES&H training on various safety topics is available through the CSO and CAES Portal. Specific modules may be required based upon the type of work each individual laboratory worker may conduct. Equivalences for ES&H training may be requested by PIs and granted by the CSO.

All assigned training needs to be completed prior to start of work. Refresher training must be done periodically as determined by the CSO and LL.

4. HAZARD IDENTIFICATION

4.1 Chemical Container Labeling

A chemical container label is the primary means for communicating the contents of a container and its hazard(s). Every container, even those just containing water, must be labeled to ensure employees and students are aware of its contents.

4.1.1 Original Container

Chemicals in original vendor containers must have labels indicating the chemical or product name and the vendor's name. Hazard warning signs or symbols should be prominently visible on the labels.

4.1.2 Laboratory Container

All containers of chemicals decanted from an original container or prepared in the laboratory must be labeled with the chemical or product name(s), concentration(s), and primary hazard(s). It should also be dated and the responsible worker's or PI's name. This includes containers of reaction products or byproducts as well as separation processes such as distillations and extractions.

4.1.3 Expiration Date

"Time sensitive chemicals (e.g., peroxide formers) must be labeled with an appropriate expiration date." The chemical inventory program on the CAES portal will be used to track expiration dates and perform an inventory every 6 months. PIs and LLs will be notified of chemicals near expiration so the proper action can be taken, with final disposal the responsibility of ISU TSO.

4.1.4 Waste Containers

All containers of chemical waste must be labeled. It is the responsibility of the laboratory worker generating the hazardous waste to label the container. Guidance on the information the label should contain can be found in the ISU Hazardous Waste Policies and Procedures Manual.

4.2 NFPA Diamond

The National Fire Protection Association developed a system to communicate hazards to emergency responders but it can be used by anyone for this purpose. Its uses range from small chemical containers to buildings.

Each color-coded diamond indicates a specific hazard:

- Blue diamond (left) Health Hazard
- Red diamond (top) Flammability Hazard
- Yellow diamond (right) Stability/Reactivity Hazard
- White diamond (bottom) Other Hazards

The blue, red, and yellow diamonds are assigned values ranging from 0 – 4. A value of 0 indicates minimal or no hazard and a value of 4 is the highest level of hazard that can be assigned. The white diamond is either blank or contains an abbreviation/symbol indicating the hazard. For example:

- COR – *Corrosive* (see def.)

- OX – Oxidizer
- W – Water reactive.

Definitions for each hazard class, the numbering system, and sources of NFPA rating information are available at http://www.osha.gov/SLTC/hazardcommunications/index.html or by contacting the CSO.

4.3 Material Safety Data Sheets

An MSDS is a document prepared by a supplier to summarize the health and safety information associated with a product. Suppliers are required to provide an MSDS for each chemical they make or offer. As required by OSHA, each MSDS must contain the following information:

Product identity

- Hazardous ingredients
- Manufacturer contact information
- Physical/chemical properties
- Physical and health hazards
- Exposure limits
- Engineering controls
- Work practices
- Personal protective equipment
- Emergency and first aid procedures
- Spill cleanup
- Special precautions

Additional information may be added to an MSDS at the manufacturer's discretion.

4.3.1 MSDS Retention and Access

Each laboratory must maintain a current MSDS binder that contains every chemical and product, and every supplier of that product/chemical, used in the lab. Past or out-of-date MSDSs will be stored out of the work area The binder with MSDSs is readily accessible to any laboratory user.

4.3.2 Obtaining an MSDS

Manufacturers and suppliers are required to provide an MSDS for every product they offer. An MSDS typically accompanies a chemical shipment or mailed separately. Companies may be contacted via telephone or written request to obtain one, but many make their MSDSs available online or they may be requested via their websites. An MSDS must be available for every chemical used and stored at CAES. CSO can also assist in obtaining an MSDS.

4.4 Additional Sources of Information

The Chemical Hygiene Plan serves as a limited resource for information on specific chemicals, chemical hazard classes, and additional hazards. Additional sources of information can be found at the TSO web page. http://www.physics.isu.edu/health-physics/tso/hw.html or by contacting the TSO. Also, information on additional training modules required on a Laboratory- or project-specific basis is available on the CAES portal.

Manufacturers may also have additional information available in regards to chemical safety.

4.5 Chemical Inventory

In accordance with this plan, each PI is responsible for entering chemical inventory data into the CAES chemical inventory database for all chemicals they bring into CAES. All LLs must submit an inventory of chemicals to the CSO on a semi-annual basis. The inventory must be broken down by individual container and include:

- Unabbreviated chemical or product name
- Concentration
  - If it is not 100%
- Product #
  - Only required for product names
- Manufacturer
- Chemical Abstract Service (CAS) Registry number
- Quantity in container
- Quantity units
- Container Owner / PI
- Date inventory performed
- Person who conducted inventory
- Storage location.

4.5.1 Inventory Example

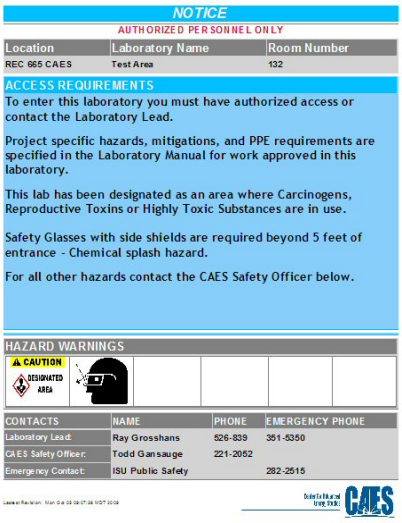
Date: 05/01/2009			Conducted by: Bob Smith				
Chemical/ Product Name	Prod. #	CAS #	Manufacturer	Qty	Units	Owner	Location
Acetone		67-64-1	JT Baker	4	L	Bob Smith	Lab 205 (Give an example of an actual CAES lab name/ number)

Acetic acid, 20%, aq.		64-19-7	Fisher	500	mL	Bob Smith	Lab 205
Stripping Buffer	SB-121		Bio Rad	500	mL	Bob Smith	Lab 205

4.6 Laboratory Signage

4.6.1 Hazard Communication Signage

Laboratories must have a Laboratory Placard posted on or near the door that clearly identifies potential laboratory hazards and entry requirements. They are to remind laboratory staff and inform visitors of this information and aid the fire department or other emergency responders. The placard must also include the lab's emergency contact information, Laboratory Lead and room number. It may include general contact information as well.


NOTICE

AUTHORIZED PERSONNEL ONLY

Location	Laboratory Name	Room Number
REC 665 CAES	Test Area	132

ACCESS REQUIREMENTS

To enter this laboratory you must have authorized access or contact the Laboratory Lead.

Project specific hazards, mitigations, and PPE requirements are specified in the Laboratory Manual for work approved in this laboratory.

This lab has been designated as an area where Carcinogens, Reproductive Toxins or Highly Toxic Substances are in use.

Safety Glasses with side shields are required beyond 5 feet of entrance - Chemical splash hazard.

For all other hazards contact the CAES Safety Officer below.

HAZARD WARNINGS

CAUTION

DESIGNATED AREA

CONTACTS	NAME	PHONE	EMERGENCY PHONE
Laboratory Lead:	Ray Grosshans	526-839	351-5350
CAES Safety Officer:	Todd Gansauge	221-2052	
Emergency Contact:	ISU Public Safety		282-2515

The CSO works with the LLs and PIs to update signage on a regular basis. Laboratory Placards will be updated as needed and at a minimum reviewed and updated annually. The background color will be changed each year to easily identify any placards that have not been reviewed for the year. LLs and PIs must notify the CSO of changes in laboratory hazards, entry requirements, and emergency contacts.

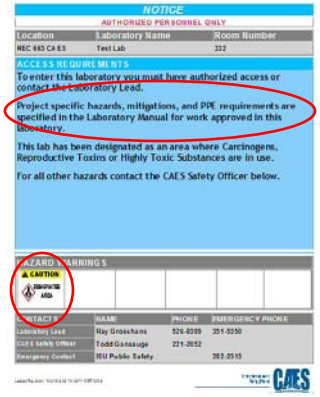
4.6.2 Emergency Contact Sheet

An emergency contact sheet must also be posted near laboratory telephones and on or near the laboratory door. The contacts must include applicable laboratory, CAES, and ISU contacts, emergency response numbers, and ISU Public Safety. The information includes links to chemical manufacturers and technical information for spill response.

4.6.3 Safety Equipment Signage

Signage must be conspicuously posted indicating location of eyewashes and safety showers. The area around and the path to the eyewashes and safety showers must be kept clear. Signage identifies the location of fire blankets, fire extinguishers, spill kits, and any other safety equipment. The signage identifies the equipment by name or an appropriate symbol.

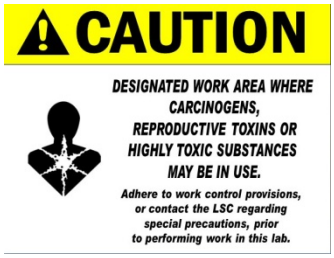
4.6.4 Particularly Hazardous Substances



Workers must be able to determine when they are entering areas in which there are particularly hazardous substances (PHSs) present. PHSs are defined in the OSHA lab standard as those chemicals that are *carcinogens* (see def.), *reproductive toxins* (see def.), or highly toxic agents.

The worker can know such substances are present via posted signs (such as the one to the right). In some cases, only part of the lab is posted, which means that these chemicals are restricted to handling within the particular designated area where the sign is present.

The standard requires that these chemicals be handled in a designated area.



5. OCCUPATIONAL TOXICOLOGY

5.1 Routes of Entry

To evaluate the risks of adverse *health effects* (see def.) from chemicals, one must be aware of the routes of entry into the body, duration of exposure, toxicity of the chemical, exposure limits, and odor threshold of the chemical. This section explains these principles and describes how to reduce chemical exposure.

5.1.1 Inhalation

Inhalation is the most common route of chemical exposure in the lab. Exposure by this route can produce poisoning by absorption through the mucous membrane of the nasal passage, mouth, throat, and lungs and can seriously damage these tissues. Inhaled gases or vapors may pass rapidly into the capillaries of the lungs and be carried into the circulatory system. Exposure can be minimized by keeping containers closed when not in use, proper storage, and the use of engineering controls (e.g., fume hood). Respiratory protection may be necessary if engineering controls cannot be used or do not provide sufficient protection. Respirators are not to be used in any CAES laboratory without prior approval of the CSO.

5.1.2 Skin and Eye Contact

Contact with the skin is the second most frequent route of chemical exposure. A common result of skin contact is localized irritation. Many materials are absorbed through the skin quickly into the underlying blood vessels, carried through the blood stream, and may cause systemic poisoning. The main routes of entry for chemicals through the skin are the hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the outer layers of the skin. The follicles and the glands are abundantly supplied with blood vessels, which facilitate the absorption of many chemicals.

Skin and eye contact with chemicals can be avoided by the use of appropriate personal protective equipment. At a minimum, wear the appropriate chemical-resistant gloves and safety glasses with side shields when working with hazardous chemicals.

5.1.3 Ingestion

Chemicals used in the lab can be extremely dangerous if they enter the mouth and are swallowed. In addition, some chemicals may damage the tissues of the mouth, nose, throat, lungs, and gastrointestinal tract producing systemic poisoning if absorbed through these tissues. To prevent entry of chemicals into the mouth, lab workers should wear gloves and wash their hands immediately after use of any chemical substance and before leaving the lab. Keep hands and tools (pens and pencils) away from the face and mouth. Storing or consuming food and drinks in the lab is prohibited. Mouth pipetting is also prohibited.

5.1.4 Injection

Exposure to chemicals by injection seldom occurs in the lab. However, it can inadvertently occur through mechanical injury from glass or metal contaminated with chemicals or when chemicals are handled in syringes. Use proper sharps handling practices Inspect glassware prior to use. Sharps, including razors and cutting blades, should be disposed of in a special ‘sharps box’ or special glass disposal container. Broken glass or spilled sharps must be collected using mechanical means (e.g., broom and dustpan) and never with one’s hands.

5.2 Exposure Assessment and Monitoring

CAES may be required to perform an exposure assessment of some laboratory work. (An exposure assessment takes into consideration any hazardous materials in use, the task being performed, the work environment including engineering controls, administrative controls, and personal protective equipment. Monitoring may be necessary to assess exposure levels to these hazards.

Laboratory workers should contact their manager, advisor, or CSO to discuss exposure concerns and request an assessment.

5.2.1 Exposure Limits

Exposure limits have been established to reduce exposure to "acceptable" levels. OSHA sets regulatory exposure limits called permissible exposure limits (PEL). The American Conference of Governmental Industrial Hygienists (ACGIH) has developed recommended exposure limits called *Threshold Limit Values* (see def,) (TLVs).

5.2.2 Frequency

Initial monitoring will be performed if there is reason to believe exposure levels for a substance could exceed the action level or permissible exposure limit. Monitoring may be necessary due to equipment or process changes, or an unanticipated release.

Periodic monitoring will be performed if the initial monitoring exceeds applicable action levels or permissible exposure limits. Monitoring frequency will be established by the CSO based upon the exposure levels (current and previous monitoring) and any requirements outlined in applicable standards. Monitoring may be terminated in accordance with the applicable standard.

5.2.3 Records

Laboratory workers will be notified of monitoring results in writing within 15 days after receipt of any laboratory results either individually or by posting in an appropriate location.

CSO shall maintain records in accordance with the record keeping requirements of applicable OSHA standards.

5.3 Medical Surveillance

CAES and an individual's home organization shall coordinate an offer for medical consultation or examination under the following circumstances:

- A lab worker develops signs or symptoms potentially associated with a hazardous chemical, which they may have been exposed to in the laboratory.
- Exposure monitoring reveals an exposure level above OSHA or ACGIH action levels or permissible exposure limits where the applicable standard requires such medical surveillance.
- An event occurs such as a chemical spill, leak, or explosion that results in the likelihood of a hazardous exposure.
- A lab worker is exposed to blood or visibly bloody fluids by a needle-stick, cut, or splash in the face.

5.4 Reporting Exposure

Laboratory workers who believe they have had an exposure should contact their PI, home organization manager or advisor and CSO for evaluation. CAES-027 Incident/Accident Report must be completed and submitted as soon as possible to both CAES and to the individual's home organization in accordance with their reporting requirements. More information on the reporting and investigation requirements is available at: http://www.isu.edu/pubsafe/errp/Chapter 11_Disaster_Response.shtml.

6. CONTROLLING HAZARDS

6.1 Hazard Minimization, Elimination, and Substitution

6.1.1 Hazard Minimization

Using smaller quantities of hazardous chemicals or substituting a less hazardous chemical reduces the risk of serious exposure or spill. Consider the following possibilities:

- Substitute less hazardous chemicals
- Work on a smaller scale
- Order only what is needed
- Share chemicals when possible.

6.2 Engineering Controls

Engineering controls eliminate or minimize exposure by removing a hazard or acting as barrier between a hazard and a worker. Engineering controls are typically more effective controlling hazards than administrative controls practices or personal protective equipment. They often require a higher cost upfront; however, they may be more cost effective in the long run. Engineering controls range in complexity and cost from something as simple as a sharps container to minimize needle sticks to an interlocking mechanism of an x-ray unit to minimize radiation exposure. In a laboratory, they are often used to minimize contact with a hazard due to chemical splash, explosion, or inhalation.

6.2.1 Local Exhaust Ventilation

Local exhaust ventilation is an engineering control used to reduce inhalation exposure. Common laboratory examples include glove boxes, extraction arms (snorkels), and fume hoods.

6.2.1.1 Glove Box

Glove boxes are complete enclosures used to perform work in a separate environment. A different environment may be necessary to control worker exposure or to protect the chemical itself (i.e., an inert atmosphere). Gloves secured to ports allow manipulation inside the unit. Depending on the type of work being conducted, the following may be required:

- Integrity testing of the unit and gloves
- Sensor calibration
- Training
- Standard operating procedures.

Contact Laboratory Leads or the CSO for additional information.

6.2.1.2 Biosafety Cabinet

Biosafety cabinets (BSC) are used to control exposure to biological aerosols and protect work materials from contamination utilizing a High Efficiency Particulate Air (HEPA) filter. HEPA filters do not capture chemical vapors. A BSC where the treated exhaust is returned to the laboratory cannot be

used for procedures involving flammable liquids, volatile toxic or odorous chemicals with the exception of small quantities of alcohols used for decontamination.

6.2.1.3 Extraction Arm (Snorkel)

Extraction arms or snorkels are typically constructed of flexible ducting and connected to the exhaust ventilation system. They are useful for capturing vapors, fumes, and dust at the source of generation, and work well when designed properly for a given process and have an adequate flow rate. They are typically ineffective for any source beyond a distance of one half the ducting's diameter. Design or modification must be approved by ISU Facilities.

6.2.1.4 Fume Hood

The fume hood is the most common method of controlling inhalation exposures to hazardous substances in the laboratory. They are useful against fumes, mists, dusts, and vapors. Their use is recommended whenever handling hazardous materials and may be required to reduce exposure to levels below applicable exposure limits. One needs to consider the chemicals and quantities used for during a process.

6.2.1.4.1 Alarm

Some fume hoods are equipped with a low flow alarm. The alarm is an indication the face velocity may be inadequate and not providing proper protection. Contact ISU IF Facilities Services Manager Ray Hart (hartray@isu.edu) with any issues.

6.2.1.4.2 Emergency Shut Off

Some buildings are equipped with emergency shut offs for the fume hood exhaust system and differ from the alarm and purge controls mentioned above. The emergency shut offs are only to be used by Facilities Operations and Maintenance (FO&M) or the fire department.

6.2.1.4.3 Certification and Maintenance

Fume hoods certification is maintained by ISU IF Facilities Services and completed on an annual basis as indicated by a sticker on the fume hood. The sticker is typically found on the side of the sash indicating the height at which it was certified.

The certification process ensures the fume hood is functioning properly and maintains a minimum face velocity measured at the sash threshold of 80 feet per minute.

The grill at the bottom of the sash threshold must be kept clear and should be inspected regularly by the laboratory. The slot should be cleaned if necessary.

Any suspected fume hood malfunctions or issues must be reported to the Laboratory Lead and ISU IF Facilities Services. Alterations must be coordinated and approved by the TSO and ISU Facilities Management (ISU FM). Any repair, relocation, or alteration requires recertification of the fume hood by ISU FM.

6.2.1.4.4 Minimizing Materials in the Fume Hood

In order for a fume hood to operate properly, adequate airflow is essential. An easy way to accomplish this is by minimizing the number and size of materials in a fume hood. Materials, such as

large equipment, supplies or chemical containers, cannot be used in a fume hood if it prevents the fume hood from functioning properly. The most common issue stems from blocking the lower baffle, which reduces adequate flow at the sash and can disrupt airflow patterns. It may be possible to elevate the materials to maintain flow to the lower baffle. For large equipment, it is generally more effective to install a specially designed enclosure so the chemical fume hood can be used for its intended purpose. Contact the CSO for assistance and assessment.

6.2.1.4.5 Sash Height

When working at the chemical fume hood, open the sash only as far as necessary to access the work area. The lowered sash helps contain contaminates in the hood and the smaller hood opening makes the hood less susceptible to room drafts and other external air disturbances. Sashes open too high can result an inadequate face velocity reducing its effectiveness. The certification sticker indicates the height at which it was tested and is the maximum working height.

When a fume hood is not in use, the sash should be completely closed.

The sash can also help protect against splashes or projectiles from chemical spills or explosions. A lowered sash does not eliminate the necessity for appropriate personal protective equipment.

6.2.1.4.6 Additional Work Practices

- Work at least six inches behind the sash threshold.
- Never put your head (or face) inside an operating chemical fume hood to check on an experiment.
- Move slowly in and around fume hoods. Also be aware opening/closing doors can disturb the airflow.

6.2.1.4.7 Perchloric Acid Use

Perchloric acid must be used in a specifically designed and dedicated fume hood with a wash down system due to potential formation and build up of explosive perchloric acid salts. The fume hood cannot be used for any other purpose especially organic chemicals.

6.3 Administrative Controls

Administrative controls consist of policies, programs, and procedures which guide work and practices to minimize exposure. CAES uses policies to outline high level objectives and requirements. For example CAES Chemical Acquisition Policy outlines the approach used to control chemicals used in CAES. Programs, such as the CHP, provide guidance on specific topics typically applying to multiple Laboratories which help guide compliance with CAES and ISU policy and regulatory requirements.

6.3.1 Laboratory Standard Operating Procedures

Laboratories must establish and maintain standard operating procedures for equipment, processes, and procedures performed in the lab. An SOP can be used to:

- Communicate to the laboratory worker the potential hazards, required hazard controls, and steps to complete a task safely and correctly.
- Satisfy regulatory requirements to document required personal protective equipment.
- Train laboratory workers in proper procedures making them consistent between laboratory workers.

SOPs may be a part of Laboratory-specific training that is properly documented with completion maintained in the Laboratory Manual.

6.3.2 Safety Information and Operating Procedures

LL and CSO develops Standard Operating Procedures (SOPs) applicable to individual or common laboratory hazards and processes. Available on the CAES portal, laboratories can use a SOP as is or modify it to conform to a lab's need. Contact CSO with SOP requests or questions.

6.3.3 Work Practices

The information in this section applies to the majority of laboratory work or work areas. Information regarding specific chemicals, chemical hazard classes, and additional hazards may be obtained from the CSO.

6.3.3.1 Prepare for Work with Hazardous Chemicals

Take the time to read and familiarize yourself with the Chemical Hygiene Plan and its appendices before handling any hazardous chemical.

1. Read the ISU Hazardous Waste Policies and Procedures Manual which contains information covering safe and proper disposal of hazardous chemicals.
2. Read applicable laboratory protocols or standard operating procedures, which should outline requirements for handling hazardous chemicals.
3. Know the nearest location of all safety equipment as well as the building's evacuation routes and meeting location.
4. Be familiar with the spill and exposure response procedures in the Chemical Hygiene Plan, the ISU Emergency Response Plan, and the Emergency Response guidance located within the lab.
5. Become familiar with the health and physical hazards of the chemicals you will be handling.
6. For extremely hazardous chemicals or procedures, consider performing a "dry" run with a manager to familiarize you with the steps.

6.3.3.2 Minimize Routine Exposure

The following are general work practices designed to minimize exposure from routine work procedures:

- Work involving hazardous chemicals should be conducted in a chemical fume hood whenever possible.
- Do not smell chemicals to determine their identity.
- Never place your head inside of a chemical fume hood to check on an experiment.
- Change gloves regularly.
- Inspect gloves for tears, cracks, discoloration, and holes before and during use.

- Release of toxic chemicals or *asphyxiants* (see def.) (e.g., chloroform, dry ice, nitrogen) in environmental rooms must be avoided. Air is recirculated in these rooms which may lead to a buildup of toxic materials or an oxygen deficient environment.
- Exhaust of an apparatus that may discharge toxic chemicals should be vented into a chemical fume hood, exhaust ventilation system, or filter.
- Storing, handling, or consuming food or beverages in laboratories, storage areas, refrigerators, environmental rooms, or laboratory glassware is prohibited.

6.3.3.3 Personal Hygiene

Personal hygiene in the laboratory can minimize exposure to hazardous chemicals. Some general guidelines for personal hygiene in the laboratory include:

- No eating, drinking, smoking, or applying cosmetics is allowed in laboratory areas. The use of contact lenses in the laboratory should be avoided in laboratory areas.
- Mouth pipetting of any substance is prohibited.
- Hands must always be washed before leaving the laboratory. Solvents must never be used to wash hands.
- Required, appropriate personal protective equipment (PPE) (e.g., lab coat, eye protection, gloves) must be worn in the laboratory whenever there is a potential for exposure to chemical or physical hazards. Please refer to laboratory specific requirements.
- PPE must not be worn in public areas such as bathrooms, offices, conference rooms, eating areas, and outdoors.
- Gloves must not be worn while touching doorknobs, light switches, telephones, or other common items unless required by the laboratory specific or standard operating procedures. Appropriate signage must indicate the PPE requirement.

6.3.3.4 Housekeeping

General guidelines for good housekeeping include:

- Areas around emergency equipment, showers, eyewashes, and exits must be kept clear.
- Areas around all circuit panels must be kept clear.
- All aisles, hallways, and stairs must be kept clear.
- All work areas should be kept clear of clutter.
- All chemicals should be returned to their proper storage area at the end of the day.
- Spills must be cleaned up promptly.

6.3.3.5 Transportation

Transportation of hazardous materials between Labs and outside of CAES must be approved by CSO. This includes, but is not limited to transportation via vehicle, cart, or person. Prior approval is required to

ensure proper containment is used, and for transportation on or across a public thoroughfare, DOT hazardous material shipping requirements must be met which may necessitate shipping papers, special labeling, packaging, placarding, or vehicle requirements.

ISU is responsible for removing hazardous chemical waste from all research laboratories. Hazardous chemical waste procedures are outlined in the ISU Hazardous Waste Policies and Procedures Manual.

6.4 Personal Protective Equipment

Personal protective equipment (PPE) is worn to minimize exposure to potential hazards and must be worn when handling hazardous materials or performing potential hazardous activities in the laboratory. Appropriate PPE is based upon the potential hazards and risks associated with those hazards. Hazards and risks can be associated with the chemicals in use, quantities, and where and how they are used. They can stem from temperatures, pressures, or mechanical action applied to a material.

Use of PPE shall only be considered after exercising all other options for reducing the hazards. Eliminating unnecessary processes and substances should be the first method used to control hazards. Engineering controls such as chemical fume hoods and glove boxes can be used to control hazards minimizing required PPE.

The Laboratory Lead for each laboratory and the PI for each project, with CSO assistance, are responsible for determining PPE requirements. PPE requirements must be documented by the laboratory in the form of either job hazard analysis or standard operating procedures.

The LL and PI must assure that appropriate types and sizes of PPE are readily available, laboratory workers are properly trained in regard to use and maintenance, and laboratory workers comply with PPE requirements.

Common laboratory PPE is discussed below. Keep in mind different or additional PPE may be required based upon the hazards and associated risks.

6.4.1 Hand and Forearm

6.4.1.1 Gloves

Gloves are required when handling hazardous chemicals or for protection from physical hazards such as against cuts, extreme temperatures, and abrasion. There is no glove currently available that will protect against all chemicals for all types of tasks. Many glove manufacturers have charts available to help determine the most appropriate glove material. Gloves come in a variety of materials, thicknesses, and cuff lengths. Glove selection must consider the chemicals in use, potential contact time, splash/splatter potential, and dexterity needs. Contact the CSO for additional guidance on glove usage.

It is recommended to change thin disposable gloves once they become contaminated or on a regular interval. In some applications, thicker gloves may be reused, but they must be inspected regularly for nicks, punctures, other damage or signs of degradation and discarded when necessary.

Lab workers must remove at least one glove before leaving the immediate work site to prevent contamination of public areas (e.g., doorknobs, light switches, telephones, etc.).

6.4.1.1.1 Latex Allergy

Latex (i.e., several protein antigens) has been shown to be a sensitizer to some individuals. Sensitization occurs over time with increased symptoms. Exposure to the latex protein is greatly increased through the use of powdered latex. The use of powdered latex is highly discouraged. If a powdered glove is desired, a powdered nitrile glove is recommended.

6.4.1.2 Tyvek sleeves

Tyvek sleeves provide greater forearm protection than a lab coat. Uncoated sleeves are fluid resistant and coated sleeves provide increased fluid protection. The sleeves must be worn over a lab coat or paired with other necessary body protection.

6.4.2 Body

Body protection may be necessary to protect against chemical splash/splatter or particulate which could cause injury or contamination of an individual or their clothing. It may also be necessary to protect a work area from outside contamination (e.g., clean room).

6.4.2.1 Lab Coat

A long-sleeved laboratory coat must be worn whenever infectious, chemical, or radioactive hazards exist assuming a similar or more protective level of PPE is not required. A lab coat, though not impervious, provides some protection against contact and contamination. Tyvek lab coats or coveralls may also be a suitable option and may offer added convenience since they are disposable.

Contaminated lab coats must be immediately removed and laundered or disposed of properly. Laundering must be done through a commercial laundry service. Home laundering is prohibited. Contact the CSO for available commercial services.

6.4.2.2 Chemical Resistant Apron

Some chemicals or activities may require protection beyond a lab coat's capabilities due to splash/spatter potential and the hazardous chemical properties. It is important to select an apron compatible with the chemical in use and an appropriate thickness for adequate protection.

6.4.3 Eyes/Face Protection

The most common types of eye and face protection consist of safety glasses, safety goggles, and face shields. Each serve their own purpose, but all of them must meet requirements outlined in American National Standards Institute (ANSI) Z87.1. "Z87" must be imprinted on the equipment indicating it meets proper specifications.

6.4.3.1 Safety Glasses

Safety glasses must be worn, at a minimum, when handling hazardous materials or where there is the potential of flying particulate. They must have side shields for added protection. They are adequate for handling small quantities of moderately hazardous materials with limited splash/spatter potential or materials of low hazard and flying particulate.

Regular prescription glasses have not been determined to meet the Z87.1 requirements. Over-the-glasses (OTG) safety glasses are available which fit over most prescription lenses and frames. A number

of retailers offer prescription safety glasses. The frames are marked with Z87 and are fitted with polycarbonate lenses. Side shields are required and typically snap on the bows.

Visitors must wear safety glasses while work is underway in the laboratory. Visitors closely observing or participating in processes must wear all required PPE for the process.

6.4.3.2 Safety Goggles

Safety goggles must be worn when handling liquid hazardous materials with the potential for splash/spatter, volatile hazardous materials, and concentrated acids or bases. Goggles fit tightly to the face minimizing liquid and vapor contacting the eye area. Vented and non-vented models are available. Vented goggles have some slits which reduces fogging but increases contact potential. Non-vented goggles fog easier but provide greater protection. An anti-fog coating is an important feature. Most prescription glasses fit under standard safety goggles.

Goggles provide better protection against large amounts of particulate and liquids compared to safety glasses.

6.4.4 Face Shield

A face shield helps protect the users face from splashes and flying particulate. A face shield is only considered supplementary eye protection so safety glasses or goggles must also be worn underneath.

6.4.5 Leg and Foot

CAES laboratories require leg protection such as long pants or similar clothing when handling hazardous chemicals or corrosive, cryogenic or highly toxic liquids to minimize chemical contact with exposed skin. Leg protection beyond regular clothing may be required for protection from hazards such as molten metal, heat, and cutting hazards. Substantial footwear is to be worn for all work performed in laboratories.

6.4.6 Respiratory Protection

Currently, no work requiring respirator use is allowed in CAES. Respirator use requires training, medical clearance, and fit testing as outlined in the Respiratory Protection Program. Respirators are not to be used in any area without prior approval of CSO. Contact CSO for additional information.

6.4.7 Additional Considerations

Additional or a different type of PPE may be necessary dependent upon the laboratory and associated activities. Each Laboratory shall designate minimum PPE for entry to work areas and include it in the Laboratory Manual.

Contaminated PPE must be decontaminated or properly disposed. Contaminated PPE may require classification as hazardous waste. Please refer to the Hazardous Waste Management Policies and Procedures Manual or contact CSO.

Foot protection, at a minimum, must consist of (impermeable?) closed toed shoes covering the top and sides of the foot. Sandals and open toed shoes are prohibited. Additional foot protection may be required such as steel toe, leather, or slip-resistant shoes.

7. EMERGENCY RESPONSE

CAES and ISU outline emergency response policy and procedures in the Emergency Response Plan which includes Emergency Response Instructions. Emergency responders can be reached by dialing 911 or contacting Security at (426-1453 need to update this number for CAES). These numbers must be posted near a laboratory phone and on the corridor door.

All emergency response activities must be reported to your supervisor and ES&H.

7.1 Emergency Equipment

In any emergency, it is critical that all staff members are familiar with the use and location of all emergency equipment. This includes fire extinguishers, fire alarms, safety showers, eyewash stations, first aid kits, and chemical spill kits.

All emergency equipment shall be on a preventive maintenance schedule. Fire alarms are tested periodically, and extinguishers are inspected monthly. ISU Facilities tests safety showers and eyewash stations monthly unless laboratories have arranged for self-testing. Laboratories (managers/leads/PI's—should specify who and if this requires documentation??) are responsible for activating their eyewashes and showers weekly.

7.2 Seeking Medical Treatment

7.2.1 911

911 should be contacted for a serious medical emergency. If you are unsure of the seriousness of the situation, make the call. If emergency responders are deemed necessary, they will respond to the scene and assess the situation. Always follow up a 9-911 call with a call to 9-282-2515 (ISU Public Safety).

7.2.2 Emergency Room or Additional Care

Any person requiring medical attention where emergency responders or their transport are not necessary should notify their PI, manager, LL, or CSO, and seek care in accordance with their home organization policies.

7.3 Chemical Exposure

The treatment of a chemical exposure takes precedent over spill cleanup, spill containment, or property damage including water damage from the use of an eyewash or safety shower.

If possible, obtain assistance to remove contaminated PPE and clothing and contact emergency responders if necessary.

Laboratories have disposable coveralls for use in case a laboratory worker's clothes become contaminated.

7.3.1 Eye Contact

Eyes must be promptly flushed with water using an eyewash for 15 minutes following contact with any chemicals. The eyes should be held open as much as possible. Medical help should be sought immediately after flushing.

7.3.2 Skin Contact

The affected areas must be immediately flushed with water for 15 minutes. Once the flushing has started, contaminated PPE and clothing must be removed. Medical attention should be sought immediately after flushing.

7.3.3 Inhalation/Ingestion

Immediately contact emergency responders for guidance.

7.3.4 Contaminated sharps injury

The affected areas must be immediately flushed with water for 15 minutes. Once the flushing has started, contaminated PPE and clothing must be removed. Medical attention should be sought immediately after flushing.

7.4 Chemical Spill

7.4.1 Small Spill

A small spill is defined as a spill less than or equal to 200 mL, not an extremely hazardous substance, and within the capabilities and comfort level of the responder and laboratory. If you are not sure or uncomfortable with the clean up, contact your PI, LL or CSO for assistance.

- Inform others in the area of the spill.
- Turn off any gas burners without putting yourself in harm's way.
- Retrieve MSDS without putting yourself in harm's way.
- Review applicable MSDS and determine controls, PPE, and need for assistance.
- Put on necessary protective clothing (gloves, safety goggles or glasses, and lab coat).
- Cover small spills with absorbent towels.
- Clean spill area working from outside toward the center.
- Rinse spill area with water.
- Label and retain spill materials for CSO.
- Contact your PI and CSO and complete a Spill Investigation Report.

7.4.2 Large Spill

A large spill is a spill greater than 200 mL, any amount of an extremely hazardous substance, or beyond the capabilities or comfort level of the laboratory.

- Inform others in the area of the spill.
- Turn off any gas burners without putting yourself in harm's way.
- Retrieve MSDS without putting yourself in harm's way.
- Evacuate the area.

- Close doors behind you.
- Immediately call 911 if necessary or if unsure of the severity. You may also pull a fire alarm. Always follow up a 9-911 call with a call to 9-282-2515 (ISU Public Safety).
- Contact the LL and PI.
- Post warning outside the area and lock doors if possible to prevent re-entry.
- Complete a Spill Investigation Report.

8. CHEMICAL STORAGE

Chemicals must always be stored in an appropriate manner to ensure safety in the laboratory. The following are guidelines for appropriate chemical storage:

- Incompatible chemicals must be segregated.
- Hazardous materials must not be stored above eye level.
- Chemicals must be stored in compatible containers.
- Containers of time-sensitive chemicals (e.g., peroxide formers) which result in an increased risk must be dated upon receipt, again upon opening and disposed in accordance with ISU Hazardous Waste Policies and Procedures Manual.
- Refrigerators or freezers used for flammable liquid storage must be designed, labeled, and rated for flammable liquid storage.
- Chemicals are stored within a secondary storage system with enough volumetric capacity to contain the materials should they spill. The secondary storage system must be composed of materials that are impervious and not-reactive with the chemicals stored within.

8.1 Expired Chemicals

Any expired or out-of-date chemical must be properly disposed if it presents an increased safety risk over time such as peroxide formers and picric acid. The PI may choose to retain chemicals past their expiration if the chemical has no increased risk and it is properly stored. The CSO strongly recommends disposal of expired chemicals if they are not needed in the foreseeable future.

8.1.1 Time-Sensitive Expired Chemical Disposal

Failure to dispose of time sensitive chemicals prior to their expiration date (Again, how are these chemicals tracked? What is the frequency for inspection?)can result in unnecessary risk, disposal difficulty, and increased cost. Depending on the chemical and its age, testing and disposal by an outside vendor may be required. In extreme cases, an explosive ordinance disposal unit (i.e., bomb squad) may be required. Costs associated with the testing and disposal of time-sensitive chemicals beyond their expiration date is the responsibility of the PI.

8.2 Specific Storage Requirements

Specific chemical storage requirements and segregation guidelines are covered in CAES-016 CAES Guidelines for Safe Chemical Storage SOP. Contact the CSO with any questions or concerns.

9. CAES CHEMICAL ACQUISITION AND REMOVAL POLICIES

The chemical inventory of CAES will be controlled by ISU. It is important that all inventory entering or leaving the building pass through a central point of control. ISU will initially establish and as feasible, maintain a *Conditionally Exempt Small Quantity Generator Status* (CESQG) for the CAES facility. A CESQG must not generate more than 100 kg/month of hazardous waste or more than 1 kg/month of acutely hazardous waste (RCRA P-listed).

Prior to bringing any chemical compounds or associated products into CAES, the project principal investigator (PI) must be granted, by CAES, approval of the associated "work planning package" and approval of the specific quantities being requested to bring into CAES. The work planning package shall contain the following information related to chemical usage: (1) Chemical species and quantities required for the project and the quantities being requested to bring into CAES, (2) Proposed storage locations, (3) Estimated rate of hazardous waste generation, (4) Plans for disposal or removal of the chemical inventory from the CAES facility at the end of the project.

Once the planning package has been approved, the following rules apply to acquiring, bringing chemicals into the CAES facility and removal of chemicals and associated products from CAES.

- The institution responsible for the project will purchase CAES approved chemicals for the project.
- Chemicals shall be brought to a central point of contact for verification before placing them in their designated storage location. Currently that point of contact is the ISU CAES Safety Officer CSO), Todd Gansauge (ganstodd@isu.edu) phone: 533-8113.
- The ISU CAES Safety Officer will notify the laboratory lead before any chemicals are brought into their laboratory.
- The PI shall include (enter) the chemicals on the CAES chemical inventory available on the CAES portal within 48 hours of bringing chemicals into CAES.
- The transport of chemicals and related products to and from CAES is the responsibility of each project's principal investigator (PI) and their home organization. This does not apply to the removal of chemicals that have been classified as waste: waste removal is the responsibility of ISU. It is the PIs responsibility to transport chemicals and products to and from CAES in accordance with all applicable State and Federal DOT requirements, their home institution requirements, and any other applicable laws and regulations.

NOTE: *The transportation of many stock chemicals on public roadways is strictly controlled by the United States Department of Transportation; researches must be in compliance at all times with any federal or state regulations. The transport of any stock reagents in private vehicles is discouraged.*

- The PI is responsible for assuring that all individuals under their authority do not dispose of any reagent or byproduct eventually declared waste and they abide by the requirements for waste disposal specified in the ISU Hazardous Waste Policies and Procedures Manual contained in each Laboratory Manual.

- ISU is the only authorized agent in CAES to dispose of any reagent or byproduct eventually declared as waste. The official declaration of a reagent or byproduct as waste is made by ISU, not the PI. This specification is intended and necessary to assure compliance with RCRA regulations.
- Anyone disposing of any reagents or byproducts should be immediately reported to ISU authorities.
- PIs shall coordinate the removal of chemicals and products from CAES with the CAES Safety Officer. First, PIs provide a list of the chemicals and related products they plan to remove and then arrange to take ownership of the listed substances. At the time of removal, the CSO and PI will update the CAES chemical inventory and document that the PI has assumed responsibility for the safe and compliant transport of the chemicals.

Appendix A

Definitions and Abbreviations

Asphyxiants	Asphyxiants interfere with oxygen and/or availability and include the following: - **Simple asphyxiants** may not normally be dangerous (e.g., nitrogen, argon, helium, or nitrous oxide), but if present in high enough concentrations, can displace oxygen in air and cause suffocation. - **Chemical asphyxiants chemically** combine with oxygen carrying sites (carbon monoxide) or with oxygen utilization (cyanide).
Carcinogens	Carcinogens cause cancer through irreversible, uncontrolled growth of cells in an organ or tissue. It is believed that there is no known minimum dose that can remove all danger of cancer. Benzene is a known carcinogen.
Corrosives	Corrosives cause rapid death of the body cells they contact. Exposure may cause pain, burning, bleeding, and fluid loss. Corrosives include acids and bases. Due to the nature of bases and some acids, pain response may not be immediate upon exposure.
Division of Building Safety (DBS)	The Division of Building Safety is part of the State of Idaho. They provide regulatory guidelines and perform regular building safety inspections.
Health Effects	- **Acute health effects** happen immediately after a chemical exposure. Effects are generally apparent and can often be easily traced to the exposure. Acute reactions are normally short lived and may be followed by recovery, although occasionally permanent damage occurs**.** - **Chronic health effects** are not always obvious and onset of symptoms is gradual. It is much harder to trace the cause of a chronic effect, since the exposure could have been 20 – 30 years prior to the appearance of the effect.
Occupational Safety and Health Administration (OSHA)	OSHA is part of the federal government and provides regulations and assistance for work place health and safety.

Permissible Exposure Limit	OSHA and DBS regulatory limits for inhalation which may consist of: - **Time Weighted Average, 8 hour (TWA_8)** – Average concentration over **an** eight hour period. - **Short Term Exposure Limit (STEL)** – Average concentration over a 15 **minute** interval. - **Ceiling (C)** – Maximum concentration at any given time. - **Action Level (AL)** – Average concentration over a specified time Exceeding any of these levels for a chemical requires additional actions to be taken which may include additional monitoring, engineering controls, administrative controls, or PPE.
Personal Protective Equipment (PPE)	PPE is worn for protection against exposure to chemicals, projectiles, or other hazards. Examples include safety glasses, safety goggles, gloves, and lab coat. -
Reproductive Toxins	Reproductive toxins are a broad class of chemicals that can: - Affect the reproductive organs (e.g., atrophied testicles, enlarged breasts, etc.). - Affect adult sexual functions (e.g., libido, fertility, menstruation, ovulation, etc.). - Affect the offspring of males or females who were exposed by causing structural abnormality, functional deficiencies, altered growth, or death of the conceptus.
Threshold Limit Value	ACGIH recommended exposure limits for inhalation which may consist of: - **Time Weighted Average, 8 hour ($TLV\text{-}TWA_8$)** – Average concentration over an eight hour period. - **Short Term Exposure Limit (TLV-STEL)** – Average concentration over a 15 minute interval.