Chapter 13 – Chemical Hygiene Program (REDACTED)

13.1 Purpose

This document establishes minimum requirements to protect laboratory workers from chemical hazards through hazard assessment, hazard communication, training, safe work practices, and special controls for some specific hazardous chemicals.

13.2 Applicability

This manual is applicable to: (1) all Ames Employees; and (2) all persons and entities who agree in writing to comply with this manual.

For Ames contractors, it is applicable through contract clauses in conformance with NASA Procurement Regulation (**REDACTED**). Non-Ames and noncontractor personnel will follow the provisions of this chapter while at Ames facilities.

This program provides Ames Research Center policies and procedures for handling hazardous materials in laboratories. The Occupational Safety and Health Administration (OSHA) Laboratory Standard focuses on materials with health hazards. Separate requirements for compressed gasses, flammable and combustible liquids, noise exposure and radiation are contained in OSHA Subparts H and G. Bloodborne pathogens are covered by a separate standard, in Chapter 32 of this manual. This document provides guidelines for compliance with the OSHA Laboratory Standard for all laboratory operations conducted at Ames. The Chemical Hygiene Program is supplemented by workplace Laboratory Safety Plans that contain site-specific information, work practices, and control measures expressly tailored to the individual laboratory workplace.

13.3 Authority

29 CFR 1910.1450	Occupational Exposure to Hazardous Chemicals in Laboratories
29 CFR 1960	Basic Program Elements for Federal Occupational Safety and Health Programs
Executive Order 12196	Occupational Safety and Health Programs for Federal Employees
OSHA Publication 2014	OSHA Record Keeping and Reporting Guidelines for Federal Agencies
NPG 1800.1	NASA Occupational Health Program Procedures

13.4 Background

REDACTED

13.5 Definitions

Acronyms/Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ARC	Ames Research Center
CAS	Chemical Abstract Number
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Plan

Acronyms/Abbreviations

CHO	Chemical Hygiene Officer
^{o}C	Degrees Centigrade
^{o}F	Degrees Fahrenheit
ft2	Square Feet
gal	Gallon
HAZCOM	Hazard Communication
IARC	International Agency for Research on Cancer
K	Kelvin
LEL	Lower Explosive Limit
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
Ppm	Part(s) per million
SOP	Standard Operating Procedure
STEL	Short-Term Exposure Limit
TGO	Santa Clara County Toxic Gas Ordinance
TLV	Threshold Limit Value
TWA	Time-Weighted Average

Action level--an exposure level, calculated as an eight-hour time-weighted average, which initiates certain required activities, such as exposure monitoring, medical surveillance, training and record keeping.

Carcinogen--see Select Carcinogen

Chemical Hygiene Officer (CHO)--An employee designated to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan(s). Qualifications include training in industrial hygiene, chemistry, or other pertinent related fields. The Industrial Hygiene Program Manager is the Ames CHO.

Chemical Hygiene Plan (CHP)--A written plan that sets forth procedures, laboratory and control equipment, personal protective gear, and work practices that are capable of protecting employees from the hazards presented by hazardous chemicals used in a particular laboratory workplace.

Chemical Inventory--a written or electronic record of chemicals used in a laboratory, by container, which includes the chemical name of all ingredients, CAS number(s), manufacturer, size of container, owner, and location. See Chapter 24, Chemical Hazard Communication (Ames HAZCOM), for specific information on the Ames inventory procedures.

Corrosive Material--Any solid, liquid, or gaseous substance that attacks building materials and metals, and burns, irritates, or destructively attacks organic tissues (mostly notably the skin, lungs, or stomach when taken internally).

Cryogenic Fluids (cryogens)--Elements and compounds that vaporize at temperatures well below room temperature. Most common cryogens have a normal boiling point below approximately 120K. Helium (4.2K), hydrogen (20K), nitrogen (77K), oxygen (90K), and methane (112K) [normal boiling point temperatures in parentheses] are examples of cryogens. Note that the cold vapor of solid carbon dioxide (sublimation temperature of 195 K at one atmosphere) can be considered a cryogenic fluid.

Designated Area--A laboratory, laboratory area, or device such as a fume hood where "select carcinogens," known human reproductive toxins, or substances with a high degree of acute or chronic toxicity are used. A designated area may be the entire laboratory, an area within the laboratory, or a device such as a laboratory-type hood.

Genotoxin--a toxin that can interact with and alter genetic material.

Hazardous Chemical--Any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or environment if released into the workplace or the environment. If hazardous chemical comprises 1% (0.1% for carcinogens) or greater of a compound or mixture, the compound or mixture must be treated as a hazardous chemical.

Health Hazard--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. Categories of health hazards include:

- Carcinogens
- Toxic or highly toxic agents
- Reproductive toxins
- Chemical asphyxiant
- Irritants
- Corrosives
- Sensitizers
- Chemicals that cause effects in organs (e.g. liver, lungs, kidney, central nervous systems, blood, eyes, skin or mucous membranes)

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

Laboratory--A facility in which research or analytical chemical procedures are performed, where hazardous materials are stored and used in quantities that may easily be handled by one person (container sizes do not exceed five gallons); a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

Laboratory use--means chemical manipulations are carried out on a laboratory scale (containers for reactions, transfers, and other handling can be easily and safely manipulated by one person); multiple chemical procedures or chemicals are used; and procedures involved are not part of a production process, nor do they in any way simulate a production process.

Laboratory Safety Plan (LSP)--contains information about each laboratory operation, the hazards present, hazards/exposure assessment, hazard control measures, PPE required, identification of "particularly hazardous substances" used and the location of the designated area, operation-specific training, and employee responsibilities.

Material Safety Data Sheet (MSDS)--Written, printed or electronically transmitted information on the hazards and properties of a particular material, including instructions for its safe use. See the Code Q website for several links.

Organic Peroxides and Peroxide Formers--Organic peroxides are a special class of compounds with unusual stability problems (stability can be significantly affected by age and contamination). They may be (or become) sensitive to shock, heat, sparks, or other forms of accidental ignition. Some compounds such as ethers auto-oxidize in the presence of oxygen and light to form peroxides.

Particularly Hazardous Substances--Select carcinogens, genotoxins, reproductive toxins, and compounds with a high degree of acute toxicity. For work with Particularly Hazardous Substances, the Laboratory Safety Plan shall include the operating procedures and appropriate precautions for identified hazards.

Permissible Exposure Limit (PEL)--Limit established by OSHA usually expressed as an 8-hour Time Weighted Average (TWA), meaning an airborne contaminant concentration that shall not be exceeded for and 8-hour work shift of a 40 hour work-week. Exposure limits for many hazardous materials are listed in 29 CFR 1910.1000.

Personal Protective Equipment (PPE)--Includes chemical and thermal resistant gloves, safety glasses, goggles and face shields, aprons, respirators, earplugs and muffs, etc.

Physical Hazard--the following categories are included:

- Combustible liquid
- Compressed gas
- Cryogen
- Explosive material
- Flammable material
- Oxidizer
- Organic peroxide
- Pyrophoric material
- Asphyxiant
- Unstable or reactive material
- Water-reactive material

Prudent Practices--Recommended guidelines for storage and use of hazardous materials, cited in 29 CFR 1910.1450, based on the National Research Council text Prudent Practices for Handling Hazardous Chemicals in Laboratories, 1981, and the updated text, Prudent Practices in the Laboratory, Handling and Disposal of Chemicals, 1995, National Academy Press, Washington, D.C.

Pyrophoric--A substance that is so rapidly oxidized by oxygen or the moisture in air that it ignites (spontaneous combustion).

Reproductive toxin (known human)--substances that are known to cause adverse effects on the reproductive system, have lethal effects on the fertilized egg developing embryo or fetus, or to cause malformation in the fetus (teratogenesis).

Safety Hazard--Any condition, action, or situation that may result in bodily injury.

Secondary Container--Any chemical container other than an original container that will be used by more that one person or will be used beyond a single workday. This definition should not be confused with secondary containment for chemical release prevention or control.

Select carcinogen--A substance that is strongly implicated as a potential cause of cancer in humans. Select carcinogens meet one of the following criteria:

- OSHA regulates it as a carcinogen.

- It is listed as "known to be a carcinogen" in the latest Annual Report on Carcinogens issued by the National Toxicology Program (NTP)
- It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC).
- It is listed under IARC Group 2A ("probably carcinogenic to humans") or 2B (possibly carcinogenic to humans) or under the category "reasonably anticipated to be a carcinogen" by the NTP, and causes statistically significant tumor incidence in experimental animals in accordance with published criteria.

Short-term exposure limit--a limit usually defined as a 15-minute time-weighted average.

Threshold Limit Value (TLV-TWA)--the exposure limit (established by American Conference of Government Industrial Hygienists), expressed as a time-weighted average airborne "concentration for a normal 8-hour workday and a 40-hr. work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect."

Toxic--The ability of a material to injure biological tissue.

Toxicity--The adverse effects resulting from a dose of, or exposure to, a material.

Training--A documented, organized presentation of information fulfilling educational objectives and regulatory requirements.

13.6 Responsibilities

13.6.1 Ames Chemical Hygiene Officer

REDACTED

13.6.2 Line Management/Supervisors (all levels)

REDACTED

13.6.3 Principal Investigator/Laboratory Chemical Hygiene Officer

REDACTED

13.6.4 Ames Health Unit

The medical staff at the Ames Health Unit responds to requests for consultation, examination and evaluation, emergency treatment, and medical monitoring for NASA Ames Research Center personnel who work with or may be exposed to hazardous materials. Responsibilities include:

1. Perform medical consultations and medical examinations, as well as provide written medical opinions as specified in 29 CFR 1910.1450, or other OSHA/NASA regulations, as appropriate.
2. Establish and maintain appropriate medical records covering the consultations and examinations (including tests and written opinions) and records of exposures to hazardous chemicals.
3. Inform each employee of the results of any examination/test given.

Note: Except for emergency treatment, contractors must see their own medical provider.

13.6.5 Laboratory Employees

Each employee is responsible for personal safety while conducting assigned tasks with hazardous materials. Employee responsibilities include:

1. Follow safe, established work practices found in the Chemical Hygiene Program and laboratory safety plans.

2. Review the MSDSs and/or other available literature for information on the chemical being used, including: hazards, exposure limits, symptoms of exposure, PPE, and engineering controls.
3. Treat a chemical of unknown composition as a hazardous substance.
4. Keep the quantity of chemicals stored in a laboratory to the minimum needed.
5. Use required engineering controls and PPE.
6. Develop good personal chemical hygiene habits.
7. Report any concerns or observations of unsafe or unhealthy working conditions to the supervisor or to the Ames Safety Division.
8. Attend safety-training classes.
9. Report to the supervisor any ill effects experienced and seek medical consultation at the ARC Health Unit if health effects are experienced during working hours.

13.6.6 Contracting Officer's Technical Representative (COTR)

REDACTED

13.7 Chemical Hygiene Plan

This section describes the policies and programs that implement the OSHA Laboratory Standard at Ames. Laboratory operations are conducted with minimal risk when each laboratory worker and supervisor develops an attitude of habitual risk assessment and implements appropriate protective measures prior to undertaking any hazardous operation. Organizations may implement specialized chemical hygiene plans for their own operations, as long as the requirements of the Ames CHP are met. Each laboratory must have a Laboratory Safety Plan to complete their laboratory-specific Chemical Hygiene Plan. Directorate and/or branch managers are encouraged to appoint their own CHO or chemical hygiene committee to provide assistance to directorate/branch personnel. The updated National Research Council text, Prudent Practices in the Laboratory, published by the National Academy Press, is adopted as Ames laboratory general procedures (See Appendix B).

13.7.1 Standard Operating Procedures

Each laboratory maintains a Laboratory Safety Plan that identifies unique operations, hazards, and responsible persons as a site-specific supplement to this Chemical Hygiene Plan. Particular attention should be given to control measures for operations that involve the use of select carcinogens or acutely toxic chemicals.

The Laboratory Safety Plan for each laboratory must contain laboratory-specific information about the facility, responsibilities, evaluation of hazardous operations (this can be used to document both the hazard assessment and the PPE assessment), PPE, and documentation of control measures. Standard Operating Procedures that contain safety instructions and precautions for hazardous operation should be included or their location referenced. The Ames Chemical Hygiene Officer can assist researchers in developing safety procedures for specific hazards. Laboratory plans are reviewed/updated annually, or whenever a new hazard is introduced into the workplace. Related environmental records, including spill logs and hazardous waste accumulation area inspection logs, are discussed in the Ames Environmental Procedures and Guidelines APG 8800.3.

Suggested Outline

1. Name of Facility/Operation
2. Location (building/room)
3. Definition of Work: Explain your project clearly and concisely, include a description of operation and processes.

4. Identify the principal hazards/exposures: See Appendix A for an optional screening tool. It can be used to document the presence/absence of hazardous operations. Contact the Ames Chemical Hygiene Officer for assistance in evaluating/monitoring chemical exposures.

   Evaluate the risk to the employee from the hazards present and describe the control measures. See Appendix D: Laboratory Risk Assessment, for additional information.

   Example:

Hazard/Exposure	Hazard Scenario	Risk	Control Measures
Describe the major hazards/exposure present	Describe how the employee could be exposed to the hazard	Discuss the risks based upon the hazard and the hazard scenario	Describe how the employee will be protected from the hazard and the risk of injury/illness minimized (i.e. engineering controls to be used, PPE to be worn, training to be received, etc)

5. Laboratory-specific rules, procedures, and controls (see Appendix B). These are based upon the hazards/exposures identified.

   Examples:

   - Materials that require special fire-fighting procedures (e.g. reactive metals)
   - Location of hazardous chemical and flammable storage cabinets
   - Labeling requirements for secondary containers and for laboratory-generated chemicals
   - Laboratory-specific training
   - Location of electrical panels serving the laboratory
   - Location of health and safety references
   - Location of equipment operating manuals and other documents
   - Description of engineering control equipment (i.e. chemical fume hoods, Biosafety cabinets, etc.) and approved activities for the equipment
   - When personal protective equipment is kept and when it is used
   - Location of spill kit
   - Location of emergency equipment (i.e. eyewash, shower, oxygen deficiency alarm, toxic gas alarm, etc.) and emergency procedures
   - Discussion of satellite waste storage areas

6. Standard Operating Procedures for work with "Particularly Hazardous Substances" or other high hazard operations (see Appendices C and F for additional information):

   - Special maintenance and repair issues,
   - Special training requirements and restrictions,
   - Personnel access (e.g., designated areas for use of "Particularly Hazardous Substances"),
   - Special emergency procedures (shut down, etc.)

7. Responsible Individuals (name, organization, ARC extension)

8. Inspection Schedule

9. Waste accumulation and disposal procedures

10. Attachments (adds as applicable):
    - Chemical Inventory
    - Training Records
    - Inspection Records
    - Composition of Laboratory-Generated Chemical Mixtures
    - Project permits (radioisotope, laser, controlled drug, confined space, etc.)

13.7.2 Control Measures

Control measures are required whenever potential health effects or other operational hazards exit. MSDSs or other reference materials can be used to identify these hazards. See the Code Q website for several links. Control measures, in order of preference, include:

- Substitution: use a less hazardous chemical or perform a less hazardous operation.
- Engineering controls: equipment which reduces the hazard; e.g. local exhaust ventilation, ground fault circuit interrupter, sharps controls, securing large compressed gas bottles with chains. Example: Volatile compounds with permissible exposure limits of less than 50 ppm must have local exhaust ventilation.
- Administrative controls and work practices: laboratory rules and standard operating procedures which if followed will reduce employee risk; employee training must be provided as part of the administrative controls.
- Personal Protective Equipment: worn by an employee to provide protection against hazards present; e.g. safety glasses, chemically resistant gloves. Considered to be the least desirable control measure. OSHA requires a written PPE assessment. The hazard/exposure assessment shall be documented in the Laboratory Safety Plan. The PPE hazard assessment process is described in Chapter 33 of the Ames Health and Safety Manual.

Control and protective measures, including PPE and training in both the hazards and appropriate use of PPE, must be provided before the work is begun, and documented in the Laboratory Safety Plan. MSDSs are a primary resource for information relevant to determining appropriate engineering controls, PPE, and special work practices. Factors considered include:

- Degree of toxicity. Example: A highly toxic gas such as hydrogen cyanide will require more ventilation control than a simple asphyxiant.
- Exposure potential. Inhalation and skin absorption are the primary routes of occupational exposure. Injection sometimes occurs when needles or other sharp implements are present. Engineering controls and PPE can reduce the exposure potential. Work practices can eliminate the risk of ingestion.
- Chemical procedures (quantities and techniques). Example: micro-volume procedures require fewer controls and present less risk to employees than high volume operations.
- Effectiveness of laboratory general rules to control employee exposures. Example: If a laboratory normally handles chemicals for plant fertilizer, the introduction of a toxic metal powder (such as manganese) would require a re-evaluation of the work practices, engineering controls, and PPE. Additional local exhaust might be required.

On request, the Ames Chemical Hygiene Officer conducts industrial hygiene review and consultation for operations with hazardous materials.

13.7.3 Laboratory General Rules

General Laboratory Practices: The exposure to hazardous chemicals in the laboratory shall be controlled through the use of good general laboratory practices, standard operating procedures specific to an individual laboratory or department, engineering controls, and personal protective equipment.

Laboratory General rules, based on recommended Prudent Practices are the primary guidelines for ensuring that laboratory exposure to chemicals is maintained below the permissible limits (see appendix B for additional information). Four fundamental principles apply to all laboratory operations:

Plan ahead: Substitute a chemical of lower toxicity and reduce quantities, when possible.

Minimize exposure to chemical: Use fume hoods to prevent exposure to airborne chemicals and avoid skin contact by using the correct personal protective equipment. All volatile, hazardous compounds shall be handled in an approved chemical hood. Alternative engineering controls should be discussed with the Ames Chemical Hygiene Officer. Always wear gloves when any skin contact is possible. Check the glove manufacturer's recommendations to determine the correct glove composition type. No one type of glove will protect against all chemicals.

Do not underestimate risks: Treat substances of unknown toxicity as toxic substances and assume that any mixture will be more toxic than its most toxic component.

Be prepared for accidents: Keep co-workers informed of hazardous activities and know what to do in the event of a hazardous material release. Maintain spill control supplies to contain any reasonably anticipated release.

Specific laboratory practices: Any deviations from general laboratory rules that are necessitated by experiment requirements should be documented in the Laboratory Safety Plan with an explanation of the circumstances (see next section).

Personal Protective Equipment: Personal protective equipment will be available to laboratory workers for use to reduce exposures to hazardous chemicals in the laboratory. Common personal protective equipment such as goggles, gloves, face shields, and aprons are recommended for use with hazardous chemicals. The Ames Chemical Hygiene Officer can assist in the proper selection, use, and care of personal protective equipment. Personal protective equipment will be readily available and most equipment is provided at no cost to the employee.

Other: Other control methods that will be used to determine and reduce employee exposures to hazardous chemicals in the laboratory may include exposure monitoring, testing eyewash and emergency shower facilities, and developing emergency procedures.

13.7.4 Special Controls for Working with Particularly Hazardous Substances

The OSHA Laboratory Standard has special provisions for work with known human carcinogens and other substances that are defined as Particularly Hazardous Substances (see Appendix C for additional information). Research involving the use of particularly hazardous substances, such as select carcinogens, reproductive toxins or acutely toxic chemicals may require prior review to ensure adequate controls are in place which will protect the worker. Refer to the MSDS and Select Carcinogen list for toxicity information. Upon request, the Ames Chemical Hygiene Officer will assist with the review and make recommendations for additional employee protection.

The following elements must be documented, reviewed, and approved by the supervisor before work begin:

- Establishment of a designated area. The area can be a single hood, a portion of a room or the entire laboratory. Identify the area in the laboratory safety plan.
- Use of containment devices such as fume hoods or gloves boxes. Specify the hood location and number.
- Procedures for safe accumulation and removal of contaminated waste.
- Decontamination procedures. Refer to the MSDS or contact the Ames Chemical Hygiene Officer for information.
- Leak detection systems.

The provision for additional controls may require the expertise and recommendations of various groups including the Safety Division, Facilities Engineering, and technical committees. All additional provisions for work with particularly hazardous materials must be incorporated into the standard operation procedures for those materials. Appendix G contains an example SOP.

Guidelines for working with substances of high toxicity, flammable substances, highly reactive or explosive chemicals, biohazardous materials, and compressed gases are published in references such as the National Research Council publication Prudent Practices in the Laboratory. OSHA regulations for work with compressed gases and flammable and combustible liquids are contained in 29 CFR 1910 Subpart H. In addition, the Santa Clara County Toxic Gas Ordinance (TGO) contains additional requirements for regulated gases that discussed in the Ames Environmental Procedures and Guidelines, APG 8800.3, Chapter 23-Toxic Gas Management Procedures.

Persons with any questions about safe practices should consult these reference materials and the Safety Division.

13.7.5 Exposure Assessment and Monitoring

Routine employee exposure monitoring of airborne concentrations is not usually warranted or practical in laboratories because chemicals are typically used for relatively short time periods and in small quantities. Also, all volatile, hazardous compounds shall be handled in an approved chemical hood. Correct PPE, particularly gloves, shall be worn when any skin contact is possible. Whenever these conditions are met, there is no reason to believe that exposure levels will routinely exceed the action/occupational exposure limit, and routine monitoring will not be required. The Ames Chemical Hygiene Officer will arrange for monitoring upon request from the employee or the principal investigator/laboratory chemical hygiene officer.

Sampling may be appropriate when a "Particularly Hazardous Substance" is used regularly (3 or more separate handling sessions per week), used for an extended period of time (greater than 2 to 4 hours at a time), or used in especially large quantities. Notify the Ames Chemical Hygiene Officer if you are using a highly toxic substance in this manner.

The exposures of laboratory employees who suspect and report that they have been over-exposed to a toxic chemical in the laboratory, or are displaying symptoms of overexposure to toxic chemicals, will also be assessed. The assessment will initially be qualitative and, based upon the professional judgment of the Ames Chemical Hygiene Officer, may be followed up by specific quantitative monitoring. A memorandum, or report, documenting the assessment will be sent to the employees involved and their supervisors within fifteen days of receipt of the results.

Individual concerns about excessive exposures occurring in the laboratory should be brought to the attention of your supervisor or the Laboratory Chemical Hygiene Officer immediately.

13.7.6 Administrative Controls and Prior Approval

Laboratory management is encouraged to contact the Safety Division for industrial hygiene and occupational safety review prior to the initiation of new hazardous operations. Safety Division personnel can assist in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation. The principal investigator/laboratory chemical hygiene officer or person responsible for the work should identify high hazard types of activities, and any type of approval process should be addressed in the laboratory or Code operating procedures. The Ames Chemical Hygiene Officer will assist in providing information to researchers about work with select carcinogens, highly toxic gases, and other high hazard chemicals.

Projects with radioisotopes, lasers, controlled substances, and human subjects have special requirements for review and prior approval (see Ames Health and Safety Manual). No person performs hazardous operations without the supervisor's approval. All purchase requests for chemicals proceed through line management approval. Purchases by BankCard are subject to the cardholder's written agreement to maintain Hazard Communication and Chemical Hygiene Plan compliance.

13.7.7 Spill and Accidents

Each person must receive task-specific training on spill and accident response. Spill control and reporting policies, procedures, and requirements are specified in the Ames Environmental Procedures and Guidelines, APG 8800.3, Chapter 3: Hazardous Materials Management.

Recommended immediate first aid actions are specified in the Building Emergency Action Plan. Any employee who may have experience a hazardous exposure due to a spill, accident, or any other circumstance should report to the Ames Health Unit for medical consultation. Information concerning the nature, amount, and circumstances of the exposure must be provided to the medical professional along with a copy of the MSDS. The Exposure Incident Description (Hazardous Chemical) provided in Appendix E should be completely by the employee's supervisor and provided to the Ames Health Unit when the employee reports for examination or consultation.

13.8 Hood Inspection and Maintenance

Chemical fume hoods are subject to annual flow measurements by the Safety Division. Sash location markers and dated calibration stickers are affixed to each fume hood. Any hood for which air velocity is unacceptable is tagged out-of-service until repaired. Fume hoods for radioisotope use meet special requirements described in the Ames Radiation Safety Guide (Radiation, APG 1700.1, Chapter 7).

Note: A current calibration sticker is not a guarantee that the hood is operating properly. For example, if personnel block the exhaust slot openings with equipment, the air velocity will be affected. Employees need to be familiar with the operation of their own hoods. If the airflow appears to fall, the Safety Division should be contacted for assistance.

13.9 Medical Consultation and Examination

The Ames Health Unit provides medical consultation and examination to Government employees with health effects from occupational exposure to chemicals. A pre-employment physical examination and/or medical monitoring is provided when physician opinion, employee concerns, regulatory requirements, industrial hygiene survey, or exposure monitoring indicate a need for medical monitoring. Each employee may review his or her personal medical records upon request.

In an emergency or for the initial evaluation of job-related chemical exposures or accidents, contractors may report to the Ames Health Unit. For routine medical treatment, contractors must report to their own medical clinic.

13.10 Employee Notification and Training

Chemical safety training is available to civil service personnel, students, and visitors. Employee training is provided:

- To all new employees
- To all employees given new job assignments for which training has not previously been received
- To supervisors (of employees handling hazardous materials)

Before using hazardous materials, laboratory employees and supervisors must have completed Ames Chemical Hygiene Plan training. Supervisors must provide laboratory/task-specific training to all employees. Additional safety and environmental compliance classes provide by the Safety Division are required for most laboratory employees. Contact the Safety Division for additional information. Contractors are required to provide/arrange for equivalent training for their employees; they may attend Ames Safety Training classes on a space available basis.

13.10.1 OSHA Laboratory Standard and Ames Chemical Hygiene Plan

Classes on the Ames CHP are available from the Safety Division. Copies of the OSHA Standard are available from the Safety Division and the OSHA website. This Plan and updates are maintained as part of the Ames Health and Safety Manual on the Safety Office Web site.

13.10.2 Laboratory-specific Training

Individual On-the-Job Training. The Principal Investigator/Laboratory Chemical Hygiene Officer is responsible for ensuring that laboratory workers have sufficient training to work safely before allowing them to work in his/her laboratory. Initial and follow-up training for laboratory workers must be documented on training records maintained with the Laboratory Safety Plan. The employees should receive training on:

- All hazards to which they may be exposed in the operations that they will perform, both routine and emergency situations;
- Details of the Laboratory Safety Plan including applicable prudent practices;
- The signs and symptoms associated with exposures to the hazardous chemicals that they are handling;
- The methods and observations that may be used to detect the presence or release of a hazardous chemical (i.e. visual appearance or odor);
- The location and availability of reference material on hazards; (note: this can include, but is not limited to, MSDSs);
- Specific laboratory provisions for storage and handling of materials and disposal of hazardous waste chemicals;
- Standard Operating Procedures for "Particularly Hazardous Substances";
- Any specialized laboratory operations;
- Safe work practices and techniques and be able to show proficiency;
- The selection and use of designated PPE;
- Manufacturer's instructions for tools and equipment;

- Foreseeable emergencies;
- Decontamination procedures; and
- Inspection requirements.

13.10.3 Occupational Exposure Limits (OEL)

Supervisors and laboratory employees must be informed of current exposure limits for materials used in the laboratory. The most restrictive published limit should be used as the guide when establishing exposure controls. The exposure limit used by Ames is the lower of the OSHA Permissible Exposure Limit or the ACGIH Threshold Value. Sources for exposure limits include:

- OSHA Air Contaminants Standard 29 CFR 1910.1000
- Substance specific standards
- NIOSH Pocket Guide to Chemical Hazards (U.S. Department of Health and Human Services)
- ACGIH Threshold Limit Values and Biological Exposures Indices (available from the Safety Division, listed on the MSDS or can be purchased from ACGIH)

Many chemicals do not have any exposure limits. If no toxicity information is available, the chemical must be considered to be toxic. Contact the Ames Chemical Hygiene Officer for assistance.

13.11 Chemical Procurement, Distribution, Storage, and Waste Disposal

The acquisition of chemicals must follow the policies and procedures described in the Chemical Hazard Communication Plan, Ames Health and Safety Manual, Chapter 24). Amounts of chemicals stored in laboratories should be as small as possible. Storage on bench tops and in hoods is inadvisable. Toxic materials must be segregated in a well-ventilated area with local exhaust ventilation. Chemicals must be segregated by hazard class. Non-compatible chemicals need to be separated by location (e.g. separate cabinets) or kept in secondary containment. Chemical storage regulations are discussed in detail in the Ames Environmental Procedures and Guidelines, APG 8800.3. Chemical compatibility guidelines are referenced in Appendix E.

For ARC policies and procedures on waste accumulation and disposal, refer to Ames Environmental Procedures and Guidelines, APG 8800.3, Chapter 3, Hazardous Materials Management and Chapter 4, Hazardous Waste Management.

13.12 Recordkeeping

Because records relative to Chemical Hygiene are subject to a variety of uses, inspections, and audits, the primary responsibilities for records are scattered. However, the laboratory itself is the location where copies of all except private or sensitive information will reside.

13.12.1 Laboratory Safety Plans

The Laboratory Safety Plan and its attachments shall be available in each laboratory.

13.12.2 Medical Records

The Ames Health Unit maintains personal medical records, including medical monitoring. Reports of exposure monitoring are provided to involved personnel, the Safety Division, and, in the case of documented chemical exposure, to the Ames Health Unit. The Safety Division maintains exposure-monitoring records.

13.12.3 Reports of Unsafe or Unhealthy Working Conditions

The Safety Division maintains records and reports of safety task orders that result from reports of unsafe or unhealthy working conditions. Laboratory workers are encouraged to maintain observation logs for any recurring, transient, or suspect condition in order to facilitate identifying the source of the problem. Any condition that appears to be an immediate health risk must be reported to the supervisor, the Safety Division, and 911 immediately. Hazards can also be reported on the Code Q website.

13.13 Related Programs at ARC

Operations in chemical laboratories are subject to many programs, in addition to Chemical Hygiene, which provide for safety in areas related to use of hazardous materials. The procedures and policies listed below complement and coordinate with implementation of the chemical hygiene plan.

Chemical Hazard Communication Plan	APG 1700.1, Chapter 24
Radiation Safety Guide	APG 1700.1, Chapter 7
Nonionizing Radiation Safety Guide	APG 1700.1, Chapter 8
Respiratory Protection	APG 1700.1, Chapter 28
Bloodborne Pathogens Protection	APG 1700.1, Chapter 32
Confined-Space Entry Program	APG 1700.1, Chapter 26
Hazard Assessment and Personal Protective Equipment	APG 1700.1, Chapter 33
Environmental Management	Ames Procedures and Guidelines, APG 8800.3

13.14 Review and Update

This Chemical Hygiene Program Plan will be reviewed annually by the Safety Division. The document may be updated by attachments issued as Interim Policy Statements. Revisions will incorporate new regulatory requirements and substantially modified procedures initiated since the previous update. The checklist is Appendix G may be used to assess implementation of this program.

13.15 Appendices

13.15.1 Appendix A: Hazard Screening Tool for Laboratory Operations (Not Mandatory)

Directions: This screening tool can be used to document the hazard identification process. The questions are intended to help identify the hazards present or absent in the laboratory. The Laboratory Safety Plan must describe the hazards present and the means of controlling those hazards.

Ionizing and Non-Ionizing Radiation

Y	N	Does this operation involve...
		Any radiation generating equipment?
		Radioactive materials (including sealed sources and wastes) being generated, processed, used, or stored?
		The use of lasers?
		Any non-ionizing radiation sources NIR?
		Example of this would be: Permanently installed Radio Frequency Microwave (RFMW); Induction heaters; Any equipment that would expose personnel to high levels of sub-radio frequency electric or magnetic fields; or Any equipment that would expose personnel to high levels of Visible Light and Near Infrared, Infrared, and/or Ultraviolet (UV) radiation

Chemicals

Y	N	Are there...
		Any chemicals or toxic materials (including wastes) handled, stored, or generated in this operation?
		Is the chemical inventory current and accurate?
		Is toxicity information (Material Safety Data Sheets can be used) available for all chemicals?
		Is this workplace a laboratory that uses chemicals in "laboratory-scale" operations as described in the Ames Chemical Hygiene Plan (CHP)?

***If the answer is NO to the above question, then the workplace falls under the hazard communication standard.

Please check the Material Safety Data Sheet or other reference for information on each specific chemical and fill-out the next table.

Y	N	Are any chemicals handled or generated...
		"selection carcinogens"?
		"particularly hazardous substances"?
		Pyrophoric?
		Peroxide forming chemicals, shock sensitive chemicals or picric acid?
		Toxic or highly toxic gases?
		Flammable or combustible gases, liquids or solids?
		Oxidizer?
		Sensitizer?
		Water-reactive?
		A volatile organic compound?
		Caustic/corrosive?
		Reproductive hazards
		Cryogens?

Y N Does your operation involve...

Any tasks where chemicals are mixed that will create an explosive mixture?

A hazardous exothermic chemical reaction? (example: polymerization)

A hazardous endothermic chemical reaction? (example: phrolysis)

Potential for skin absorption of toxic chemical/wastes? (PPE)

The transportation of chemical over public road?

Biological

Y N Could a worker be exposed to any biological hazard including the handling of human body fluids or human tissues?

Is recombinant DNA used?

Are NIH?CDC regulated agents requiring

Biosafety level of 2 or greater used? See www.edc.gov for more information

Is any animal-handling required? See www.cdc.gov for more information

Physical

Y N Is there any...

Electrical equipment used in the operation?

Electrical equipment NOT listed on the Nationally Recognized Testing Laboratories list?

Electrical equipment built locally involved?

Work done on or near exposed conductors?

Potential mechanical energy or mechanical hazards such as motors, pulleys, machinery/shop equipment, forklifts, or hoists and cranes present in this operation?

Handling, processing, use, or storage (including waste) of explosives?

Any source of thermal hazards, other than commercially available units that are less than 1° C (30°F) or greater than 54°C (130°F)?

Pressure source (positive or negative) to be considered (i.e. compressed gas cylinders, pressure vessels, hydraulic systems, vacuum systems, etc.) in this operation?

Are there any sources of excessive noise (e.g., such that you have to shout at a distance of 3 feet to communicate to a coworker or louder than busy traffic) involved in this operation?

Does this operation include any space that might meet the definition of a confined space?

If YES to the above question, will personnel be required to enter the confined spaces?

Are there any ergonomic issues (repetitive, motion, vibration, lifting, etc.)?

Does any of the laboratory equipment create a hazard?

Does this operation involve: the use of equipment, tools or materials outside of the design specifications or outside of the manufacturer's recommendations OR the use of equipment or apparatus built locally?

Will this operation be left unattended?

Will operation require work outside normal working hours?

Will this operation require 2-person rule?

Will this operation require special attention or contribute to a hazardous condition in the event it is left unexpectedly for long periods of time?

Environmental

Y N Are there any environmental concerns? If yes, please fill-out the table below.
Will this operation generate or will personnel be required to handle.
Hazardous waste?
Acutely hazardous waste?
Infectious, medical or biohazardous waste?
Radioactive waste?
Mixed waste?
Air emissions?
Toxic gas emissions?
Wastewater discharge?

Hazard Control Measures

Y N Are measures taken to minimize the potential hazards and mitigate risks?
Is any local ventilation used in this operation? (Example: chemical hood)
Is an eyewash/shower available?
Are interlocks or Lockout/tagout equipment use in the operation?
Is any personal protective equipment used in this operation?
Will respiratory protection be required for this operation?
Have employees received all required training?

13.15.2 Appendix B: General Procedures for Working with Hazardous Chemicals

Reprinted with permission from *PRUDENT PRACTICES IN THE LABORATORY*. Copyright 1995 by the National Academy of Sciences. Courtesy of the National Academy Press, Washington D.C. Qualifying notes for Ames Research Center are printed in italics.

Personal Behavior

Professional standards of personal behavior are required in any laboratory:

- Avoid distracting or startling other workers.
- Do not allow practical jokes and horseplay at any time.
- Use laboratory equipment only for its designated purpose.
- Do not allow visitors, including children and pets, in laboratories where hazardous substances are stored or are in use or hazardous activities are in progress.
- If children are permitted in laboratories, for example, as part of an educational or classroom activity, ensure that they are under the direct supervision of qualified adults.
- Make sure that teaching materials and publicity photographs show people wearing appropriate safety gear, in particular, eye protection.

Minimizing Exposure to Chemicals

Precautions should be taken to avoid exposure by the principal routes, that is, contact with skin and eyes, inhalation, and ingestion.

1. Avoiding Eye Injury

- Eye protection should be required for all personnel and visitors in all locations where chemicals are stored or used. Eye protection is required whether or not one is actually performing a chemical operation. Visitor safety glasses should be made available at the entrances to all laboratories.
- Researchers should assess the risks associated with an experiment and use the appropriate level of eye protection.
- Safety glasses with side shields provide the minimum protection acceptable for regular use. Safety glasses must meet the American National Standards Institute (ANSI) standard Z87.1-1989, Standard for Occupational and Educational Eye and Face Protection, which specifies a minimum lens thickness, certain impact resistance requirements, and so on.
- Safety splash goggles or face shields should be worn when carrying out operations in which there is any danger from splashing chemicals or flying particles. These thin shields do not provide protection from projectiles, however, goggles are preferred over regular safety glasses to protect against hazards such as projectiles, as well as when working with glassware under reduced or elevated pressures (e.g., sealed tube reactions), when handling potentially explosive compounds (particularly during distillations), and when employing glassware in high-temperature operations.
- Because goggles offer little protection to the face and neck, full-face shields should be worn when conducting particularly hazardous laboratory operations. In addition, glassblowing and the use of laser or ultraviolet light sources require special glasses or goggles.

Ordinary prescription glasses do not provide adequate protection against injury. Prescription safety glasses and goggles can be obtained.

Contact lenses offer no protection against eye injury and cannot be substituted for safety glasses and goggles. It is best not to wear contact lenses when carrying out operations where chemical vapors are present or a chemical splash to the eyes or chemical dust is possible because contact lenses can increase the degree of harm and can interfere with first aid and eye-flushing procedures. If an individual must wear contact lenses for medical reasons, then safety glasses with side shields or tight-fitting safety goggles must be worn over the contact lenses. *Employees are advised to inform the supervisor when contact lenses will be worn for operations with hazardous chemicals.*

2. Avoiding Ingestion of Hazardous Chemicals

Eating, drinking, smoking, gum chewing, applying cosmetics, and taking medicine in laboratories where hazardous chemicals are used should be strictly prohibited. Food, beverages, cups, and other drinking and eating utensils should not be stored in areas where hazardous chemicals are handled or stored. Glassware used for laboratory operations should never be used to prepare or consume food or beverages. Laboratory refrigerators, ice chests, cold rooms, ovens, and so forth should not be used for food storage or preparation. Laboratory water sources and deionized laboratory water should not be used for drinking water.

Laboratory chemicals should never be tasted. A pipette bulb or aspirator should be used to pipette chemicals or to start a siphon; pipetting should never be done by mouth. Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.

3. Avoiding Inhalation of Hazardous Chemicals

Toxic chemicals or compounds of unknown toxicity should never be smelled. Procedures involving volatile toxic substances and operations involving solid or liquid toxic substances that may result in the generation of aerosols should be conducted in a laboratory hood. Dusts should be recognized as potentially contaminated and hazardous. Hoods should not be used for disposal of hazardous volatile materials by evaporation. Such materials should be treated as chemical waste and disposed of in appropriate containers in accord with institutional procedures.

The following general rules should be followed when using laboratory hoods:

Note: *For more information, see OSHA Personal Protective Equipment Standard (29 CFR 1910.132-138) for hand protection.*

6. Clothing and Protective Apparel

Long hair and loose clothing or jewelry must be confined when working in the laboratory. Unrestrained long hair, loose or torn clothing, and jewelry can dip into chemicals or become ensnared in equipment and moving machinery. Clothing and hair can catch fire. Sandals and open-toed shoes should never be worn in a laboratory in which hazardous chemicals are in use.

It is advisable to wear a laboratory coat when working with hazardous chemicals. This is particularly important if personal clothing leaves skin exposed. Apparel giving additional protection (e.g., nonpermeable laboratory aprons) is required for work with certain hazardous substances. Because many synthetic fabrics are flammable and can adhere to the skin, they can increase the severity of a burn. Therefore, cotton is the preferred fabric.

Housekeeping

There is a definite correlation between orderliness and level of safety in the laboratory. In addition, a disorderly laboratory can hinder or endanger emergency response personnel. The following housekeeping rules should be adhered to:

- Never obstruct access to exits and emergency equipment such as fire extinguishers and safety showers.
- Clean work areas (including floors) regularly. Properly label . . . and store . . . all chemicals. Accumulated dust, chromatography adsorbents, and other chemicals pose respiratory hazards.
- Secure all compressed gas cylinders to walls or benches.
- Do not store chemical containers on the floor.
- Do not use floors, stairways, and hallways as storage areas.

Transport of Chemicals

Chemicals being transported outside the laboratory or between stockrooms and laboratories should be in break-resistant secondary containers. Secondary containers commercially available are made of rubber, metal, or plastic, with carrying handle(s), and are large enough to hold the contents of the chemical containers in the event of breakage. When transporting cylinders of compressed gases, the cylinder should always be strapped in a cylinder cart and the valve protected with a cover cap. When cylinders must be transported between floors, passengers should not be in the elevator.

Storage of Chemicals

The accumulation of excess chemicals can be avoided by purchasing the minimum quantities necessary for a research project. All containers of chemicals should be labeled properly. Any special hazards should be indicated on the label. For certain classes of compounds (e.g.,

ethers as peroxide formers), the date the container was opened should be written on the label. Peroxide formers should have the test history and date of discard written on the label as well. Only small quantities (less than 1 liter (L)) of flammable liquids should be kept at workbenches. Larger quantities should be stored in approved storage cabinets. Quantities greater than 1 L should be stored in metal or break-resistant containers. Large containers (more than 1 L) should be stored below eye level on low shelves. Hazardous chemicals and waste should not be stored on the floor.

Refrigerators used for storage of flammable chemicals must be explosion-proof, laboratory-safe units. Materials placed in refrigerators should be clearly labeled with water-resistant labels. Storage trays or secondary containers should be used to minimize the distribution of material in the event a container should leak or break. It is good practice to retain the shipping can for such secondary containers.

All chemicals should be stored with attention to incompatibilities so that if containers break in an accident, reactive materials do not mix and react violently.

Disposal of Chemicals

Note: *This section contains practical guidelines for waste accumulation. For ARC policies and procedures, refer to Ames Environmental Management Manual, Chapter 4.*

Virtually every laboratory experiment generates some waste, which may include such items as used disposable labware, filter media and similar materials, aqueous solutions, and hazardous chemicals. The overriding principle governing the handling of waste in prudent laboratory practice is that no activity should begin unless a plan for the disposal of nonhazardous and hazardous waste has been formulated. Application of this simple rule will ensure that the considerable regulatory requirements for waste handling are met and that unexpected difficulties, such as the generation of a form of waste (e.g., chemical-radioactive-biological) that the institution is not prepared to deal with, are avoided.

Each category of waste has certain appropriate disposal methods. In choosing among these methods, several general principles apply, but local considerations can strongly influence the application of these rules:

- Hazardous or flammable waste solvents should be collected in an appropriate container *pending pickup by the ARC contractor for hazardous waste* for transfer to the institution's central facility or satellite site for chemical waste handling or pickup by an outside disposal agency.
- Waste solvents can usually be mixed for disposal, with due regard for the compatibility of the components. Sometimes halogenated and nonhalogenated wastes must be segregated for separate handling.

Note: *The Safety Office will provide consultation and guidance on request.*

- The container used for the collection of liquid waste must be appropriate for its use. Glass bottles are impervious to most chemicals but present a breakage hazard, and narrow necks can cause difficulty in emptying the bottles. The use of plastic (e.g., polyethylene jerrycans) or metal (galvanized or stainless steel) safety containers for the collection of liquid waste is strongly encouraged and, indeed, required for flammable liquids.

Note: *Approved containers are provided on request by the Ames contractor for hazardous waste.*

- Galvanized steel safety cans should not be used for halogenated waste solvents because they tend to corrode and leak. Flame arresters in safety cans can easily become plugged if there is sediment and may need to be cleaned occasionally.

- Waste containers should be clearly and securely labeled as to their contents and securely capped when not in immediate use.
- Aqueous waste should be collected separately from organic solvent waste. Some laboratories may be served by a wastewater treatment facility that allows the disposal of aqueous waste to the sanitary sewer if it falls within a narrow range of acceptable waste types. Thus, solutions of nonhazardous salts or water-miscible organic materials may be acceptable in some localities. Note: Ames is served by both Sunnyvale and Palo Alto water treatment facilities. The Safety Office provides consultation and guidance regarding requirements that apply to each building at Ames. Solutions containing flammable or hazardous waste, even if water-miscible, are almost never allowed and water-immersible substances must never be put down the drain. Aqueous waste for non-sewer disposal should be collected in a container selected for resistance to corrosion. Glass should not be used for aqueous waste if there is danger of freezing. Depending on the requirements of the disposal facility, adjustment of the pH of aqueous waste may be required. Such adjustment requires consideration of the possible consequences of the neutralization reaction that might take place: gas evolution, heat generation, or precipitation.
- Solid chemical waste, such as reaction by-products, or contaminated filter or chromatography media, should be placed in an appropriately labeled container to await disposal or pickup. Unwanted reagents should be segregated for disposal in their original containers, if possible. If original containers are used, labels should be intact and fully legible. Every effort should be made to use, share, or recycle unwanted reagents rather than commit them to disposal.

Note: *The Ames Chemical Exchange (ACE) program for sharing excess chemicals is described in the Ames Environmental Management Manual.*

- Nonhazardous solid waste can be disposed of in laboratory trash or segregated for recycling. Institutional policy should be consulted for these classifications. (See Chapter 7 for further information regarding disposal, and check the appropriate LCSS to determine toxicity.)

Note: *Ames policy is described in the Ames Environmental Management Manual, Chapter 4.*

Use and Maintenance of Equipment and Glassware

Good equipment maintenance is essential for safe and efficient operations. Laboratory equipment should be inspected and maintained regularly and serviced on schedules that are based on both the likelihood of and the hazards from failure. Maintenance plans should ensure that any lockout procedures cannot be violated.

Careful handling and storage procedures should be used to avoid damaging glassware. Chipped or cracked items should be discarded or repaired. Vacuum-jacketed glassware should be handled with extreme care to prevent implosions. Evacuated equipment such as Dewar flasks or vacuum desiccators should be taped or shielded. Only glassware designed for vacuum work should be used for that purpose.

Hand protection should be used when picking up broken glass. Small pieces should be swept up with a brush into a dustpan. Glassblowing operations should not be attempted unless proper annealing facilities are available. Adequate hand protection should be used when inserting glass tubing into rubber stoppers or corks or when placing rubber tubing on glass hose connections. Cuts from forcing glass tubing into stoppers or plastic tubing are the most common kind of laboratory accident and are often serious. Tubing should be fire polished or rounded and lubricated, and hands should be protected with toweling and held close together to limit movement of glass should it fracture. The use of plastic or metal connectors should be considered.

Handling Flammable Substances

Flammable substances present one of the most widespread hazards encountered in the laboratory. Because flammable materials are employed in so many common laboratory operations, basic prudent laboratory practice should always assume the presence of fire hazard unless a review of the materials and operations in the laboratory verifies the absence of significant hazard. For example, simple operations with aqueous solutions in a laboratory where no flammable organic liquids are present involve no appreciable fire hazard. In all other circumstances, the risk of fire should be recognized and kept to a minimum.

For a fire to start, an ignition source, fuel, and oxidizer must be present. Prudent laboratory practice in avoiding fire is based on avoiding the presence of one of these components. The flammability and explosive characteristics of the materials being used should be known. Solvent labels, LCSSs, or other sources of information can be consulted to learn the flash point, vapor pressure and explosive limit in air of each chemical handled. While all flammable substances should be handled prudently, the extreme flammability of some materials requires additional precautions.

To ensure that laboratory workers respond appropriately, they should be briefed on the necessary steps to take in case of a fire. The laboratory should be set up in such a way that the locations of fire alarms, pull stations, fire extinguishers, safety showers, and other emergency equipment are marked and all laboratory personnel alerted to them. Exit routes in case of fire should be reviewed. Fire extinguishers in the immediate vicinity of an experiment should be appropriate to the particular fire hazards. Proper extinguishers must be used because fires can be exacerbated by use of an inappropriate extinguisher. Telephone numbers to call in case of an accident should be readily available.

Responsibility for Unattended Experiments and Working Alone

Generally, it is prudent to avoid working alone at the bench in a laboratory building. Individuals working in separate laboratories outside of working hours should make arrangements to check on each other periodically, or ask security guards to check on them. Experiments known to be hazardous should not be undertaken by a worker who is alone in a laboratory. Under unusually hazardous conditions, special rules may be necessary.

Laboratory operations involving hazardous substances are sometimes carried out continuously or overnight with no one present. It is the responsibility of the worker to design these experiments so as to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Laboratory lights should be left on, and signs should be posted identifying the nature of the experiment and the hazardous substances in use. If appropriate, arrangements should be made for other workers to periodically inspect the operation. Information should be posted indicating how to contact the responsible individual in the event of an emergency.

13.15.3 Appendix C: Special Rules for Working with Particularly Hazardous Substances

PRUDENT PRACTICES IN THE LABORATORY. Copyright 1995 by the National Academy of Sciences. Chapter 5D

Note: Guidelines have been adapted for Ames Research Center policies and procedures.

Approvals

Prepare a Standard Operating Procedure for use of these materials and obtain the approval of the laboratory supervisor. Attach the SOP to the Laboratory Safety Plan. See suggested format (Appendix G).

Access

Conduct all transfers and work with these substances in a "designated area;" (hood, glove box, or portion of a lab). Document the location and that all people with access are aware of the substances being used and necessary precautions in the SOP.

Fume Hoods

Always use a hood (previously evaluated to confirm adequate performance with an average face velocity of 100+ 20 linear feet per minute (ARC standard) or other containment device for procedures that may result in the generation of aerosols or vapors containing the substance.

Glove Boxes

Contact the Safety Division for assistance.

Decontamination

Document decontamination procedures in the SOP. Decontamination vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the designated area. Decontaminate the designated controlled area before normal work is resumed there.

Exiting

On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck.

Medical surveillance

If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult with the Ames Chemical Hygiene Officer concerning desirability of regular medical surveillance. Include this information in the SOP.

Records

Keep accurate records of the amounts of Particularly Hazardous Chemicals stored and used, the dates of use, and names of users.

Signs and labels

Assure that the designated area is conspicuously marked with warning and restricted access signs.

Assure that all storage cabinets and containers of these substances are appropriately labeled with identity and warning labels.

Storage

Store containers of Particularly Hazardous Chemicals only in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant containers.

Spills

Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available. (See Ames Environmental Procedures and Guidelines, APG 8800.3, Chapter 3, Hazardous Materials Management, for spill reporting requirements)

Waste

Ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the designated area in a secondary container under the supervision of authorized personnel.

Bag, label, and dispose as hazardous waste any contaminated clothing or shoes.

Store contaminated waste in closed, suitably labeled, impervious containers.

See also: APG 8800.3, Chapter 4, Hazardous Waste Management

13.15.4 Appendix D: Laboratory Risk Assessment

Include in the Laboratory Safety Plan. For each chemical consider the toxicity, frequency and duration of use, the quantity of material handled, and the inhalation and skin exposure potential. Reference: *PRUDENT PRACTICES IN THE LABORATORY*. Copyright 1995 by the National Academy of Sciences. Courtesy of the National Academy Press, Washington, D.C.

Quick Guide to Risk Assessment for Hazardous Chemicals

The major items:

- Identify chemicals to be used and circumstances of use.
- Consult sources of information.
- Evaluate type of toxicity.
- Consider possible routes of exposure.
- Evaluate quantitative information on toxicity.
- Select appropriate procedures to minimize exposure.
- Prepare for contingencies.

Note the signs and symptoms of exposure to the chemicals to be used in the proposed experiment. Note appropriate measures to be taken in the event of exposure or accidental release of any of the chemicals.

Toxicity:

Review the Material Safety Data Sheets and other available reference for toxicology and health hazard information. The table below can be used to assist the rating of acutely toxic chemicals.

Low: transitory, mild health effects

Moderate: effects from which the person would recover; would not produce chronic effects that would negatively impact on the quality of life.

High: all compounds which meet the "Particularly Hazardous Chemical" definition and any compound which has no available toxicity information.

Hazard Level	Toxicity Rating	Oral LD50 (Rats, per kg)	Skin Contact LD50 (Rabbits, per kg)	Inhalation LC50 (Rats, ppm for 1h)	Inhalation LC50 (Rats, mg/m3 for 1h)
High	Highly toxic	<50 mg	<200 mg	<200	<2,000
Medium	Moderately toxic	50 to 500 mg	200 mg to 1 g	200 to 2,000	2,000 to 20,000
Low	Slightly toxic	500 mg to 5 g	1 to 5 g	2,000 to 20,000	20,000 to 200,000

Reprinted with permission from *PRUDENT PRACTICES IN THE LABORATORY*. Copyright 1995 by the National Academy of Sciences. Courtesy of the National Academy Press, Washington, D. C. Table 3.1.

Routes of Exposure:

Inhalation and skin exposure are the most probable types of exposure for laboratory workers. Accidental injection can also occur if needles or other sharp implements are used in any procedures. The actual potential for an exposure to occur can be reduced by the use of hazard/exposure control measures.

Examples:

Inhalation Exposure Potential:

- Low: Use is always in vented hoods or glove boxes with appropriate protection (i.e., gloves, lab coat); or in closed containers outside of fume hood; or, substance/material is a non-volatile solid or a dilute solution (e.g. <0.1%) used in a manner which will not create significant airborne exposures.
- Moderate: Substance/material is volatile or a finely divided particulate and is used outside ventilated enclosure for a period of <1/2 hr/mo.
- High: Open containers used outside of vented enclosures where substance/material is volatile or a finely divided particulate and/or the material is used >1/2 hr/mo.

Skin Exposure Potential: Evaluate this exposure route independently of the inhalation route. Consider (1) the potential for contact with unprotected skin and the potential for surface contamination (e.g. dusts); (2) frequency of use; and, (3) the chemical's ability to be absorbed through the skin.

If the risk/exposure potential is high or moderate, the experimental protocol should be adjusted, whenever possible, to reduce the level. The correct use of engineering controls and personal protection equipment lowers the exposure potential. If the assessment is still high, contact the Ames Chemical Hygiene Officer for further evaluation.

13.15.5 Appendix E: Chemical Compatibility/Incompatibility

Reprinted (adapted) with permission from Prudent Practices in the Laboratory. Copyright 1995 by the National Academy of Sciences. Courtesy of the National Academy Press, Washington, D.C.

Chemicals in the two columns should be kept separate. Consult the MSDS for substance-specific information.

Classes of Incompatible Chemicals

Acids	Bases
Alkali and alkaline earth metals including: carbides hydrides hydroxides oxides peroxides	Water Acids Halogenated organic compounds Oxidizing agents*
Azides, inorganic	Acids Heavy metals and their salts Oxidizing agents*
Cyanides, inorganic	Acids Strong bases
Nitrates, inorganic	Acids Reducing agents
Nitrites, inorganic	Acids Oxidizing agents*
Organic compounds including: Organic acylhalides Organic hydroxy and amino compounds Organic anhydrides Organic hydroxy and amino compounds Organic halogen compounds Organic nitro compounds	Oxidizing agents* Bases Group IA and IIA metals Aluminum Strong bases
Oxidizing agents Chlorates Chromates Chromium trioxide Dichromates Halogens Halogenating agents Hydrogen peroxide Nitric acid Nitrates Perchlorates Peroxides Permanganates Persulfates	Reducing agents Ammonia, anhydrous and aqueous Carbon Metals Metal hydrides Nitrites Organic compounds Phosphorus Silicon Sulfur
Reducing agents	Oxidizing agents Arsenates Arsenites Phosphorus Selenites Selenates Tellurium salts and oxides
Sulfides, inorganic	Acids

* Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

Specific Chemical Incompatibilities

Chemicals in corresponding columns A and B should be kept separate. Consult the MSDS for substance-specific information.

Column A	Column B
Acetylene and monosubstituted acetylene (R-C CH)	Halogens Group IB and IIB metals and their salts
Ammonia and NH_4OH	Halogens Halogenating agents Silver Mercury
Carbon, activated	Oxidizing agents*
Hydrogen peroxide	Metals and their salts
Nitric acid	Metals Sulfuric acid Sulfides Nitrites, other reducing agents Chromic acid and chromates Permanganates
Mercury and its amalgams	Ammonia and NH4OH Nitric acid Acetylene Sodium azide
Oxalic acid	Silver Mercury
Phosphorus (yellow)	Oxygen Oxidizing agents* Strong bases
Phosphorus pentoxide	Water Halogenating agents
Sulfuric acid	Metals Chlorates Perchlorates Permanganates Nitric acid

- Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

13.15.6 Appendix F: Example of Standard Operation Procedure for Particularly Hazardous Substances

A copy of the completed SOP must be filed with the Laboratory Safety Plan.

Purpose of a SOP (reference: SOP)

- Standard methods and procedures to prevent systemic errors;
- Reminder of how to correctly conduct a procedure;
- Training tool;
- Regulatory compliance

Chemical Name of Substance:
CAS Registry Number of Substance:
Physical and Chemical Properties:

_____	Solid	_____	Liquid	_____	Gas		
_____	Stable	_____	Unstable	_____	Volatile	_____	Nonvolatile
_____	Flammable	_____	Nonflammable	_____	Explosive	_____	Reactive

Toxic Effects:

Major known Toxic Effects or Symptoms:

Description of Use: Step-by-step instructions on performing the operation, including the identification of "critical steps" and any specific hazards and hazardous operations.

Frequency of use: _____
Quantity to be used at any one time: _____
Highest Concentration to be used: _____
Any solvent or diluent used: _____
Duration of use: _____
Exposure potential: _____
Inhalation: _____
Skin: _____

Authorized personnel: Use of this material requires prior written approval from the **PI** or _____, Title: _____. Access to the designated area and use of the substance will be limited to the following personnel:

Name	Title	Date Trained/Authorized	Responsibilities

Training requirements: The user must demonstrate competency and familiarity regarding the safe handling and use of this material prior to purchase. Training should include the following:

Review of hazard/toxicity information
Review of the OSHA Lab Standard
Review of the Chemical Hygiene Plan
Review of Laboratory Safety Plan
Special training provided by the Principal Investigator
_____
_____

Safety meetings and seminars:
_____

Use location: Materials shall be used only in the following designated areas in areas in room
_____

Check all that apply:

Demarcated area in lab (described) _____ fume hood _____ glove box _____ other (described) _____

Personal protective equipment: All personnel are required to wear the following personal protective equipment whenever handling this material (check all that apply):

Chemical safety goggles _____ Face Shield _____ Gloves (type) _____

Respirator (type) _____ Rubber Apron _____ Lab Coat _____

Tyvek clothing _____ Other (describe) _____

Purchasing: All purchases of this material must have written approval from the Principal Investigator or _____ before ordering. Quantities of this material will be limited to _____, or the small amount necessary to complete the experiment.

Storage: Materials will be stored according to compatibility and label recommendations in a designated area: _____. Storage areas will be regularly inspected by _____ to ensure safety. Periodic inventory reductions will be scheduled.

Waste disposal: The authorized person using this material is responsible for the safe collection, preparation and proper disposal of waste unless otherwise stated below. Waste shall be disposed of as soon as possible and in accordance with all ARC procedures.

Specific instructions:

Decontamination. Specific instructions:

Specialized maintenance and repair issues:
Example: decontamination procedures, training of maintenance personnel on specific hazards, etc.

Emergency procedures to be followed:
Examples
Emergency shutdown procedures
Information to be provided to emergency response personnel.
Exposures:

Skin/eye contact—symptoms:
First Aid:

Ingestion—symptoms:
First Aid:

Inhalation—symptoms:
First Aid:

Spills: Spill cleanup materials to be used, location of materials, PPE to be used, disposal of cleanup materials, etc. Please be a complete as possible.

Phone numbers:

Other: Special precautions, incompatible/reactive materials, useable shelf life, etc. Please be as specific as possible.

Prepared by: _____ Date: _____

Reviewed: _____

13.15.7 Appendix G: Chemical Compatibility/Incompatibility

Principal Investigator:_____

Location: _____

Date: _____

Program Administration	Y	N
Do all research laboratories have a Laboratory Safety Plan?		
Is the plan complete and up to date?		
Does each laboratory have a designated Chemical Hygiene Officer?		
Is the CHO familiar with his/her duties?		
Identification of Hazards	Y	N
Major laboratory hazards are identified and addressed in the Laboratory Safety Plan?		
Laboratory personnel know how to get chemical safety information?		
Chemical safety information is included in the laboratory safety plan?		
Incompatible chemicals are separated?		
Are labels left on incoming containers?		
Are secondary containers labeled in accordance with the laboratory safety plan?		
Are compressed gases secure?		
Is the composition of laboratory-generated mixtures attached to the Laboratory Safety Plan?		
Is the chemical inventory accurate?		
Is a spill kite available?		
Prior Approval Procedures	Y	N
Are there any operations or activities that require prior approval before performing?		
Are these documented in the Laboratory Safety Plan?		

Particularly Hazardous Substances	Y	N
Is there an adequate procedure for identifying particularly hazardous substances used in the laboratory?		
Have they been identified in this laboratory?		
Are there written SOPs for handling particularly hazardous substances?		
Are they followed?		
Are areas or hoods where these substances are in use posted with a designated area sign?		
Engineering Controls	Y	N
Are laboratory hoods and local exhaust systems provided where needed?		
Are hoods inspected annually?		
Is there an inspection sticker?		
Personal Protective Equipment	Y	N
Has the correct PPE been selected based on a document analysis of the hazards?		
Is PPE available as needed?		
Have workers been trained on when and how to use their PPE?		
Do laboratory workers use required PPE?		
Training	Y	N
Have all laboratory workers received Chemical Hygiene Plan training?		
Have all laboratory workers received training on the Laboratory Safety Plan and all hazards present in the laboratory?		
Is the training documented?		
Exposure Monitoring	Y	N
Have any potential exposures above the allowable limit (Action Level or Permissible Exposure Limit) been identified?		
Has the Ames Chemical Hygiene Officer been contacted to schedule air-sampling?		

Example questions which laboratory personnel should be able to answer:

- Where is the Chemical Hygiene Plan?
- Who is the Chemical Hygiene Officer for the laboratory?
- Where are the laboratory's safety rules located?
- What particularly hazardous substances do you work with?
- Where are the written SOPs for handling them?
- Where is the designated area for handling them?
- What are the signs and symptoms of over-exposure to _____ (select a substance used by the employee)?
- Where would you find information about the hazard of this compound?
- What PPE should you wear when working with this compound?
- Where is the chemical inventory? Is this substance listed correctly?
- What would you do, if you spilled this chemical?
- How do you know that your laboratory hood is functioning properly?

END OF DOCUMENT