JOHN H. GLENN RESEARCH CENTER

CHEMICAL HYGIENE PLAN

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CHEMICAL HYGIENE PLAN

INTRODUCTION

OSHA LABORATORY STANDARD

On January 31, 1990, the Occupational Safety and Health Administration (OSHA) issued a final rule entitled, Occupational Exposures to Hazardous Chemicals in Laboratories, also called the Laboratory Standard. Title 29, Code of Federal Regulations (CFR), Part 1910.1450 codifies this rule. The final standard applies to all laboratories that use hazardous chemicals that meet the definition of laboratory use and laboratory scale provided in the standard.

Laboratories as defined by 1910.1450 include the following buildings and areas:

Building 6 Rooms 36, 38, 102/104
Building 49
Building 55 Room 122
Building 105 Rooms 207, 209, 214
Building 110 Rooms 212, 220
Building 309

Building 23 Rooms 202-206

Building 77
Building 106
Building 302

ATF Building 7143
ATF Building 1411, Room 215

ATF Building 9148

The Laboratory Standard also defines the need for each laboratory to develop a Chemical Hygiene Plan. This document, the NASA Glenn Research Center (GRC) Chemical Hygiene Plan, fulfills the requirements as specified in the OSHA standard.

NASA GLENN RESEARCH CENTER CHEMICAL HYGIENE POLICY

The GRC Occupational Health Programs Manual, Chapter 25, outlines the Center's policy about the Laboratory Standard. The definition of the authorities and responsibilities are in a manner that allows flexibility to adjust the program to the specific needs of each laboratory.

NASA GLENN RESEARCH CENTER CHEMICAL HYGIENE PLAN

This document establishes the NASA GRC Chemical Hygiene Plan. This Plan is a mandatory chemical hygiene program designed to minimize employee and property risks. This program is a regular, continuing effort not merely a standby or short-term activity. All GRC employees at Lewis Field and Neil A. Armstrong Test Facility (ATF), along with tenant organization employees and resident contract personnel who are laboratory workers as defined in the Laboratory Standard, shall follow its recommendations. The Plan is administered by the Occupational Health Branch (OHB) of the Safety and Health Division (SHeD).

This Chemical Hygiene Plan, in conjunction with Laboratory Standard Operating Procedures (LSOPs), including the Nanomaterial Standard Operating Procedure establishes the procedures; equipment; Personal Protective Equipment (PPE); and work practices that are capable of protecting laboratory employees from the physical and health hazards presented by hazardous chemicals used in the workplace. This Plan meets the requirements of 29 CFR 1910.1450: Occupational Exposures to Hazardous Chemicals in Laboratories. The GRC Chemical Hygiene Officer will review this plan annually to ensure that the procedures still meet the needs of the Center.

Change Record

Rev.	Effective Date	Description
Basic	8/22/2003	Initial
B	6/10/2004	Revision
C	5/23/2006	Revision
D	5/17/2010	Revision
E	11/1/2011	Revision
F	11/1/2012	Revision
G	12/1/2013	Revision
H	12/2014	Revision
I	12/2015	Revision
J	12/2016	Revision
K	12/2017	Revision
L	12/2018	Revision
M	12/2019	Revision
N	12/2020	Revision
O	12/2021	Revision
P	12/2022	Revision
Q	12/2023	Revision

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CHAPTER 1 - GENERAL STANDARD OPERATING PROCEDURES

The laboratories at the NASA Glenn Research Center (GRC) are diversified in nature, scope, and in the chemicals that they use. There are, however, basic and fundamental safety and health considerations that are applicable to all laboratory settings. The basic norms for work in chemical laboratories at GRC are in this Chapter. This listing is not exhaustive. All laboratory workers shall use good practices, common sense and good attention to detail in safety and health areas.

PLANNING

Good chemical hygiene planning is essential to a safe and healthful work area. Each laboratory user is responsible for obtaining information and advice about the hazards of the chemicals they plan on using and the appropriate safe-handling procedures. Each user shall plan appropriate protective procedures and plan the best and safest positioning of equipment before beginning any new operation.

Information

Each employee involved in the laboratory use of hazardous chemicals shall read and understand the Safety Data Sheet and label before beginning work with any hazardous chemical. Do not work with a material if you are not aware of its hazards or if your laboratory space lacks the facilities to properly use the material. If you need additional information, contact the supplier, SHeD or your supervisor. Only work with chemicals whose hazards you understand and which you can safely handle. New procedures or testing should begin with a job hazard analysis to ensure that safe procedures are used for all steps of the procedure. Please use this document and other sources of information such as Prudent Practices in the Laboratory (National Research Council, National Academy Press) to fully evaluate any new procedures.

Make sure that you have all the necessary permits. If you need a review of the permit process, contact the Area Safety Committee.

Choice of Chemicals

Substitute chemicals with a lower physical and/or health hazard over a high hazard chemical whenever possible. Keep amounts of chemicals to a minimum to reduce possible exposure amounts.

Be sure the laboratory is equipped to safely handle the chemicals you are using. This includes ventilation and storage, as well as personal protective equipment.

Each laboratory has specific ventilation capabilities. Some laboratories have additional hoods or other ventilation equipment available. Each ventilation system has capability limits. Use only those chemicals for which the ventilation systems available are appropriate to ensure safety and health of the users and the facility.

Nanomaterials

Engineered nanomaterials are very small objects or particles and are used on a global scale in commercial and consumer goods. Using chemicals and materials in a nanoscale form can completely alter their nature, often making them very different from the parent material, where unique characteristics such as mechanical strength, electrical conductivity, optical properties and large surface areas enhance end-product functionality. The nanomaterial characteristics of size, shape, surface area, charge, chemical properties, solubility, and agglomeration determine the interaction of these materials with biological systems. The size range of nanomaterials of 1 to 100 nanometers indicates a respiratory hazard and raises concern about whether nanoparticles can cross biological membranes and translocate to other areas of the body. Safe work practices are required to control contact with the skin, mucus membranes, eyes and the mouth, via hand to mouth contact. At this time, the human health impacts are not fully understood and NIOSH advises the use of precautionary measures. Toxicity research on these materials indicates the need for a nanomaterial-specific occupational health approach to controlling the potential health risks in the workplace, thus the Agency mandate for a Center level Nanotoxicology Program.

USERS

Keep the work area clean and uncluttered. Label and store chemicals and equipment properly. Clean up the work area upon completion of an operation or at the end of each day.

Be alert to unsafe conditions. Notify your supervisor to ensure correction of the unsafe conditions when detected. If the unsafe condition cannot be corrected immediately, place appropriate warning signs and/or labels to notify others of the hazards until the unsafe condition is corrected.

Do not eat, drink, smoke, chew gum or apply cosmetics or lotions in areas where laboratory chemicals are present. Wash hands, using potable water, before conducting these activities. Do not store, handle or consume food or drinks in storage areas, refrigerators, laboratory glassware or utensils. Do not engage in practical jokes or other behaviors that might confuse, startle or distract another worker. Do not use personal electronic devices such as devices with ear buds that may cause distractions. The use of compressed air for cleaning lab equipment surfaces is prohibited.

Avoid working alone in a building. Do not work alone in a laboratory if the procedures being conducted are hazardous. (Reference: Glenn Safety Manual, Chapter 22, The Glenn Buddy System).

Avoidance of Routine Exposure

Develop and encourage safe habits: Avoid unnecessary exposure to chemicals by any route. It is prudent to minimize all chemical exposures. Always avoid skin contact with chemicals. Do not smell or taste chemicals. Never use mouth suction to pipette or start a siphon.

Avoid underestimation of risk: Minimize exposure, even for substances of no known significant hazard. Take special precautions for work with substances that present special hazards. Assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.

Do not exceed Occupational Exposure Limits (OEL) including the Permissible Exposure Limits (PEL's) listed in OSHA regulation 29 CFR 1910.1000, as revised, the Threshold Limit Values (TLVs) of the American Council of Governmental Industrial Hygienists (ACGIH) and specific NASA Health Standards issued by the NASA Office of the Chief Health and Medical Officer (OCHMO). The use of all materials with OSHA substance-specific standards shall be evaluated by an industrial hygienist. Refer to Occupational Health Program Manual Chapter 26, Occupational Exposure to Hazardous Chemicals and Substances or contact an Occupational Health Branch Industrial Hygienist.

> NOTE: There are very limited OELs for engineered nanomaterials. Currently adequate data sets exist to establish recommended exposure levels for materials such as carbon nanotubes and nanofibers (1.0 µg/m3), titanium dioxide (0.3 mg/m3), and fullerenes (0.8 mg/m3). Most of the current OELs for particles are based on mass, which may or may not be a suitable measure for engineered nanomaterial exposures. Exposures to nanomaterials shall be kept to As Low As Reasonably Possible (ALARP) by utilizing the basic hierarchy of implementing engineering controls first then administrative controls and then PPE.

Do not allow release of toxic substances in cold rooms, clean rooms and warm rooms, since these have contained re-circulated atmospheres. Take all precautions not to contaminate the air in the room.

Visitors

Take extra care to ensure no hazardous chemical exposure to any visitor of the laboratory. Each visitor shall wear all the necessary and proper personal protective apparel.

Unattended Operation

Leave lights on. Place an appropriate sign, which includes operator(s) telephone number(s), on the door and provide for containment (such as cooling water) in case there is failure of a utility service to an unattended operation.

Notify the Office of Protective Services if the unattended operation poses a potential hazard to security personnel, maintenance, housekeeping or other nearby work areas or offices.

Notify the Safety and Health Division at (216) 433-3016 (ATF at (419) 621-3222), if the unattended operation poses a potential hazard to the laboratory or if special precautions are necessary if there is an emergency.

Exiting Laboratory

Wash areas of exposed skin thoroughly with soap and potable water as soon as practical after working with chemicals. Remove (and properly clean, using potable water, if reusable) all personal protective apparel, taking care to avoid incidental exposure, before leaving the laboratory. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Sinks with non-potable are identified through appropriate signage. For other PPE (respirators, glasses, goggles etc.), use non-alcohol wipes.

EQUIPMENT

Handle and store laboratory glassware with care to avoid damage. Do not use damaged glassware and replace damaged glassware immediately. Dispose of damaged glassware using a sharps container provided by Waste Management.

Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap Dewar flasks or other evacuated glass apparatus to contain chemicals and fragments should an implosion occur.

Use equipment only for its designed purpose. Inspect and maintain equipment regularly. Test glove boxes before use.

Vent apparatus that may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.

Only use the appropriate personal protective apparel when working with hazardous chemicals. Inspect gloves, safety glasses, chemical goggles, lab coats, aprons, respirators and all other personal protective equipment before use. Reusable gloves shall be washed using potable water after each use before removing. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Lab coats shall never be worn outside of the lab.

Engineering controls for nanomaterials include local exhaust ventilation (laboratory hoods, snorkels) and the use of enclosures with localized filtration (glove boxes). HEPA filtration of ventilation systems is most desirable as noted in the Industrial Ventilation Manual issued by the American Conference of Governmental Industrial Hygienists.

Ventilation Hoods

Use the hood for all operations that might result in release of toxic chemical vapors, mists or dust. Leave the hood “on” when it is not in active use if storing toxic substances in it or if it is uncertain whether adequate maintenance of general laboratory ventilation exists when it is “off”.

All hoods shall meet the ventilation requirements as specified in the GRC Occupational Health Program Chapter 7, Local Exhaust Ventilation.

Confirm adequate hood performance before use. Compliant laboratory hoods shall have a green survey tag that indicates the hood velocity and an expiration date beyond the date of use. The sash height location at which adequate hood velocity was determined, or the height the flow was measured will be specified on the survey tag. Also, verify that continuous flow monitoring system is operational and showing the required flow (e.g.-for lab hoods 80 – 120 fpm). Contact the Industrial Hygiene Program Lead if the hood has a yellow or red survey tag, and for testing of hoods or interpretation of velocity testing results. Red or yellow tagged hoods shall not be used.

Do not use hoods for storage of large volumes of chemicals or equipment. If small volumes of chemicals must be stored in the hood, keep the volume stored to a minimum and do not allow materials to block vents or airflow.

If a work order is placed to repair or maintain a ventilation hood, the work order shall include any hazard information concerning the hood and applicable SDS for chemicals used or stored in the hood shall accompany the work order.

Autoclaves

Always use Autoclaves according to the manufacturers' specifications. Approval of the supervisor is necessary for any alteration of the autoclave to perform differently or for use with non-recommended materials. Submit a written Standard Operating Procedure to the applicable Safety Committee Chairman for a review of all changes.

Use all the proper personal protective equipment and apparel when autoclaving materials. The autoclave unit and the area require proper ventilation.

Centrifuges

Use all centrifuges according to the manufacturers' specifications. Each user must take extra care not to overfill the containers such that spills will occur during operation.

Use only the recommended containers with the centrifuge. The supervisor shall approve any alterations. Submit a written Standard Operating Procedure to the applicable Safety Committee Chairman for a review of all changes.

Furnaces

All furnaces must be used according to the manufacturer's specifications and must be properly vented. Proper PPE should be worn when conducting furnace activities and care should be taken no to disturb the furnace insulation. Please contact an Occupational Health Branch Industrial Hygienist for guidance or verification of flow-rates.

LABORATORY STANDARD OPERATING PROCEDURES

Each chemistry laboratory operation must have a written Laboratory Standard Operating Procedure (LSOP) for each distinct operation. Figure 1-1 presents the GRC outline for the content of a laboratory LSOP. Each laboratory will maintain a copy of its LSOP. In addition to describing safe operating practices, the LSOP shall also address regulatory compliance requirements. Each laboratory shall submit a copy of each LSOP to the Chemical Hygiene Officer. The LSOP shall be reviewed on an annual basis and/or updated whenever there is a change of operations in the lab. Decisions concerning expiration of the LSOP will be made at each annual review.

It is the responsibility of the designated Laboratory Contact to submit and revise the LSOP. The Laboratory Contact and the Chemical Hygiene Officer or Industrial Hygiene professional will review and approve each laboratory LSOP.

A Job Hazard Analysis (JHA), GRC239 form, shall be conducted for any short-term experimentation that does not qualify for an LSOP. In addition, GRC personnel currently engaged in research, manufacture, and operations involving nanomaterials shall complete a nanomaterial-specific hazard assessment by completing the GRC Nanomaterial SOP Form, GRC765; an industrial hygienist competent person shall review the GRC765 form and follow up with a site visit to review the exposure controls in place and address potential employee exposures. Completed GRC765 forms shall be made an addendum to, or referenced in, established hazard analysis documentation such as a LSOP, Safety Permit or Job Hazard Analysis. The GRC239 and GRC765 forms are available in the NASA Electronic Forms System, search "forms" on the Inside Glenn page.

FIGURE 1-1: Standard Operating Procedures Guide

LABORATORY STANDARD OPERATING PROCEDURES

Process Name: _____
Building #:_____
Laboratory Room #(s): _____
LSOP #: _____
Safety Permit #: _____
Issue Date: _____ Expiration Date: _____

Designated Contacts: **(names(s)** and phone number(s)) in case of emergency
EMERGENCY CALL NUMBER: 911 (Internal GRC phone only)
LABORATORY OFF-HOURS CONTACT: **name(s)** and phone number(s)
LABORATORY CONTACTS DURING DAY SHIFT:
name(s) and phone numbers

I. SUMMARY OF ACTIVITIES
II. SPECIFIC OPERATION PROCEDURES
II. A. Laboratory Operating Procedure
III. REGULATORY COMPLIANCE REQUIREMENTS
III. A. Environmental Compliance
- **Industrial Hygiene**
- **Water Discharges**
- **Air Emissions**
- **Waste Disposal**

III. B. Safety Compliance
IV. EMERGENCY RESPONSE PROCEDURES
V. REVISING THIS STANDARD OPERATING PROCEDURE

CHAPTER 2 - PERSONAL PROTECTIVE EQUIPMENT

PERSONAL PROTECTIVE EQUIPMENT

Read the Safety Data Sheet and Laboratory Standard Operating Procedure (LSOP) to determine the appropriate personal protective equipment (PPE) to use when working with hazardous chemicals. Consult with the Industrial Hygiene Program Lead for further guidance. PPE may include:

- Eye and face protection (e.g., goggles and face shields)
- Head protection (e.g., hard hats)
- Foot protection (e.g., safety shoes)
- Hand protection (e.g., gloves)
- Chemical-protective clothing (CPC; e.g., full body suits)
- Flame resistant garments
- Respiratory protection (e.g., respirators)

Do not use damaged or inappropriate PPE. Use only PPE compatible with the required level of performance for substances being handled. Use any other PPE and protective equipment, as appropriate, to minimize exposure to hazardous chemicals. Specific PPE requirements are to be listed in the LSOP.

Clean and maintain PPE before and after each use. Make sure that there are no tears or defects before using PPE.

Eye

Ensure that all persons wear the appropriate eye protection, including visitors, in areas of chemical storage or handling. Follow all procedures as specified in the Glenn Safety Manual, Chapter 15, Personal Protective Equipment, as revised. Eye wash stations are to be provided for emergency use.

Chemical goggles provide the best all-around protection against chemical splashes, vapors, dusts and mists. Goggles that have indirect vents or are not vented provide the most protection. If using a laser, wear safety glasses or goggles which provide protection against the specific wavelength of that laser. If there is a risk of an exothermic reaction or explosion, both safety goggles with a face-shield should be worn.

Prescription glasses do not provide adequate protection in a laboratory setting. Prescription safety glasses can be used with the appropriate goggles for maximum eye protection.

Contact lenses offer no protection against eye injury and are not an acceptable substitute for safety glasses and/or chemical splash goggles. If an individual chooses to wear contact lenses in the laboratory, chemical splash goggles must be worn to protect against both vapors and splash hazards. Contact lenses shall not be worn if the following chemicals are being used in the lab:

* 1, 2-dibromo-3-chloropropane (DBCP): OSHA regulation (1910.1044 App A)
* 4, 4’-methylene dianiline: OSHA regulation (1910.1050 App. A)
* * Ethylene oxide: OSHA regulation (1910.1047 App. A)
* * Methylene chloride: OSHA regulation (1910.1052 App. A)
* Any other chemical in which the literature or the SDS recommends or requires that contact lenses not be worn

Hearing

Use hearing protection when needed as specified in the GRC Occupational Health Program Manual, Chapter 3, Hearing Conservation Program. Check with the Occupational Health Branch for details and applicability.

Respiratory

When engineering controls cannot sufficiently control employee exposures to airborne contaminant concentrations, employees shall use appropriate respiratory protection equipment, as identified by the SHeD OHB. Respiratory

protection may be necessary for nanomaterial usage. Contact an OHB Industrial Hygienist for exposure monitoring and a determination of respiratory equipment needs.

Respiratory protection users must be enrolled in a Respiratory Protection Program and comply with NASA respiratory protection policies as specified in the GRC Occupational Health Program Manual, Chapter 4: Respiratory Protection. Remember to inspect your respirator and perform a user seal check before each use and comply with the respirator selection and cartridge change schedule as issued by SHeD OHB.

Clothing

Confine long hair and loose clothing, such as neckties, scarves, etc., to ensure that they cannot become contaminated, with a hazardous material, causing exposure or an accident through incidental contact. Wear a laboratory coat when working with chemicals. Remove the laboratory coat immediately upon significant contamination. Laboratory coats, when not in use, shall be kept in the laboratory or other designated area. Have laboratory coats professionally laundered frequently to avoid chemical build-up and possible exposure. A contaminated lab coat shall not be worn outside of the lab for any reason.

Rubber coated aprons should be worn to protect against chemical splashes especially when using corrosive materials. If worn, an apron should be worn over a laboratory coat for additional protection.

Face shields can protect against impact, dust, particulates, and chemical splashes for the face, eyes and throat. Always wear additional eyewear such as goggles underneath a face shield because the face shield only offers protection against impact and splashes. Chemical vapors and splashes can still travel under and around a face shield. If scratches or cracks are noticed in the face shield, replace the window.

Gloves

Wear appropriate gloves when the potential for skin contact or skin absorption with toxic materials exists. If unsure, please contact a SHeD industrial hygienist or a manufacturer for appropriate glove selection. Inspect gloves for defects before each use. Reusable gloves shall be washed using potable water before removal and replaced periodically. If potable water hand wash facilities are not available inside the lab, disposable gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab.

Shoes

Always wear substantial protective shoes in the laboratory. Do not wear sandals, perforated shoes or sneakers at any time in the lab because these types of shoes do not form a good barrier against chemical exposure. Safety shoe material shall be of leather or other non-permeable safety shoe material.

CONTROL OF NANOMATERIALS

Personal protective equipment may be necessary for nanomaterials usage and may include respiratory protection, gloves, lab coats and eye protection, as discussed above. Contaminated clothing shall be rinsed off, laundered or disposed of as appropriate.

The following are examples of actions to be taken to ensure control of employee exposure to nanomaterials via inhalation, penetration of the skin or eyes, and ingestion via hand to mouth contact. Nanomaterials tasks shall be planned to control and prevent employee exposures, and the contamination of work surfaces and equipment. Facility and equipment work surfaces shall be cleaned of contamination at the end of the task or shift by good housekeeping practices, including wet wiping and HEPA vacuuming. Dry sweeping and use of a compressed air hose for cleaning is prohibited.

- Hand washing is required before eating, drinking, smoking, and leaving work.
- Handling liquids that contain nanomaterials: use appropriate gloves.
- Performing liquid operations that generate aerosols: use enclosures, local exhaust ventilation.
- Handling powders: use enclosed or local exhaust ventilation systems. Sticky mats may be used for areas outside nano material dry powder operations. Contamination at the end of the task or shift shall be addressed

by good housekeeping practices, including HEPA vacuuming and wet wiping. Wet wipes shall be bagged so as not to re-aerosolize products.

- Machining, grinding, sanding products with nanomaterials: use enclosures, local exhaust ventilation. Dust collection systems should include HEPA filtration.
- Generating gas-phase aerosols: use enclosed systems.
- Performing ventilation maintenance tasks such as filter changes and cleaning dust collection systems: inform maintenance of the nanomaterial hazard on Work Order request; the nanomaterial hazard reference will ensure the work procedure includes a GRC Health and Safety Plan (HASP) which reviewed by the OHB.

Although not fully known, nanomaterials may pose a risk of fire, explosion, and/or catalytic reaction because of the surface area and their unique properties. Physical hazards must be considered prior to use of nanomaterials.

EMERGENCY EQUIPMENT

These are to be available for each laboratory:

An easily accessible drench-type safety shower supplied with potable water;
An eyewash fountain supplied with potable water;
A fire extinguisher;
Access to a nearby fire alarm and telephone for emergency use; and
Other items designated by the laboratory supervisor.

If all of the above protective equipment is not available in the laboratory, the Operational Safety Branch, the Chemical Hygiene Officer, the area supervisor and the laboratory manager will make a determination of the steps taken to either to upgrade the laboratory or to find alternative protective equipment that will ensure comparable safety and hygiene.

All of the protective equipment listed above may not be feasible based on laboratory set-up or size, or in some cases, may result in an increased risk to the employee. In such cases, the SHeD Operational Safety Branch, the Chemical Hygiene Officer and the laboratory manager will determine alternative protective equipment to ensure that the employee has a safe and healthful laboratory.

With the assistance of the SHeD Operational Safety Branch, the laboratory manager is responsible of ensuring that all protective/emergency equipment is inspected regularly. The laboratory supervisor, the SHeD Operational Safety Branch and the Chemical Hygiene Officer may examine equipment during scheduled and unscheduled inspections for cleanliness, functionality and employee ease of access.

EMERGENCY EQUIPMENT AND PPE

Special emergency equipment and PPE determined to be necessary for each laboratory is to be available from NASA or the SSC employer. Employees shall be trained in its proper use and should be included in each LSOP.

The use of certain highly toxic chemicals, such as hydrofluoric acid or certain cyanide compounds, may require that first aid antidote kits be readily available near to where an exposure could occur. These first aid antidote kits are to be used until emergency medical assistance arrives. It is the responsibility of the laboratory manager to ensure that the kits are acquired before the use of these chemical begins; the expiration dates of the kits are monitored; and personnel are trained in the proper use of the kits.

TRAINING

All users of personal protective equipment and apparel shall be properly trained in the selection and use. Contact the Industrial Hygiene Program Lead or the SHeD Operational Safety Branch PPE manager for information on selection and training.

CHAPTER 3 - SPILLS AND ACCIDENTS

Glenn Research Center takes spills and accidents very seriously. The Center continues to take steps to reduce the risk of spills and accidents. In addition, there is an Emergency Preparedness Plan and an Emergency Response Team to reduce the scope of any accident or incident at the Center. Always take all steps to reduce the risk of spills and accidents in the laboratories.

SPILL CONTROL

Large Scale Spills and Accidents

In the event of a spill, determine the risk to yourself and others in the building. If no risk, dial Waste Management at (216) 433-2124 and SHeD at (216) 433-3016 or refer to the LSOP if it contains a spill containment plan.

If the material poses a risk to health or life, evacuate the area or building. In the case of a severe hazard, immediately call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222), from a safe location. Apprise the dispatcher of the situation, including location of the spill, size of spill, material spilled, known hazards of the material, also if the hazard is increasing with time.

A large spill will be defined by the type and amount of chemical that has been spilled. A spill will be defined as a large spill when it meets ANY of the following specifications:

- The material is identified in the LSOP as a hazardous substance and includes spill cleanup criteria.
- The spill is too large for you to handle
- The spill involves more than 500-mL of any hazardous materials
- The spill involves ANY amount of the following materials:
    - Strong acids such as hydrofluoric, fuming sulfuric, perchloric, red nitric or any acid that could emit gases
    - Strong bases concentrated enough to emit vapors such as ammonium hydroxide
    - Inhalation poisons that emit vapors or gases at room temperature and are highly toxic such as isocyanates and formates
    - Reactive compounds such as organic peroxides or phosphorous metal that are sensitive to air, shock, friction, water or temperature.
    - Mercury in any form
    - Radioactive materials
    - Biological materials
    - Extremely toxic substances that can be absorbed through the skin and are extremely toxic at low concentrations such as benzene and sodium cyanide.
- A large volume of nanomaterials.

For all large spills and accidents call the GRC Dispatcher at 911 (internal GRC phone only, or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222)) from a safe location. Give as much information regarding the incident as possible and follow instructions given until help arrives. Written emergency spill and accident plans, Glenn Safety Manual, Chapter 21, Mishap Reporting/Accident Investigation, as revised, and Glenn Safety Manual, Chapter 27, Building Emergency Evacuation Plan Program, as revised, include consideration of prevention, containment, clean-up and reporting. All personnel are to act in accordance with the plans

There is an audible alarm system in all parts of the laboratory buildings including isolation areas such as cold rooms. On the sound of the alarm, all persons are to secure the area and evacuate until SHeD or the first responders allows reentry.

Simple Spills and Accidents

A simple spill is classified by a spill that does not meet any of the criteria of a large spill as detailed above. Simple spills do not necessarily require assistance. Laboratory workers who have had the proper training and possess the

appropriate equipment can safely and effectively handle simple spills but if you are unsure of the proper techniques or safety protocols to follow call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222). Contact SHeD with any additional questions or concerns about a spill clean-up activity at (216) 433-3016 and Waste Management concerning waste disposal.

For a small-scale nanomaterial spill, it shall be cleaned up by using the appropriate PPE. Approaches to cleaning up these spills include the use of HEPA-filtered vacuum cleaners, wetting powders complete with surfactant, wetted cloths, and the application of absorbent materials.

Spill Control Plan

As appropriate, each laboratory shall develop its spill control plan. Spill control kits shall be available where appropriate. Laboratory personnel shall be aware of the proper use of spill kits. A highly detailed spill control plan is necessary when working with the following:

aromatic amines;
biological materials;
carbon disulfides;
corrosives;
ethers;
flammable, volatile, or toxic chemicals;
hydrazine;
mercury;
nano-materials;
acids and bases;
nitro and nitrite compounds; and
radioactive materials.

Promptly clean spills, using appropriate protective apparel and equipment and proper disposal. Never attempt to cleanup a spill if you have any doubt as to the safety or proper protocol. If a spill reaches a drain inside a lab or anywhere outside a building, follow the large spill and accidents procedures.

Pyrophoric or Water-Reactive Spills

Call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222) immediately if a spill occurs with a pyrophoric or water-reactive material or if these types of materials are near the spill. Pyrophoric and water-reactive materials pose a greater threat to the safety and health of the responders to the spill.

Nanomaterial Spills

Small -scale material spills shall be cleaned up by using the appropriate PPE. Approaches to cleaning up these spills include the use of HEPA-filtered vacuum cleaners, wetting powders complete with surfactant, wetted cloths, and the application of absorbent materials.

Evacuation of Disabled Employees

If there is a spill or accident, take special care to ensure the safety and health of any disabled person(s) in the laboratory. Laboratory supervisors shall ensure that the procedures specified in the Glenn Safety Manual, Chapter 27, Appendix A: Emergency Evacuation Procedures for Employees with Disabilities, as revised, are in place to evacuate any disabled employee from the laboratory area in an emergency. This plan can be found in the Glenn Safety Manual, Chapter 27.

ACCIDENTS

All laboratory standard operating procedures should include control measures and emergency response procedures if there is fire, explosion, flooding, ventilation system shutdown, or any other natural catastrophe that may affect the chemicals in the laboratory. IF THERE IS AN ACCIDENT YOU ARE REQUIRED TO:

1) Call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222) in the case of any accident.

2) In addition, report all mishaps and close calls within 24 hours in the NASA Mishap Information system (NMIS). Even without an account, you can report an incident using this system. https://nmis.sma.nasa.gov/

A close call is an event that has the potential to cause a mishap, but results in no injury, minor injury requiring first aid only, and less than $20,000 in equipment and property damage.

The Safety and Health Division (SHeD) carefully analyzes all mishap and close call reports to improve safety. A mishap investigation will be completed to determine cause and what should be done to prevent recurrence. Analysis of close calls allows SHeD to decide if there are preventive measures that could be established to reduce the number and severity of mishaps.

DRILLS

The SHeD Operational Safety Branch conducts annual emergency evacuation drills and recommends improvements in the evacuation method.

FIRST AID

If feasible, it is recommended that two people per work shift, within each laboratory or work area, have emergency first aid response training. First aid training shall include cardio-pulmonary resuscitation (CPR) and potentially Blood-Borne Pathogen awareness training

Unless otherwise specified in the standard operating procedure, follow these first aid and clean-up measures if there is an accident or major spill:

Step 1: Call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222), from a safe location.

Step 2: Unless otherwise specified, follow these interim first aid measures while waiting for help to arrive if there is chemical exposure:

Eye contact: Promptly flush eyes with potable water for a prolonged period (15 minutes minimum) and obtain medical attention.
Skin contact: Promptly flush the affected area with copious amounts of potable water for at least 15 minutes and remove any contaminated clothing. If symptoms persist after washing, obtain medical attention.
Inhalation: Remove victim to fresh air. If not breathing, give mouth-to-mouth resuscitation. Obtain medical attention.
Ingestion: Encourage the victim to drink large amounts of potable water. Obtain medical attention. Do not force liquids through the mouth of an unconscious person.

CHAPTER 4 - STORAGE

Store all chemicals properly. Refer to the Safety Data Sheet or obtain additional information where appropriate for special storage requirements of hazardous chemicals. Avoid storage of hazardous chemicals on bench tops and in hoods. Amounts of hazardous chemicals permitted for storage in the laboratory are to be as small as practical.

Store containers of hazardous chemicals in a well-ventilated, limited access area. Avoid exposure of hazardous chemicals to heat or direct sunlight. Store hazardous chemical containers in appropriately labeled, rugged, chemically resistant, secondary containers whenever the material poses a high health or safety hazard. (Refer to the chapters in this plan: Moderately Chronic or Highly Acute Toxicity Materials and Highly Chronic Toxicity Materials.) Hazardous chemicals shall be stored in location that minimizes the possibility of hazardous vapors entering a building ventilation system. Hazardous chemicals storage considerations shall include temperature, ignition sources, ventilation, segregation and identification.

Compressed gas cylinders shall be stored and handled in accordance with OSHA 1910.101, NASA STD-8719.11, and the Compressed Gas Association requirements. Hazardous Materials shall be stored in accordance with OSHA 1910.1200, 1910.1450, NPR 8715.1, NASA STD-8719.11, NASA STD-8719.12, or any local or state requirements, as applicable.

CHEMICAL INVENTORY

An inventory of hazardous chemicals, with the assistance or oversight from personnel designated by the Chemical Management Team, will be conducted at the frequency described below. During this inventory unneeded and unused items will be evaluated. If chemicals are no longer needed in the laboratory, properly discard the chemical (see the GRC Environmental Programs Manual, Chapter 5, Waste Disposal). Chemical Management shall maintain the chemical inventory database as specified in the GRC Hazard Communication Program.

The chemical inventory will be maintained through daily maintenance and a cyclical wall-to-wall inventory. Chemicals that exceed the manufacturer's expiration date must be properly disposed unless an expired chemical review is requested and granted. An expired chemical review will extend the chemical's expiration date for one year. After one year, the owner will need to request an additional extension. All chemical storage areas and cabinets shall be inspected at least quarterly by the manager of the storage area or storage cabinet, or his/her designated representative, to verify integrity of the cabinet and storage shelving and safe storage of hazardous chemicals.

INCOMPATIBLE CHEMICALS

The term 'incompatible chemicals' refers to chemicals that can react with each other:

- Violently; or
- With evolution of substantial heat; or
- To produce flammable products; or
- To produce toxic products.

Handle, store and pack incompatible chemicals so that they cannot accidentally contact each other.

For guidelines for common laboratory chemicals that are incompatible and which need segregation refer to Tables 4-1 and 4-2. Table 4-1 lists general classes of compounds that require separate storage areas. Table 4-2 lists specific compounds that can pose reactivity hazards. Keep chemicals in each grouping in column A of each table separate from each grouping in column B.

> NOTE*: The safety risks of many engineered nanomaterials are not yet fully understood and may pose inherent safety risks beyond those indicated by the safety hazards of traditional materials. In the case of some metals, explosion risk can increase significantly as particle size decreases.*

TABLE 4-1: GENERAL CLASSES OF INCOMPATIBLE CHEMICALS

CHEMICAL GROUP (FAMILY)	INCOMPATABLE WITH:
Acids	Bases
Oxidizing agents[a] Chlorates Chromates Chromium trioxide Dichromates Halogens Halogenating agents Hydrogen peroxide Nitric acid Nitrates Perchlorates Peroxides Permanganates Persulfates	Reducing agents[a] Ammonia, anhydrous and aqueous Carbon Metals Metal hydrides Nitrites Organic compounds Phosphorus Silicon Sulfur

[a] The examples of oxidizing and reducing agents illustrate common laboratory chemicals. They are not exhaustive.

TABLE 4-2: SPECIFIC CHEMICAL INCOMPATIBILITIES

CHEMICAL (GROUP)	INCOMPATABLE WITH:
Acetylene and monosubstituted acetylenes	Group IB and IIB metals and their salts
Halogens	Halogenating agents
Ammonia, anhydrous and aqueous	Halogens and Halogenating agents Mercury Silver
Alkali and alkaline earth Carbides Hydrides Hydroxides Metals Oxides and peroxides	Water Acids Halogenated organic compounds Halogenating agents Oxidizing agents
Azides, inorganic	Acids Heavy metals and their salts Oxidizing agents[a]
Cyanides, inorganic	Acids Strong bases
Mercury and its amalgams	Acetylene Ammonia, anhydrous and aqueous Nitric acid Sodium azide
Nitrates, inorganic	Acids Reducing agents[a]
Nitric acid	Bases Chromic acid Chromates Metals Permanganates Reducing agents Sulfides Sulfuric acid
Nitrites, inorganic	Acids Oxidizing agents[a]

[a] See list of examples in Table 4-1.

POTENTIALLY EXPLOSIVE CHEMICALS AND REAGENT COMBINATIONS

Table 4-3 lists some common classes of laboratory chemicals that have potential for producing a violent explosion when subjected to shock or friction. Table 4-3 also lists a few illustrative combinations of common laboratory reagents that can produce explosions when they contact each other or that give reaction products that can explode without any apparent external initiating action. This list is not exhaustive.

TABLE 4-3: SHOCK-SENSITIVE COMPOUNDS

- Alkyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerin
- Alkyl and acyl nitrites
- Alkyl perchlorates
- Amine metal oxosalts; metal compounds with coordinated ammonia, hydrazine, or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate or other oxidizing group
- Azides, including metal, nonmetal and organic azides
- Chlorite salts of metals, such as $AgClO_2$ and $Hg(ClO_2)_2$
- Diazo compounds such as CH_2N_2
- Diazonium salts, when dry
- Fulminates (silver fulminate, AgCNO, can form in the reaction mixture from the Tollens' test for aldehydes if it is allowed to stand for some time. This can be prevented by adding dilute nitric acid to the test mixture as soon as the test has been completed.
- Hydrogen peroxide becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals
- N-Halogen compounds such as difluoroamino compounds and halogen azides
- N-Nitro compounds such as N-nitromethylamine, nitrourea, nitroguanidine and nitric amide
- Oxo salts of nitrogenous bases: perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia amines, hydroxylamine, guanidine, etc
- Perchlorate salts. Most metal, nonmetal and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials
- Peroxides and hydroperoxides, organic
- Peroxides (solid) that crystallize from or are left from evaporation of peroxidizable solvents
- Peroxides, transition-metal salts
- Picrates, especially salts of transition and heavy metals, such as Ni, Pb, Hg, Cu and Zn. Picric acid is explosive but is less sensitive to shock or friction than its metal salts and is relatively safe as a water-wet paste
- Polynitroalkyl compounds such as tetranitromethane and dinitroacetonitrile
- Polynitroaromatic compounds, especially polynitro hydrocarbons, phenols and amines

WATER-REACTIVE CHEMICALS

Table 4-4 lists some common laboratory chemicals that react violently with water and that shall always be stored and handled so that they do not come into contact with liquid water or water vapor. These chemicals are prohibited from landfill disposal, even in a lab pack, because of the characteristic of reactivity.

TABLE 4-4: WATER-REACTIVE CHEMICALS

- Alkali metals
- Alkali metal hydrides
- Alkali metal amides
- Alkyl silanes
- Metal alkyls, such as lithium alkyls and aluminum alkyls
- Grignard reagents
- Halides of nonmetals, such as $POCl_3$, $SOCl_3$, SO_2Cl_2
- Inorganic halides, such as $POCl_3$, $SOCl_3$, SO_2Cl_2
- Anhydrous metal halides, such as $AlCl_3$, $TiCl_4$, $ZrCl_4$, $SnCl_4$
- Phosphorus pentoxide
- Calcium carbide
- Organic acid halides and anhydrides of low molecular weight

PYROPHORIC CHEMICALS

Store pyrophoric chemicals in tightly closed containers under inert atmosphere (or, for some, an inert liquid), and carry out all transfers and manipulations of them under an inert atmosphere or liquid. Pyrophoric chemicals cannot be put into a landfill because of the characteristic of reactivity. For information on pyrophoric nanomaterials: https://link.springer.com/chapter/10.1007/978-3-319-59208-4_5 Table 4-5 contains a listing of some pyrophoric chemicals.

TABLE 4-5: PYROPHORIC CHEMICALS

- Alkyl silanes
- Grignard reagents
- Metal alkyls and aryls, such as R_3Al, R_2Zn
- Metal carbonyls, such as $Ni(CO)_4$, $Fe(CO)_5$, $Co_2(CO)_8$
- Metal powders, such as Al, Co, Fe, Mg, Mn, Pd, Ti, Sn, Zn, Zr
- Metal hydrides, such as NaH, $LiAlH_4$
- Nonmetal hydrides, such as B_2H_6 and other boranes, PH_3, AsH_3
- Nonmetal alkyls, such as R_3B, R_3P, R_3As
- Phosphorus (white)

PEROXIDE-FORMING CHEMICALS

Many common laboratory chemicals can form peroxides over time when exposed to air. A single opening of a container to remove some of the contents can introduce enough air for peroxide formation to occur. Some types of compounds form peroxides that are treacherously and violently explosive in concentrated solutions or as solids. Accordingly, never evaporate to dryness peroxide-containing liquids. Peroxide formation can also occur in many polymerizable unsaturated compounds, and these peroxides can initiate a runaway, sometimes explosive polymerization reaction. Any peroxidizable chemical with visible discoloration, crystallization, or liquid stratification shall be treated as potentially explosive. Call the Waste Management Team for immediate assistance. All containers of peroxide-forming chemicals shall be labeled with the date the chemical was received and the date the container was opened. Peroxide-forming chemicals shall not be distilled to dryness.

Table 4-6 provides a list of chemical moieties that are most likely to form peroxides. Please refer to the NASA Safety Standard for Explosives, Propellants and Pyrotechnics for a comprehensive list of peroxide forming chemicals.

TABLE 4-6: MOIETIES THAT CAN FORM ORGANIC PEROXIDES

1.Ethers and acetals with α-hydrogen	6.Vinyl alkynes with α-hydrogen	11.Secondary alcohols
2.Alkenes with alyllic hydrogen	7.Alkylalkynes with α-hydrogen	12.Ketones with α-hydrogen
3.Chloroalkenes, fluoroalkenes	8.Alkylalkynes with tertiary α-hydrogen	13.Aldehydes
4.Vinyl halides, esters, ethers	9.Alkanes and cycloalkanes with tertiary α-hydrogen	14.Ureas, amides and lactams with α-hydrogen atom on a carbon attached to nitrogen
5.Dienes	10.Acrylates, methacrylates	

Containers shall be used or discarded by the manufacturer's expiration date, if the expiration date is available. If there is no expiration date identified on the container, containers shall be tested or stored as described below:

- Test chemicals in Groups 1 through 7 (as identified in TABLE 4-6) within 12 months of receipt and every 6 months thereafter. Discard or deperoxidize if peroxides are detected.
- Test chemicals in Groups 8 through 14 (as identified in TABLE 4-6) within 12 months of opening and every 6 months thereafter. Discard or deperoxidize if peroxides are detected.
- Uninhibited chemicals shall be stored for $\leq$ 5 days.
- If inhibited, chemicals may be stored for 12 months.

Testing may be done using a peroxide detection test strip, follow manufacturer's directions.
Compounds listed in Tables 4-6 through 4-8 shall always be tested for peroxides prior to distillation.
Rusted or stuck caps on a container of peroxide-forming chemical shall not be forced.

TABLE 4-7: CHEMICALS THAT FORM POTENTIALLY EXPLOSIVE PEROXIDES WITHOUT CONCENTRATION[a]

Butadiene[b]	Chloroprene[c]
Divinyl acetylene	IsoPropyl ether
Tetrafluoroethylene[b]	Vinylidene chloride

[a]Materials other than those listed may form peroxides.
[b]When stored in an inhabited liquid monomer.
[c]When stored in a liquid monomer.

Materials that may spontaneously form peroxides that will make the material shock- or heat-sensitive "on the shelf", without any further concentrations through evaporation or distillation shall have a three-month storage limit and they shall be stored under nitrogen.

TABLE 4-8: CHEMICALS THAT FORM POTENTIALLY EXPLOSIVE PEROXIDES ON CONCENTRATION[a,b]

Acetal	Acetaldehyde
Benzyl alcohol	2-Butanol
Cyclohexanol	2-Cyclohexen-1-ol
Cumene	Decahydronaphthalene
Diethyl ether	Diethylene glycol dimethyl ether (Diglyme)
Dioxanes	Ethylene glycol dimethyl ether (Glyme)
4-Heptanol	Methyl acetylene
Methyl isobutyl ketone	3-Methyl-1-butanol
Methyl cyclopentane	2-Pentanol
4-Pentene-1-ol	1-Phenylethanol
2-Phenylethanol	2-Propanol (isoPropanol)
Tetrahydrofuran	Tetrahydronaphthalene
Vinyl ethers	Other secondary alcohols

[a]Materials other than those listed may form peroxides.
[b]Warning! May become unstable if concentrated intentionally or accidentally by the user.

TABLE 4-9: CHEMICALS THAT AUTOPOLYMERIZE[a]

Acrylic acid	Acrylonitrile
Butadiene[b]	Chloroprene
Chlorotrifluoroethylene	Ethyl methacrylate
Styrene	Tetrafluoroethylene
Vinyl acetate	Vinyl acetylene
Vinyl chloride	Vinyl pyridine

[a]Materials other than those listed may form peroxides.
[b]When stored as a gas.

These compounds may autopolymerize (and thus explode) when relatively small quantities of peroxides are formed.

STORAGE UNITS

Chemical Storage Cabinets

A large variety of storage cabinets are on-site at GRC. Use these cabinets to store chemicals that are relatively inert, pose no undue hazard in storage and are compatible with other chemicals stored there. Each cabinet shall be clearly labeled as to the hazard class of the materials stored within the cabinet (e.g., Acids, Flammables, etc.). Each cabinet or room/area, as appropriate, shall be labeled with the name, phone number, and organizational code of the responsible person(s). Each cabinet must be rated for use with the hazard class of the most hazardous content stored.

Review the chemicals in all storage cabinets regularly (at least annually) for continued need. Address broken, leaking or bulging containers of chemicals immediately upon discovery. Make an evaluation to determine if the material needs repackaging with an appropriate label affixed or if the material needs disposal. At Lewis Field and Neil A. Armstrong Test Facility (ATF), complete a Form C-260a, Waste Disposal Request, to notify the Waste Management Program Lead that you wish to dispose of chemicals that are no longer used or needed. Waste Management will then come to your location to pick up the waste and containers.

Keep all storage cabinets in good working order. Clean all small spills and leaks immediately.

Ensure that sufficient capacity is available in each cabinet to ensure that there is enough volume to contain a spill of the largest container, either using trays for each shelf or the bottom of the cabinet spill catch, in case it is broken. No chemical storage cabinet will be overcrowded.

Ensure that all cabinets, laboratory refrigerators and freezers are labeled with the owner, organization and phone number or the laboratory or storage area is labeled with the information at the entrance to the area.

Flammable Storage Cabinets

Only flammable or combustible materials should be stored in flammable storage cabinets. Do not overload flammable cabinets with chemicals. Flammable storage cabinets must be listed with an approved testing laboratory (UL, FM, etc.) for the intended use.

Because the risk of fire is great, do not vent flammable storage cabinets. Upon review by Chemical Hygiene Officer, ventilation of a flammable storage cabinet may be recommended if health hazards are determined to be more severe than the risk of fire. Do not store highly chronic toxicity materials in the same cabinet with other flammable materials.

Corrosive Cabinets

Designate each corrosive cabinet as an acid or base cabinet. Contact Chemical Management for labeling needs. The acid or base cabinet shall also have a spill catch and be made of a material not easily attacked by the acid or base. Never store both acids and bases in the same corrosive cabinet.

Acid Cabinets

Acid cabinets shall have a spill catch and be of a material not easily attacked by the acid. Acid cabinets may be vented.

Not all acids are compatible for storage in the same cabinet. Be careful to store nitric acid in a cabinet away from chromic acids and sulfuric acids (See Table 4-2). In addition, Glacial Acetic Acid is considered an organic acid and should be stored in a flammable cabinet away from other acids and oxidizers.

Base Cabinets

Designate each corrosive cabinet as an acid or base cabinet. Contact the Chemical Management Program Lead for labeling needs. Base cabinets may be vented. The base cabinet shall also have a spill catch and be made of a material not easily attacked by the base. Never store both acids and bases in the same corrosive cabinet.

Refrigerators

There may be materials in use at the Center that are not stable at room temperatures. In these cases, a refrigerator or freezer is necessary for safe storage. There are also refrigerators used for chemical storage that merely extend the shelf life of contents. All chemical storage refrigerators shall be labeled, “For Chemical Use Only”. NO FOOD OR BEVERAGES may be stored in refrigerators designated for chemical use. Standard Operating Procedures for the laboratory shall include all emergency procedures required for refrigerators during a power outage, if necessary, to avoid a hazardous condition. These procedures may include providing a back-up power supply. Chemicals stored in explosion-proof refrigerators or cold rooms shall be sealed and labeled with the name of the responsible person(s) and contact information.

HAZBINS

HAZBINs are typically used to store chemicals outdoors. These storage units shall be inspected on a regular basis. Each lab that uses a HAZBIN shall include adequate instructions on their use.

CHAPTER 5 - WASTE DISPOSAL

GENERAL

The GRC Environmental Programs Manual, Chapter 5, Management of Hazardous Materials and Waste for Reuse, Recycling or Disposal, (https://nasa.sharepoint.com/sites/grc-f/SitePages/fe.aspx) as revised, specifies how to collect, segregate, store and transport waste. Transport from the Center shall be in accordance with U.S. Department of Transportation (DOT) regulations. All laboratory workers shall comply with the proper disposal methods as stipulated in Chapter 5 of the Environmental Programs Manual.

DISCARDING CHEMICAL STOCK

Unlabeled containers of chemicals and solutions shall be properly labeled or shall undergo prompt disposal.

Before a worker's employment in the laboratory ends, return all the chemicals for which that person was responsible, with appropriate labeling, to storage or discard, or reassign to another laboratory worker.

METHOD OF DISPOSAL

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Center. Use existing waste disposal programs. Do not use hoods as a means of disposal for volatile chemicals. Call the Waste Management Program Lead at (216) 433-2124 with any questions on how to dispose of a hazardous chemical.

Use disposal by recycling or chemical decontamination when possible. Check with the Waste Management Program Lead to ensure that procedures are acceptable and within the scope of the regulations as well as GRC policies.

FREQUENCY OF DISPOSAL

Remove waste from laboratories to a central waste area at least once per week. Remove waste from the central waste storage area at regular intervals established by the Waste Management Team.

DISPOSAL PLANS FOR SPECIFIC CHEMICAL CATEGORIES

At Lewis Field, complete a NASA Form C-260a, Waste Disposal Request, for disposal of chemicals. The form is available through the NASA Web page URL https://nef.nasa.gov/nef/. Use the Forms search engine to search for Form "GRC260a."

Contact Waste Management Program Lead at (216) 433-2124 for proper disposal procedures.

DISPOSAL INTO THE SEWER

The Center will not tolerate indiscriminate disposal by pouring waste chemicals down the drain or adding them to mixed refuse for landfill burial. This behavior is unacceptable and illegal.

Do not discharge in the sewer concentrated acids or bases; highly toxic malodorous (bad smelling) or lachrymatory (tear causing) substances or any substance that might interfere with the biological activity of wastewater treatment plants; create a fire or explosion hazard; cause structural damage or obstruct flow.

Follow all the procedures for disposal of chemicals as specified in the GRC Environmental Programs Manual, Chapter 5, Management of Hazardous Materials and Waste for Reuse, Recycling or Disposal.

CHAPTER 6 - SIGNS AND LABELS

SIGNS

Post prominent signs and labels of the following type in a conspicuous place:

- Emergency telephone numbers of emergency personnel, building managers, supervisors and laboratory workers;
- Identity labels showing contents of containers (including waste receptacles) and associated hazards;
- Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits and areas where food and beverage consumption are permitted; and
- Warning at areas of equipment where special or unusual hazards exist.

The SHeD Occupational Health Branch can provide consultation on appropriate signage. It is the responsibility of the lab manager or supervisor to procure all signs.

CHEMICAL LABELS

Label all hazardous chemicals, including nanomaterials, with the name of the chemical and the hazard warnings appropriate to the material. GRC labels are available from Chemical Management. Labels can also be requested using Form NASA C-375 through the GRC Web page https://nef.nasa.gov/nef/ Use the Forms search engine to search for Form "GRC375."

All vats, tanks and other types of vessels containing hazardous chemicals shall be labeled in accordance with the Hazard Communication Standard, 29 CFR 1910.1200. A label or a placard containing the name of the chemical and the hazard warnings shall be displayed where it is unmistakably associated with the vessel.

CHAPTER 7 - HOUSEKEEPING, MAINTENANCE AND INSPECTIONS

HOUSEKEEPING

Laboratories shall be kept clean. All chemicals that are not being used shall be stored properly. Bench tops shall be kept clean and uncluttered. All fume hoods shall be kept clean and uncluttered.

Clean floors regularly. Clean bench tops immediately if contaminated. Dispose of all contaminated cleaning materials properly.

Do not use passageways, stairways and hallways as storage areas. Never block accesses to exits, emergency equipment and utility controls.

MAINTENANCE

Eyewash Stations:

Inspect eyewash stations at intervals of not less than once per year. The flow rate of the eye wash station (0.4 gallons of potable water per minute) shall be checked during the annual inspection. The flow rate shall be available for a minimum of 15 minutes. The Institutional Maintenance Contractor shall conduct the annual inspections and record the results on tags attached to each eyewash station.

In addition to the annual inspection, plumbed eyewash stations shall be activated weekly by the users to verify proper operation (ANSI. Z 358.1-2014). The weekly test shall entail a quick activation of the eyewash station to ensure that water flow is unimpeded or that the water line has not been damaged or closed and that the temperature of the water is not too hot or too cold. Each eyewash station should have a checklist to ensure that it has been activated on a weekly basis and should be used to document the weekly check, an example of a Weekly Eyewash/Safety Shower form (Form C-196) is included as an appendix at the end of this document.

Safety Showers:

Test safety showers not less than once a year. The flow rate of the safety shower (20.0 gallons of potable water per minute) shall be checked during the inspection. This flow rate shall be available for a minimum of 15 minutes. The Institutional Maintenance Contractor shall conduct the inspections and record the results on tags attached to each safety shower. Inspect other safety equipment regularly; no less than once a year or when a new use arises. The SHeD Operational Safety Branch is available to confirm the proper operation of safety equipment when initially installed.

In addition to the annual inspection, plumbed safety showers shall be activated weekly by the users to verify proper operation (ANSI. Z 358.1-2014). The weekly test shall entail a quick activation of the safety shower to ensure that water flow is unimpeded or that the water line has not been damaged or closed and that the temperature of the water is not too hot or too cold. Each safety shower should have a checklist to ensure that it has been activated on a weekly basis and should be used to document the weekly check, an example of a Weekly Eyewash/Safety Shower form (Form C-196) is included as an appendix at the end of this document.

Drench Hoses:

Test drench hoses not less than once a year. The flow rate of a drench hose should be, at a minimum, 0.4 gallons of potable water per minute and shall be checked during the annual inspection. This flow rate shall be available for a minimum of 15 minutes. The Institutional Maintenance Contractor shall conduct the inspections and record the results on tags attached to each safety shower. Inspect other safety equipment regularly; no less than once a year or when a new use arises. The SHeD Operational Safety Branch is available to confirm the proper operation of safety equipment when initially installed.

In addition to the annual inspection, drench hoses shall be activated weekly by the users to verify proper operation (ANSI. Z 358.1-2014). The weekly test shall entail a quick activation of the safety shower to ensure that water flow is unimpeded or that the water line has not been damaged or closed and that the temperature of the water is not too hot or

too cold. Each safety shower should have a checklist to ensure that it has been activated on a weekly basis and should be used to document the weekly check, an example of a Weekly Eyewash/Safety Shower form (Form C-196) is included as an appendix at the end of this document.

Alternative Equipment:

Eyewash bottles or other personal eyewash equipment shall be inspected at a frequency according to the manufacturer's directions and must ensure that the eyewash fluid is not expired. The user organization is responsible for setting up an inspection program and schedule.

The employee shall inspect their respirator before each use, perform a user seal check and comply with the respirator selection and cartridge change schedule. Contact OHB industrial hygiene for respirator concerns.

Follow all Glenn Research Center (GRC) lock-out/tag-out procedures, as appropriate.

INSPECTIONS

Hold formal housekeeping and chemical hygiene inspections at least semiannually for units that have frequent personnel changes and annually for others. Informal inspections are continual and need no announcement.

The cleaning contract organization, laboratory supervisors, resident support contractors, Area Safety Officers and the Chemical Hygiene Officer may conduct inspections.

RECORDS

Laboratory inspections shall be maintained in the QCARD system for all inspections.

CHAPTER 8 - ALLERGENS AND EMBRYO TOXINS

Follow these procedures along with all the previous standard operating procedures for work with substances known to be allergens or embryo toxins. Allergens are any substances that can induce or produce symptoms of an allergy. Embryo toxins are toxins that are harmful to the developing embryo with or without severely affecting the mother. Also included are reproductive toxins that target the human reproductive system. These may also include certain teratogens and mutagens.

ALLERGENS

Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity. Take all precautions necessary to avoid incidental contact by any other person as well as yourself.

Disposable gloves are recommended but if reusable gloves are used, they shall be washed thoroughly using potable water after each use and before removing. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Have laboratory coats laundered after each use. Wash hands and arms thoroughly with soap and potable water as soon as practical after working with known or suspected allergens.

EMBRYO AND REPRODUCTIVE TOXINS

If you are a person of childbearing age, consult a physician and/or the Industrial Hygiene Program Lead: Reproductive Hazards for exposure evaluation and risk assessment. These substances should only be handled in a hood with confirmed satisfactory performance, using appropriate protective apparel (especially gloves) to prevent skin contact. Review each use of these materials with the research supervisor and review continuing use annually or whenever a procedural change occurs. Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

Disposable gloves are recommended but if reusable gloves are used, they shall be washed thoroughly using potable water after each use and before removing. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Wash hands and arms thoroughly with soap and potable water as soon as practical after working with embryo toxins.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Follow all additional procedures specified for particular embryo toxins, such as mercury or mercury compounds. Contact the Industrial Hygiene Program Lead for program information.

CHAPTER 9 - MODERATELY CHRONIC OR HIGHLY ACUTE TOXICITY MATERIALS

The aim of these additional procedures is to minimize exposure to these toxic substances by any route using all reasonable precautions. These additional procedures are appropriate for substances with moderate chronic toxicity, which are chemicals, other than the types specified as highly chronic (see Chapter 10 in this plan), that have a chronic hazard.

These precautions also apply to substances with high acute toxicity, which are chemicals that meet any of the following criteria:

- A chemical that has a median lethal dose (LD50) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
- A chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
- A chemical that has a median lethal concentration (LC50) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Toxicity information is often available on the Safety Data Sheet (SDS). If not, contact the Chemical Management Program Lead for information. Request an SDS using NASA Form C-377 through the GRC Web page https://nef.nasa.gov/nef/ or use the SDS database to search for the specific chemical.

LOCATION

Use and store these substances only in areas of restricted access with special warning signs. Always use a hood (previously evaluated to confirm adequate performance with a face velocity of between 80 to 120 linear feet per minute) or other containment device for procedures that may result in the generation of aerosols or vapors.

PERSONAL PROTECTION

Always avoid skin contact by use of gloves impermeable to the chemical and long sleeves (and other protection as appropriate). Reusable gloves shall be washed thoroughly using potable water after each use and before removing. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Have laboratory coats laundered after each use. Always wash hands and arms thoroughly with soap and potable water as soon as practical after working with these materials.

RECORDS

Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved. Submit an update of any changes to these records to the Chemical Hygiene Officer (MS 6-4) (at ATF, contact the SHeD Operational Safety Branch for guidance) on an annual basis, at minimum.

PREVENTION OF SPILLS AND ACCIDENTS

Be prepared for accidents and spills. Ensure that at least 2 people are always present if a compound in use is highly toxic or of unknown toxicity. Follow all spill and clean-up guidelines as found in the laboratory standard operating procedures for small bench top spills.

If a large spill occurs outside the hood, evacuate the area and call the GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222), for proper spill cleanup.

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper.

WASTE

Thoroughly decontaminate or incinerate contaminated clothing or shoes. Collect and dispose of properly all wastes generated in the decontamination process. Contact the Waste Management Program Lead at (216) 433-2124 (at ATF, the Support Service Contractor Environmental Technician at (419) 621-3358) for assistance. Store contaminated waste in closed, suitably labeled, impervious containers.

SPECIFIC HAZARDOUS MATERIAL INSTRUCTIONS

Follow all additional procedures or requirements as specified for a particular hazardous material as found in GRC Environmental Programs Manual or Glenn Safety Manual. The following hazardous materials have specific additional instructions:

Asbestos, Chapter 2, GRC Occupational Health Programs Manual, as revised

Explosives, Propellants and Pyrotechnics, Chapter 18, Glenn Safety Manual, as revised

Hydrogen, Chapter 6, Glenn Safety Manual, as revised

Hazardous Materials, Chapter 5, GRC Environmental Programs Manual as revised

Oxygen, Chapter 5, Glenn Safety Manual, as revised

Radiation Protection Programs, Chapter 8, 9 and 10 GRC Occupational Health Programs Manual, as revised

CHAPTER 10 - HIGHLY CHRONIC TOXICITY MATERIALS

Further supplemental rules to be followed, along with all those mentioned in the previous sections, for work with substances of known highly chronic toxicity that are:

"select carcinogens" or human carcinogens or substances with high carcinogenic potency in animals that are considered to be a carcinogen if:

(a) It has been evaluated by the International Agency for Research on Cancer (IARC), and found to be a carcinogen or potential carcinogen; or,
(b) It is listed as a carcinogen or potential carcinogen in the Annual Report on Carcinogens published by the National Toxicology Program (NTP, latest edition); or,
(c) It is regulated by OSHA as a carcinogen
(d) It is a listed as a carcinogen by ACGIH.
(e) It is listed as a carcinogen by NIOSH.
(f) It is listed as a carcinogen by EPA.

reproductive toxins which are toxins that target the human reproductive system; category that may also include certain teratogens and mutagens

mutagenic toxins which are any of a number of chemical compounds able to induce mutations in DNA and in living cells

teratogenic toxins which are reproductive toxins that damage the fetus during its development

neurotoxins which include any substance that can damage nerve cells.

(See OHPM Chapter 22 on Reproductive and Developmental Hazards for more information).

Toxicity information is often available on the Safety Data Sheet (SDS). If not, contact the Chemical Management Program Lead for information. Request a SDS using NASA Form C-377 through the GRC Web page https://nef.nasa.gov/nef/.

CONTROLLED AREA

Conduct all transfers and work with these substances in a "controlled area". Controlled areas can also be a restricted access hood, glove box or portion of a lab designated for use of highly toxic substances. All people with access need awareness of the hazards of the substances being used in the controlled area and the necessary precautions.

Storage

Only store containers of these chemicals in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant, secondary containers.

Glove boxes

For a negative pressure glove box, ventilation rate shall be at least 2 volume changes/hour and pressure at least 0.5 inches of water. For a positive pressure glove box, thoroughly check for leaks before each use. In either case, trap the exit gases or filter them into the hood.

Signs and Labels

Ensure that the controlled area markings are conspicuous with warning and restricted access signs. Also ensure that the labeling of all containers of these substances is appropriate with identity and warning labels.

Decontamination

Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area.

Decontaminate the controlled area before normal work resumes there.

Before leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container). Reusable gloves shall be washed thoroughly using potable water after each use and before removing. If potable water hand wash facilities are not available inside the lab, disposal gloves shall be worn and discarded before exiting the lab. Hands should then be washed as soon as practical after exiting the lab. Thoroughly wash hands, forearms, face and neck with soap and potable water as soon as practical after working with these materials.

Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder. Dispose of contaminated cleaning materials properly.

Spills

Ensure that contingency plans, equipment and materials to minimize exposures of people and property in case of accident are available. Follow all procedures established in the laboratory standard operating procedures.

SPECIFIC HAZARDOUS MATERIAL INSTRUCTIONS

Follow all additional procedures or requirements as specified for a particular hazardous material as found in Glenn Safety Manual, or GRC Environmental Programs Manual. The following hazardous materials or classifications have specific additional instructions:

OSHA Regulated Materials, Chapter 24, GRC Occupational Health Program Manual, as revised
Lead Program, Chapter 5, GRC Occupational Health Program Manual, as revised
Cadmium Program, part of Chapter 24, GRC Occupational Health Program Manual, as revised.
Reproductive and Developmental Hazards, Chapter 22 of the Occupational Health Programs Manual.

Refer to Chapter 16 of this plan for a listing of additional medical surveillance programs available.

MEDICAL SURVEILLANCE

When using toxicologically significant quantities of such a substance on a regular basis (for example, 3 times per week), consult the OHB Industrial Hygiene concerning the necessity and/or desirability of regular medical surveillance.

RECORDS

Keep accurate records of the amounts of these substances stored and used, as well as the dates used and names of users. Records shall be available to the Chemical Hygiene Officer for review.

WASTE

Use chemical decontamination whenever possible. Always transfer containers of contaminated waste (including washings from contaminated flasks) in a secondary container under the supervision of authorized personnel. Contact the Waste Management Program Lead at (216) 433-2124 (at ATF, the Support Service Contractor Environmental Technician at (419) 621-3358) for assistance with disposal of all waste materials.

CHAPTER 11 - HAZARD IDENTIFICATION

Each user is responsible for minimizing the risk for each process performed in the laboratory. Perform high risk operations in the smallest scale to reduce the hazard. Contact the Chemical Hygiene Officer for assistance.

SAFETY DATA SHEETS (SDS)

Each laboratory shall maintain access to the SDSs for each hazardous material found in the laboratory.

SDSs are maintained electronically through the GRC Web page http://shedapps.grc.nasa.gov/msds/home.cfm and are readily available for anyone who is working in, visiting or inspecting the laboratory facility. Contact SHeD ATF Operational Safety Branch personnel for more information.

To obtain a paper copy of a SDS from the Chemical Management Program Lead, request an SDS using NASA Form C-377 through the GRC Web page https://nef.nasa.gov/nef/ or use the SDS database to search for the specific chemical. Production of a chemical substance for another user outside the laboratory requires complying with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of a safety data sheet and proper labeling.

PROCEDURES FOR WRITING AN SDS

The employee (researcher) is to fill out all the information on the SDS form, NASA-C-10007. This form is available through the GRC Web https://nef.nasa.gov/nef/
The SDS package sent to the Chemical Management Program Lead (MS 6-4) is to include the following:

- The completed SDS form.
- The formulation which includes the chemicals and the percentage by weight or volume. Also include any process methods if needed.
- All constituent raw SDSs.
- Any additional information available on product or raw material.

Send the completed SDS package to the Chemical Management Program Lead, MS 6-4.

The Chemical Management Program Lead will then review the SDS. The Chemical Management Program Lead may use other reviewers if necessary.

The formulator will then receive a reviewed and numbered SDS. The Chemical Management Program Lead keeps a copy of the SDS with the review package in its central file as required by OSHA.

Any changes to the formulation of a product will require that the SDS be reviewed to determine if a revision will be necessary.

LABELS

Labels shall consist of the product name, which shall match the name on the SDS and the chemical inventory, hazard warnings and the GRC name and address. The Hazard Communication Standard (29 CFR 1910.1200) including the labeling requirements applies to all chemicals produced for use outside the laboratory. Please review the Hazard Communication Plan for guidance on label elements.

Each laboratory worker is to ensure that labels on incoming containers of hazardous chemicals remain on the container and are legible. Each laboratory worker is to ensure that all chemicals in the laboratory have proper labels. This includes all chemicals that the laboratory worker makes and stores. If labels are needed contact the Chemical Management Program Lead or submit a NASA Form C-375 request through the GRC Web page https://nef.nasa.gov/nef.

INVENTORY

Each user is responsible to minimize the volume of chemicals stored. In addition, the user is responsible to minimize the waste generated by each process. Any change in the inventory requires the user to complete a Chemical Inventory Usage Form, NASA-C-3032 and submit the completed form to the Chemical Management Program Lead. Form C-3032 is available on the GRC Web site at https://nef.nasa.gov/nef. The Chemical Management Program Lead analyzes and maintains the results of the chemical inventory database. At ATF, support service contractor personnel are responsible for updating the chemical inventory; the SHeD Occupational Health Branch assesses the inventory data as necessary.

Take extra care when moving chemicals to or from the laboratory. Use secondary unbreakable containers for moving or storing hazardous chemicals. Label all chemicals moved out of the laboratory in accordance with OSHA 29 CFR 1910.1200, Hazard Communication Standard. Contact Chemical Management for proper labeling.

Direct any question about the chemical inventory to the Chemical Management Program Lead, MS 6-4.

HAZARD ASSESSMENT AND EXPOSURE MONITORING

LSOPs are reviewed by an Industrial Hygiene Program Lead: Hazard Assessment. When extremely or highly hazardous materials, such as an OSHA regulated chemical, a non-regulated carcinogen, a reproductive hazard, etc., are being used, exposure monitoring may be scheduled depending upon use conditions, amount, frequency, controls and other factors. Contact the OHB industrial hygiene for more information.

For nanomaterial usage, employees complete the GRC Nanomaterial SOP form, GRC765. The variety of engineered nanomaterials used in GRC research activities is broad and with the lack of material-specific toxicity data the standard approach defaults to keeping employee exposures to ALARP. Currently toxicity data will be reviewed by the OHB industrial hygienist and, where possible, employee exposure monitoring for the specific type of nanomaterial being handled will be conducted.

CHAPTER 12 - LABORATORY PERMITS AND RISK ASSESSMENT

PERMITTING

It may not be necessary for each laboratory to have a Safety Permit for general laboratory operations. However, certain specific operations or chemicals within the laboratory that pose a significant risk may require a Safety Permit. Refer to the Glenn Safety Manual, Chapter 1A, Safety Permit System for additional information.

RISK ASSESSMENT

Each Laboratory Manager is responsible for initiating the Safety Permit Review process for each chemical laboratory under his/her area of responsibility. It is the responsibility of the Area Safety Committee to determine whether or not a Safety Permit will be issued for a particular laboratory process. If a Safety Permit is determined to be appropriate, the risk assessment procedures in the Glenn Safety Manual, Chapter 1A, Safety Permit System, will be followed.

RESTRICTED LABORATORIES

Special restrictions will be placed on laboratories using the following:

Chemicals defined as ‘select carcinogens’ in 29 CFR 1910.1450;

Chemicals known or suspected to cause reproductive toxicity;

Chemicals known or suspected to be mutagenic;

Chemicals known or suspected to be teratogenic;

Chemicals which are known to change in hazards upon aging or have a specific shelf life (example: chemicals which form peroxides that may cause death, serious injury or mission loss); or

Laboratories with Class 1 chemicals, which are chemicals that may cause death, serious injury or mission loss.

These chemicals shall be used in the restricted area only. Any planned use of these chemicals outside of the restricted area shall be approved by the Glenn supervisor and the appropriate signs and labels shall be posed in the area.

Signs and Placards shall be displayed at all entry points to the ‘controlled area’.

ACCESS TO RESTRICTED LABORATORIES

Access to restricted laboratories will be limited to the laboratory personnel assigned to the laboratory and trained in the hazards and use of the chemicals. Short term access will be permitted for cleaning, security, safety and environmental personnel as necessary to perform their duties.

TRAINING

All persons entering a restricted laboratory shall have completed appropriate training relative to the potential hazards of the material in the laboratory. Suitable training for the individuals will be determined by the supervisor.

SPECIAL SIGNS AND PLACARDS

The outside of a restricted laboratory shall display the following information:

Risk assessment hazard classification;

Name of the chemical(s);

Type of hazard(s) for each chemical listed;

Responsible party;

Designated area of use;

Emergency actions and notifications; and

Appropriate warning signs and placards.

DURATION

Restricted laboratories will be reviewed at minimum on an annual basis to determine if the status has changed. Laboratory workers can request the chemical Hygiene Officer to review a restricted area for reclassification when highly toxic chemicals have been removed and are no longer used.

DISPOSAL

Disposal of the chemical and/or materials contaminated by the chemical shall be in accordance with the stipulations of the permit and the Environmental Management Program Lead.

RECORDS

Inventory records of usage shall be recorded on NASA C-3032 form and sent to Chemical Management, MS 6-4. Records cam be maintained within each laboratory by one designated individual within a multi-user laboratory.

CHAPTER 13 - LABORATORY DESIGN

Depending on the type of research to be conducted, consideration shall be given for each laboratory facility to have:

The design of laboratories incorporates the requirements of State and Federal codes required for the individual Center (e.g., building, electrical, and fire protection for laboratory facilities).

Escape routes are provided, designed, and marked in accordance with the NFPA 101, Life Safety Code.

Occupational safety and health considerations such as ventilation, shower stalls, and eye wash stations are included in the design of laboratories.

Laboratory facilities and areas with significant quantities of flammable, combustible, corrosive, and toxic liquids, solids, or gases are protected in accordance with provisions of NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals. Laboratories not using NFPA 45 yet housing unique, mission-critical, or high-value research equipment, conform to the provisions of NASA-STD 8719.11, Safety Standard for Fire Protection.

> Note: In the design of laboratories, special facilities should be considered to ensure the integrity of the terrestrial environment as well as the integrity of biological and physical samples returned from space.

Laboratory designs include additional considerations for biohazards resulting from use or handling of biological materials such as infectious microorganisms, viruses, medical waste, or genetically engineered organisms.

> Note: See 29 Part CFR 1910.1030, Blood Borne Pathogens, and NPR 1800.1, NASA Occupational Health Program Procedures, for additional details.

Laboratory designs include additional considerations to protect physical samples returned from space against terrestrial contamination and to protect the terrestrial environment against potential biological or toxic hazards due to these samples.

- Two exits for each laboratory;
- An appropriate general ventilation system with air intakes and exhausts located so as to avoid intake of contaminated air;
- Adequate, well-ventilated stockrooms/storerooms;
- Laboratory hoods and sinks;
- A fire extinguisher;

Other safety equipment including eyewash fountains and drench showers, each supplied with potable water; eyewash and safety showers shall be installed based on the criteria provided in ANSI Z358.1-2009 and shall be placed in appropriate areas no more than 10 seconds or 50 feet of the potential hazard.

In addition, the design, fabrication, or modification of laboratories used for experimentation, testing, or analyses performed on human or animal subjects are coordinated in advance with OCHMO at (202) 358-2390.

MAINTENANCE

Chemical hygiene related equipment (hoods, incinerator, etc.) shall undergo continuing appraisal by laboratory personnel, supervisors and/or industrial hygienists and be modified if inadequate.

USAGE

The work conducted and its scale shall be appropriate to the physical facilities available and, especially, to the quality of ventilation.

VENTILATION

The laboratory ventilation system shall provide a source of fresh air for breathing and for intake to local ventilation devices.

Do not rely on the system alone for protection from toxic substances released into the laboratory.

To prevent any increase of air concentrations of toxic substances during the working day the ventilation system will ensure the continual replacement of laboratory air.

The system will direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building.

Hoods

A laboratory hood with 2.5 feet of hood space per person shall be provided for every 2 workers if they spend most of their time working with chemicals. Each hood shall have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use. If this is not possible, avoid work with substances of unknown toxicity or provide other types of local ventilation devices.

Other local ventilation devices

Provide ventilated storage cabinets, canopy hoods, snorkels, etc. as needed. Each canopy hood and snorkel shall have a separate exhaust duct.

Special ventilation areas

Pass exhaust air from glove boxes and isolation rooms through scrubbers or other treatment before release into the regular exhaust system. Cold rooms and warm rooms shall have provisions for rapid escape and for escape if there is electrical failure.

Modifications

Make any alteration of the ventilation system only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate. Contact the Industrial Hygiene Program Lead for air testing on any alteration.

Performance

A rate of 4-12 room air changes/hour is normally adequate general ventilation if using local exhaust systems such as hoods as the primary method of control.

Quality

General air flow shall be relatively uniform throughout the laboratory and not turbulent. There shall be no high velocity or static areas. Air flow into and within the hood shall not be exceedingly turbulent. Hood face velocity shall be adequate (typically 80-120 feet per minute).

Evaluation

Evaluations of laboratory hoods shall be conducted according to the provisions of Chapter 7 of the Occupational Health Program Manual, Local Exhaust Ventilation.

CHAPTER 14 - CHEMICAL PROCUREMENT AND DISTRIBUTION

PROCUREMENT

Before receiving a substance, all those involved in its use shall be familiar with the information on proper handling, storage and disposal. Accept no container without an adequate identifying label. All the procedures outlined in the GRC Occupational Health Programs Manual, Chapter 14, Acquisition of Hazardous Chemicals and Materials, as revised, are to be followed. Chemical Management Program Lead reviews and releases all purchase requests for all chemicals and hazardous materials at Lewis Field.

STOCKROOMS/STOREROOMS

Segregate toxic substances in a well-identified area with local exhaust ventilation. Place chemicals that are highly toxic or other chemicals with open containers in unbreakable secondary containers. Examine stored chemicals periodically (at least annually) for replacement or disposal based on deterioration and container integrity.

Do not use stockrooms/storerooms as preparation or repackaging areas. Make storerooms/stockrooms readily accessible during normal working hours. Designate one person to control the storeroom/stockroom.

DISTRIBUTION

Place the container in a secondary container or bucket when hand carrying chemicals. Use freight-only elevators whenever possible when transporting chemicals.

CHAPTER 15- EMPLOYEE EXPOSURE MONITORING

The GRC Safety Health Division has a number of programs that have trigger mechanisms in place to initiate exposure monitoring; the goal of exposure monitoring is to assess employee exposures to hazardous chemicals and materials and ensure adequate exposure control measures are in place. Air monitoring and dermal exposure assessments may be performed as a result of a LSOP, JHA, Nanomaterial SOP, Safety Permit Request or renewal, ventilation survey, or whenever an employee raises an airborne or surface contamination concern. Any GRC employee (civil servant, support service contractor or tenant) may request an exposure assessment by contacting the SHeD OHB Industrial Hygiene Program Lead. A written report with hazard assessment or exposure assessment results and recommendation will be provided to affected employees and their supervisors.

MONITORING FOR ENVIRONMENTAL COMPLIANCE

Air Emissions

Typical hoods used in laboratory operations are sources of air emissions. For most purposes, these emission activities are considered “trivial” by regulatory agencies. When the emission rate from the hood exceeds one pound per day for specific chemicals, an air permit may be required. Regardless of the chemicals used or rate of emission in any laboratory hood, accurate inventory records need to be maintained. These records may be used in the calculation of total emission rates for the entire Center for annual discharge fees. All questions regarding air permitting or the use of specific chemicals shall be directed to the Environmental Management Program Leads at Lewis Field and at ATF.

Water Discharges

The Center will not tolerate indiscriminate disposal by pouring waste chemicals down the drain or adding them to mixed refuse for landfill burial. This behavior is unacceptable and illegal.

Do not discharge into the sewer concentrated acids or bases; highly toxic malodorous (bad smelling) or lachrymatory (tear causing) substances or any substance that might interfere with the biological activity of wastewater treatment plants; create a fire or explosion hazard; cause structural damage or obstruct flow. All questions regarding the discharge of any chemical to sewers shall be directed to the Environmental Management Program Leads at Lewis Field and at ATF.

Waste Disposal

See Chapter 5 in this plan, Waste Disposal, and Chapter 5 of the Environmental Programs Manual for issues dealing with the disposal of chemicals. Contact the Waste Management Program Lead at (216) 433-2124 with any questions on how to dispose of any chemical (at ATF contact the Waste Management ATF Team).

CHAPTER 16 - OCCUPATIONAL MEDICINE PROGRAM

COMPLIANCE WITH REGULATIONS

Occupational Medical Services, as described in the GRC Occupational Health Programs Manual, Chapter 1 and Chapter 26, Occupational Exposure to Hazardous Chemicals and Substances, performs medical surveillance exams for CS employees, as required by OSHA regulations and at the discretion of the Occupational Physician. SSC and other non-NASA employees shall consult their employers for guidance on health care access for medical surveillance concerns.

Employers shall provide all employees who work with hazardous chemicals and materials an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
- Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements. Medical surveillance shall be established (as described in the Specific Medical Programs listed below) for the affected employee as prescribed by the particular standard.
- Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

The employees Supervisor shall ensure the employee can provide the following information to the examining physician:

- The identity of the hazardous chemical(s) to which the employee may have been exposed;
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

For any medical examination or consultation required due to the circumstances described above, the employee shall be provided a written opinion from the examining physician which shall include the following:

- Any recommendation for further medical follow-up;
- The results of the medical examination and any associated tests;
- Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and

The medical surveillance results and written opinion shall be provided to the employee and recorded in the NASA Electronic Health Record System (EHRS).

SPECIFIC MEDICAL PROGRAMS ADMINISTERED BY OCCUPATIONAL MEDICAL SERVICES

Specific medical programs developed by Occupational Medical Services exist for the following:

- Arsenic Surveillance Program
- Asbestos Surveillance Program
- Cadmium Surveillance Program
- General Medical Surveillance Program
- Hearing Conservation Program
- Lead Surveillance Program
- Mercury Surveillance Program

- Respiratory Protection Program
- Soldering Certification Program

Contact Industrial Hygiene Program Lead for appropriate exposure monitoring, evaluation and referral to Occupational Medical Services, if appropriate, for any known or suspected chemical exposures.

FIRST AID

Emergency Medical Service (EMS) is available by dialing GRC Dispatcher at 911 (internal GRC phone only) or from an external cell phone at (216) 433-8888 (ATF at (419) 621-3222).

CHAPTER 17 - TRAINING AND INFORMATION

The aim of training and information is to ensure that all individuals at risk know about the work in the laboratory, its risks and what to do if an accident occurs.

TRAINING PROGRAM

A general training program is presented a minimum of annually for new GRC laboratory employees. The program consists of review of the laboratory standard, awareness of the GRC Chemical Hygiene Policy as well as training in personal protective equipment and emergency procedures. All laboratory workers shall attend this general training program.

All new laboratory employees shall also attend the Hazard Communication (HAZCOM) Standard General Training program. This program outlines the HAZCOM regulation, defines what an SDS is and how to read one, identifies several labeling styles that manufacturers use, and identifies what an employee needs to know and do to work safely with hazardous chemicals.

Content of training

The following information is to be presented in initial and refresher training. As a minimum, employees shall be informed of:

- The contents of 29 CFR 1910.1450. The standard and its appendices shall be made available to employees;
- The contents of this Laboratory Chemical Hygiene Plan shall be made available to employees;
- The location and availability of this Laboratory Chemical Hygiene Plan;
- The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
- Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory;
- The location and availability of reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Safety Data Sheets received from the chemical supplier; and
- Methods and observations that may be used to detect the presence or release of a hazardous chemical.

Supervisors Training Responsibilities

Supervisors will ensure that new employees are trained on the specific hazards of the chemicals in the laboratory, laboratory standard operating procedures and sources for more information on the hazards of chemicals.

Supervisors will ensure that all appropriate laboratory employees are trained on the specific hazards of any new chemical that comes into the laboratory.

The supervisor may conduct additional general training of employees on several topics pertinent to laboratory employee's safety and health. The Chemical Management Program Lead can provide information and assistance on training topics.

These topics are to include but not be limited to:

Safety Data Sheets (SDSs) and labeling
Supervisors will ensure that their employees know the location and content of all relevant SDS for the hazardous materials in the laboratory, how to read and understand the SDSs and labels for the hazardous chemicals in the laboratory and when an SDS and/or label needs to be written by the laboratory employee and assist the employee in writing the SDS and/or label properly.

New chemicals
Supervisors will ensure that employees know the physical and health hazards; proper personal protective equipment and apparel; proper storage; spill procedures; accident response; disposal procedures and all other

procedures and precautions for each new hazardous chemical at the time the chemical arrives into the laboratory. The supervisor will also ensure that an employee is trained when a new chemical is created.

Emergency and Personal Protection Training

Every laboratory worker shall know the location and proper use of available protective apparel and equipment. Training classes are available for personal protective apparel through the GRC training schedule.

Training (such as CPR, Fire Extinguisher Use, Choking Charlie, and First Aid Instruction) is highly recommended and encouraged for every laboratory worker.

Receiving and stockroom/storeroom personnel shall know about the chemical hazards, handling equipment, protective apparel and relevant regulations.

FREQUENCY OF TRAINING

The training and education program is to be a regular, continuing activity not simply an annual presentation. General Laboratory Standard training which reviews the regulation and the GRC policy and program shall be attended by each laboratory personnel at a minimum of once every three years. Specialized training will be available on an as needed basis.

Additional retraining shall also be conducted whenever a periodic inspection reveals, or whenever there is reason to believe, that there are deviations from or inadequacies in the employee's knowledge of proper lab safety practices or procedures. The retraining shall reestablish employee proficiency and introduce new or revised practices and procedures, as necessary.

NANOMATERIAL TRAINING

Employees working with nanomaterials shall be trained in the current health-based research, potential routes of exposure, safe work practices, sampling limitations and types, proper use of PPE, engineering controls, emergency response procedures for spills, and disposal recommendations. Nanomaterial Health and Safety Training is provided by SHeD Occupational Health Branch, through the System for Administration, Training, and Educational Resources for NASA (SATERN).

INFORMATION

Literature and consulting advice concerning chemical hygiene are readily available to laboratory personnel for their use. Contact the Chemical Hygiene Officer at MS 6-4, for assistance.

CHAPTER 18 - RECORDS

The Management Integration Office retains mishap investigation records.

The Chemical Hygiene Plan records document that the GRC has policies and procedures that are compatible with current knowledge and regulations.

The Chemical Management Program Lead maintains the chemical inventory database and usage records as provided by the user and as verified by regular inventory audits.

The Occupational Medical Services retains medical records in accordance with the requirements of state and federal regulations, and the NASA EHRS.

The Environmental Management Office maintains the environmental monitoring records.

The Human Capital Development Division maintains training records in the System for Administration, Training, and Educational Resources for NASA (SATERN).

The SHeD Occupational Health Branch maintains hazard assessment and exposure assessment data and reports, and Nanomaterials SOPs in the OHB industrial hygiene files and in the NASA EHRS.

REFERENCES

Glenn Research Center Emergency Preparedness Plan, as revised

Glenn Research Center Environmental Programs Manual, as revised.

Glenn Safety Manual, as revised.

NASA-STD-8719.12 – Safety Standard for Explosives, Propellants and Pyrotechnics

ANSI Z358.1-2014: American National Standard for Emergency Eyewash and Shower Equipment

NPR 8715.1B – NASA Safety and Health Programs

NID 8715.140 NASA Hazardous Chemical Storage Requirements.

NASA STD-8719.11 - NASA SAFETY STANDARD: SAFETY STANDARD FOR FIRE PROTECTION

NID 8715.140 - NASA Hazardous Chemical Storage Requirements

LIST OF CONVENIENT RESOURCES:

Environmental, Health, and Safety Help Line 3-8848

Label Request C-375

Glenn Research Center Environmental Programs Manual

Glenn Safety Manual

SDS Request C-377

Waste Disposal Request C-260a

Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards
National Academy Press, Washington DC. 2011.

National Institute for Occupational Safety and Health Approaches to Safe Nanotechnology, 2009

National Institute for Occupational Safety and Health Progress. Toward Safe Nanotechnology in the Workplace, 2010

International Council on Nanotechnology Review of Safety Practices in the Nanotechnology Industry, November 13, 2006

Nanotoxicology Chapter 4.6 NASA NPR 1800.1C

Identifying and Evaluating Hazards in Research Laboratories. American Chemical Society's Committee on Chemical Safety, 2013.