

Bermuda Institute of Ocean Science

Safety Manual

This document describes a Health and Safety Plan for the Bermuda Institute of Ocean Sciences (BIOS) as required by Bermuda's Occupational Safety and Health Act 1982 and subsequent amendments and with reference to the Occupational Safety and Health Regulations 2009 and subsequent amendments (the "Act"). Anyone working at BIOS, for any reason, must comply with BIOS's safety policy.

CONTENTS

- 1 Roles and Responsibilities Defined.....**
 - 1.1 The Employer (BIOS).....
 - 1.2 The Safety and Health Committee.....
 - 1.3 Laboratory Operations Technician.....
 - 1.4 The Principal Investigator/Supervisor
 - 1.5 Employee
- 2 Fire.....**
 - 2.1 Know Your Exits.....
 - 2.2 Know Your Exit Procedure
 - 2.3 Recognize Emergency Alarm Sounds
 - 2.4 Know How to Activate an Alarm.....
- 3 Laboratories**
 - 3.1 General Safety and Operational Guidelines
 - 3.2 Personal Protective Equipment.....
 - 3.3 Safety Equipment
 - 3.4 Material Safety Data Sheets (MSDSs)
 - 3.5 Safety Training
 - 3.6 Chemical Safety.....
 - 3.7 Chemical Hygiene Plan
 - 3.8 Chemical Spill Procedures
 - 3.9 Compressed Gas Safety
 - 3.10 Disposal of Broken Glassware.....
 - 3.11 Shared Use Equipment.....
- 4 Marine Department**
 - 4.1 Marine Warehouse and Dock.....
 - 4.2 R/V Atlantic Explorer
 - 4.3 Small Boats
- 5 Scuba Diving**
 - 5.1 Diving Operations.....
 - 5.2 SCUBA Tank Filling.....
- 6 Radiation Policy**
 - 6.1 Organization And Purpose
 - 6.2 The Procurement And Usage Of Radioisotopes And Equipment
 - 6.3 Specific Radioactivity Safety Standards.....
 - 6.4 Protective Clothing.....
 - 6.5 Contamination Control.....
 - 6.6 Receipt Of Radioisotopes
 - 6.7 Storage, Transporting, And Handling Of Radioactive Materials
 - 6.8 Disposal Of Radioactive Waste
 - 6.9 Tritium Bioassays.....
 - 6.10 Iodine Bioassays.....
 - 6.11 Survey Instruments.....
 - 6.12 Responsibility For Training In Health Physics.....
- 7 Maintenance and Operations Departments**
 - 7.1 Vehicles.....
 - 7.2 Electrical Safety.....
 - 7.2 Workshop.....

1.1 THE EMPLOYER (BIOS)

As the employer, BIOS shall ensure the health safety and welfare of all employees, as far as it is reasonably practicable. Towards this end, it shall provide the necessary resources so that an effective health and safety committee may be formed and carry out its mission as stipulated by the Act.

1.2 THE SAFETY AND HEALTH COMMITTEE

The safety and health committee will be comprised of more than two and no more than 12 members of BIOS staff. At least one-half of these members shall be staff-elected, with the remainder being management-appointed. The duties of the committee include: participation in the identification and control of the safety and health hazards within BIOS; the drafting and promotion of safety and health programs for education and information of employees; the receipt, consideration and disposition of matters respecting the safety and health of employees and such other duties as may be specified in the Act or regulations made under the Act.

The quorum of this committee shall consist of the majority of the members of the committee, of which at least half are staff-elected members and at least one is management-appointed.

It is neither feasible nor technically appropriate to attempt to provide specific procedures or protocols for individual laboratories in a general safety document. However, individual laboratories and departments should develop their own specific safety plans by augmenting the BIOS Safety Manual. It is the responsibility of each Principal Investigator or his or her appointed Supervisor to incorporate safety as part of their standard operating procedures.

1.3 LABORATORY OPERATIONS TECHNICIAN

- I. Day to day focus upon safety and health issues related to shared/temporary/visitor-use laboratory operations;
- II. Identifying and clearly posting the location of dangerous areas or other hidden hazards;
- III. Providing & maintaining general protective equipment (first aid kits, safety showers, eye wash stations, etc.);
- IV. Ensuring that the MSDSs for incoming hazardous chemicals be on-hand prior to the receipt of hazardous chemicals whenever possible;
- V. Make MSDSs accessible to all employees along with safety information and instruction where necessary;
- VI. Maintaining a storeroom, which includes personal protective equipment and advising on the use of such equipment;
- VII. Maintaining chemical stores in a safe manner;
- VIII. Maintaining and administering a hazardous waste program and organizing the disposal of such waste;
- IX. Participating in the implementation of the safety plan;
- X. Notifying the Safety and Health Committee of any general protective equipment in need of repair or replenishment and assist in the correction thereof;

- XI. Documenting and reporting to the Safety and Health Committee any unsafe practices, spills or accidents;
- XII. Being available to listen to any employees' safety concerns and ensuring that these are reported promptly to the Safety and Health Committee.

1.4 PRINCIPAL INVESTIGATORS/SUPERVISORS

- I. Working with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices for their individual work areas and staff;
- II. Ensuring that workers know and follow the BIOS Safety and Health policy, as well as other practices appropriate for the tasks being performed in their laboratory;
- III. Identifying and posting appropriate signs identifying the hazards on the door(s)—especially if selected carcinogens, reproductive toxins, or acute toxins are used in a specific area;
- IV. Determining the required levels of Personal Protective Equipment and ensuring that the equipment is available and in working order;
- V. Monitoring procurement, use and disposal of chemicals in labs;
- VI. Maintaining an accurate Chemical Inventory List that identifies all the chemicals in labs, who uses the chemicals, where they are stored and approximate amounts;
- VII. Continuously seeking ways to improve the chemical hygiene plan;
- VIII. Ensuring that all containers in the work area are properly labeled and stored properly;
- IX. Maintaining MSDSs for each hazardous substance in the laboratory and making them readily accessible and understandable to staff.

1.5 EMPLOYEE

All employees are responsible for conducting work in accordance with safe procedures and complying with BIOS's Safety and Health Policy. In addition, each employee is responsible for the reporting of accidents, spills or unsafe working conditions to their supervisor and the Safety and Health Committee. Forms for this can be found at reception and/or on the server (biosfs01/Department Data/Human Resources/PPPM Forms/BIOS_Accident_Form) and on the BIOS webpage under 'About/Forms/Applications'. All employees are obligated to participate in all safety training and drills deemed appropriate by management.

2 Fire

FIRE EMERGENCY PROCEDURES FOR ALL STAFF, STUDENTS & VISITORS

Plan Ahead

- Know Your Exits
- Know Your Exit Procedure
- Recognize Emergency Alarm Sounds
- Know How To Activate An Alarm
- Know Who Your Fire Marshals Are

2.1 KNOW YOUR EXITS.

Always know the location of your assigned emergency exits. Know **TWO** ways out of your building. The emergency routes established in relation to your position on the Station and the location of available fire equipment.

2.2 KNOW YOUR EXIT PROCEDURE

Should the fire alarm sound, leave your work area and go out of the building quickly and quietly using your assigned fire exit. If you are not in your work area, you must proceed in accordance with those persons near you. Go to the assembly point on the North side of Wright Hall or as directed by your fire marshal. If you are outside the building, stay out until the fire marshals or Fireman in charge tell you that it is safe to return.

If your exit is blocked by smoke, then move toward your alternate exit. Crawl low in smoke. The air near the floor is cleaner and easier to breathe.

If your alternate escape is too dangerous because of fire and smoke, then find a room with a window to the outside. Close the door. Signal at the window to rescuers. If there is a phone in the room, give the fire department your exact location, even if they are on the scene.

If you are unable to leave your room and it is beginning to fill with smoke, then cover air vents where smoke may be seeping through. If possible, stuff any cracks to keep out smoke. Slightly open windows at the top and bottom to let fresh air enter. IF ABSOLUTELY NECESSARY, break the glass. Signal at the window to rescuers.

2.3 RECOGNIZE EMERGENCY ALARM SOUNDS

Survival time may be measured in seconds. **Make sure that you know the sound of the alarm in your building.**

The fire marshals will assist you in your safe evacuation via your assigned exit route to the agreed meeting place.

2.4 KNOW HOW TO ACTIVATE AN ALARM

Know the location of alarms and how to operate them. Activate the nearest manual pull station as soon as smoke or fire is discovered. It is important to warn others. Know how to directly notify the fire department. **The fire department should always be notified.** A prompt response can prevent a small fire becoming a large one.

It will be the responsibility of the person observing a fire to notify 911, alert the fire department, and provide the building name, the street address and indication of what type and the direct location of the fire.

3 Laboratories

3.1 GENERAL SAFETY AND OPERATIONAL GUIDELINES

People who work in or around scientific laboratories are exposed to many kinds of hazards. In some cases, the hazards are well recognized (those of ordinary fire, for example) and the precautions to be taken are obvious. Laboratories, however, involve a greater variety of possible hazards than do most workplaces and some of these hazards call for particular or unique precautions. Therefore, this manual is provided to inform and guide the laboratory worker in safe practices that should help to avoid accidents.

All employees shall take note of and agree to the following general safety and operational guidelines:

3.1.1 General Duties of Employer

It shall be the duty of BIOS and the principal investigator(s) as employers to ensure, so far as is reasonable, the health, safety and welfare at work for all employees. The matters to which this duty extends includes:

- I. Maintaining the facilities so as to provide a safe workplace
- II. Ensuring that all practices connected to the use, handling, storage and transport of hazardous substances is safe and/or minimizes any potential risk.
- III. Providing information, instruction, training and supervision as is necessary to protect the health and safety of all employees in the workspace.

3.1.2 General Duties of Employees

It shall be the duty of every employee at work to take reasonable care to protect their own health and safety and the health and safety of other persons who may be affected by their acts or omissions at work. This shall be accomplished by agreeing to abide by the following safety guidelines:

3.1.3 General Laboratory Rules of Safety

- I. No running, jumping or horseplay in the laboratory areas shall be permitted.
- II. No open-toed shoes shall be worn when working with hazards, and full Personal Protection Equipment (lab coat, goggles, gloves, closed toed shoes, long sleeves and pants) shall be used when working with hazards.
- III. No food or drink consumption, food storage or washing of dishes/utensils is permitted in any laboratory.
- IV. Spills shall be cleaned up immediately and a spill report form should be filled out and submitted to the safety committee through reception or to a committee member.
- V. It is the responsibility of everyone working in the laboratory to make certain that the laboratory is left clean after work is performed.
- VI. Unsupervised children and pets are not to be allowed in areas considered potentially hazardous such as laboratories, dock area, warehouses, etc.
- VII. Lifting of heavy items must be performed in the proper fashion, using the legs to lift and not the back.
- VIII. Any laboratory using chemicals that require an antidote or neutralizing agent (such as hydrofluoric acid, calcium gluconate) should have these materials

readily available. The location and administration procedures of these antidotes should be known to all workers in the area.

3.1.4 Personal Hygiene

- I. Wear personal protective equipment (lab coats, gloves, goggles, etc.) that is appropriate for the task being performed.
- II. Wash promptly whenever a chemical has contacted the skin. Know what you are working with and have the necessary cleaning/neutralization material on hand and readily available.
- III. Clothing worn in the laboratory should offer protection from splashes and spills should be easily removable in case of an accident. Aprons or lab coats offer the most satisfactory and the least expensive protection.
- IV. Laboratory clothing should be kept clean and replaced when necessary. Clothing should be replaced or laundered using appropriate decontamination procedures whenever contamination is suspected.
- V. **Lab coats and gloves are NOT to be worn outside the laboratory**, especially in rest room or dining facilities. Any lab coats, respirators or other protective gear must be left in the lab areas. Employees must, as a matter of routine, be responsible for washing, cleaning and any other decontamination required when passing between the lab and any other area. Washing should be done with soap and water or as appropriate.
- VI. "Sniff-testing" should not be done, as inhalation is one of the four modes of entry for chemical exposure.
- VII. Never pipette by mouth. Always use a bulb to pipette.
- VIII. Do not drink, eat, smoke or apply cosmetics in the laboratory or chemical storage areas. Food, beverage, tobacco or cosmetic products should not be stored in the laboratory or chemical storage areas at any time.
- IX. Wearing contact lenses is not recommended in laboratories. If contact lenses must be worn, the person must wear safety goggles when performing any activity that has the potential to cause eye injury.

3.1.5 Laboratory Practices

- I. The working area must be kept as clean as the work allows. All employees shall be responsible for maintaining the tidiness and cleanliness of their area.
- II. Reagents and equipment items should be returned to their proper place after use. This also applies to samples in progress. Contaminated or dirty glassware should be placed in specific cleaning areas and not allowed to accumulate.
- III. Chemicals, especially liquids, should never be stored on the floor except in closed-door cabinets suitable for the material. Nor should any chemicals be stored above head height.
- IV. Reagents, solutions, glassware, or other apparatus shall not be stored in fume hoods. Besides reducing the available workspace, they may interfere with the proper airflow pattern and reduce the effectiveness of the hood. All work done in fume hoods shall be performed in the "Safety Zone" defined as 6 inches minimum from the sash.
- V. Stored items or equipment should not block access to the fire extinguishers, safety equipment, exits, passageways or other emergency items.
- VI. All containers must be labeled with at least the identity of the contents, the name of the user and the initial date. Reagents and waste containers shall be labeled using the JT Baker Labeling system.
- VII. Signs should be posted on the door of all laboratories identifying the major hazards located within (i.e. radioactivity, corrosives, biohazard, etc.). If any

experiment is set up in a shared used area, a sign shall be posted on the door outlining all possible hazards, along with the appropriate MSDS sheet and contact information for the person responsible.

3.1.6 Vacuum Operations

- I. Apply vacuum only to glassware specifically designed for this purpose, i.e. heavy walled filter flasks, desiccators, etc.
- II. Never evacuate scratched, cracked, or etched glassware. Always check for stars or cracks before use.
- III. Rotary evaporator condensers, receiving flasks and traps should be taped or kept behind safety or fume hood shields when under vacuum.
- IV. All condensers connected to rotary evaporators should be cooled with circulating cold water.

3.1.7 Glassware

- I. Glass breakage is a common cause of injury in laboratories. Only glass in good conditions should be used.
- II. Discard or send for repair all broken, chipped, starred or badly scratched glassware.
- III. Clean all glassware before sending for repair.
- IV. When using glass tubing, all ends should be fire-polished. Lubricate tubing with glycerin or water before inserting into rubber stoppers or rubber tubing.
- V. Do not store glassware near the edge of shelves. Store large or heavier glassware on lower shelves.
- VI. Broken glass containers are cheap and easily available. When the container is 2/3 full, Lab Ops should be notified for removal. New containers should have the bottom firmly taped before use. This will prevent full bags from breaking through when the container is removed.
- VII. When disposing of glass chemical jars they should be rinsed well with the appropriate cleanser or neutralizer, the label should be removed – if this is not practical write on the label indicating it was neutralized and the date this was done. The jar should then be placed in the appropriate storage area (i.e. for use as a waste bottle, recycling, broken glass container...)

3.2 PERSONAL PROTECTIVE EQUIPMENT

A variety of personal protective equipment is commercially available and commonly used in laboratories. However, for the equipment to perform the desired function, it must be used and managed properly. Laboratory supervisors and/or safety representatives shall determine a need for such equipment, monitor its effectiveness, train the employees and monitor and enforce the proper use of such equipment.

3.2.1 Eye Protection

Eye protection is mandatory in all areas where there is potential for injury. This applies to persons who work continuously in these areas and also to persons who may be in the area only temporarily, such as maintenance, visitors or clerical personnel.

- I. The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. Reactions that have the potential for explosion or during the mixing of strong caustics or acids, a face shield or combination face shield and safety goggles should be used. Face shields are available from lab ops.

- II. Safety glasses are adequate protection for the majority of laboratory operations; they are not sufficient for certain specific operations where there is danger from splashes of corrosive liquids or flying particles. In these cases, a face shield should be used.
- III. If despite all precautions, an employee should experience a splash of chemical in the eye, the employee is to proceed (with assistance of a co-worker if possible) to the nearest eyewash fountain/station and flush the eye for at least 20 minutes. During this time, the co-worker should notify the laboratory supervisor and/or safety representative. Any eye injury should require an immediate trip to the hospital after flushing or a call to EMS during flushing for assistance. Take MSDS to the Hospital with you. An accident report should be filled out and spill report if appropriate.

3.2.2 Contact Lenses

It is recommended that contact lenses not be worn in the laboratory. The reasons for this prohibition are:

- I. If a corrosive, liquid should splash in the eye, the natural reflex to clamp the eyelids shut make it very difficult, if not impossible, to remove the contact lens before damage is done.
- II. The plastic used in contact lenses is permeable to some of the vapors found in the laboratory and these vapors can be trapped behind the lenses and can cause extensive irritation.
- III. The lenses can prevent tears from removing the irritant.

However, if the supervisor chooses to allow contact lenses to be worn in their lab, it should be well known who is wearing contact lenses and they shall wear protective goggles during any laboratory procedure that has any associated risk to the eye. The protective goggles for use with contact lenses fit loosely around the eyes and have no vents for access by vapors.

If chemicals contact the eyes while wearing contact lenses:

- I. Continuously flush the eyes for at least 20 minutes
- II. During flushing wash hands thoroughly to be sure no chemical or soap remain and remove lenses if flushing has not already done so.
- III. Seek medical attention immediately.

3.2.3 Clothing

The following guidelines for laboratory clothing are offered strictly from a safety standpoint.

- I. Lab coats should be provided for protection and convenience. They should be worn when chemicals are in use. Due to the possible absorption and accumulation of chemicals in the material, lab coats should NOT be worn in the dining room or elsewhere outside the laboratory.
- II. Closed-toed shoes and other Personal Protective Equipment should be worn when handling hazardous chemicals.

3.2.4 Gloves

There is no glove currently available that will protect a worker against ALL chemicals. When handling chemicals, it is recommended that the correct gloves be

used to protect the worker from accidental spills or contamination. If the gloves become contaminated, they should be removed and discarded as soon as possible.

- I. Employees shall remove gloves before leaving the immediate work site to prevent contamination of the doorknobs, light switches, telephones, etc.
- II. When gloves are removed, pull the cuff over the hand turning the glove inside out, and then dispose in an appropriate manner.

Appendix A is a chart that lists the chemical resistance of each type of glove for the chemical it is exposed to. It should be consulted to determine if the gloves currently in use are the most appropriate for each individual laboratory applications.

3.3 SAFETY EQUIPMENT

Workers in a laboratory environment are always surrounded by physical and chemical hazards, and the potential for accident and injury is always present. Adequate safety equipment in good working order shall be provided to the employee/visitor by the supervisor before any hazardous activity is undertaken.

3.3.1 Fire Extinguishers

The Safety Officer and/or his or her designate are responsible for the procurement, placement, inspection and maintenance of all fire extinguishers on station.

- I. Laboratory personnel should be adequately trained regarding pertinent fire hazards associated with their work.
- II. Fire extinguishers must be clearly labeled to indicate the types of fire they are designed to extinguish
 - Class A- ordinary combustible materials such as wood, cloth, paper, rubber and many plastics.
 - Class B- flammable liquids, oils, greases, tars, oil-based paints, lacquers and flammable gases.
 - Class C- energized electrical equipment where electrical conductivity of the extinguishing medium is of importance.
- III. Fire extinguishers should never be concealed from general view or blocked from access.
- IV. Notify a safety representative if it is noted that a fire extinguisher is discharged or not fully charged, or its safety pin is pulled out, an extinguisher is obstructed from view, or is not hanging in its proper location.

3.3.2 Safety Showers

If all protective measures fail and a person receives a chemical splash to their body, then safety showers should be used for immediate and thorough washing of the body.

- I. Employees should familiarize themselves with the location of the nearest safety shower.
- II. Employees should be familiar with the operation of the safety showers.
- III. Safety showers are designed to flood the entire body in the event of a clothing fire or a major chemical spill. In either case, an employee should simply stand under the shower and activate the shower, flooding the affected area for a minimum of 15 to 30 minutes.

- IV. In the case of a corrosive liquid spill, the employee should remove the affected portion of clothing to reduce potential contact. Removal of clothing should be done while the individual is under the activated shower.
- V. If the reason that the shower was activated was due to exposure to a chemical, the rinse water shall be treated as a liquid spill during clean up.
- VI. Safety showers are to be tested monthly by the safety representative.

3.3.3 Eyewash fountains/stations

If all protective measures fail and a person receives a chemical splash to their eyes, then eyewash fountains should be used for immediate and thorough washing of the eyes.

- I. Employees should familiarize themselves with the location and operation of the nearest eyewash fountain/station.
- II. If the employee is wearing contact lenses, they should be removed immediately. Always wash and rinse hands thoroughly before removing lenses.
- III. Always flush the eyes for at least 20 minutes, flushing from the inside corner of the eye outwards.
- IV. After thorough washing the proper authorities should be notified, i.e. the Safety Officer and subsequent medical care for the employee should be provided. Serious damage may have already occurred before the eye was thoroughly rinsed and/or the damage may not be immediately apparent.
- V. Eyewash fountains/stations should be inspected regularly by the Safety Officer to insure proper operation and to prevent formation of bacteria in the rinse water.
- VI. If an employee notices the seal on an eyewash bottle is broken, notify the laboratory operations manager so that it can be immediately replaced.

3.3.4 First Aid Kits

- I. First aid kits are to be used for the immediate response to minor injuries, such as cuts or minor burns. All injury victims have the option of obtaining medical treatment or consultation.
- II. Minor injuries requiring first aid shall always be reported to a supervisor. A minor injury may indicate a hazardous situation that should be corrected to prevent a more serious injury.
- III. The location and phone number of emergency services should be clearly posted.
- IV. The laboratory operations manager should inspect first aid kits on a quarterly basis.
- V. Any laboratory using materials requiring an antidote or neutralizing agent (such as hydrofluoric acid or calcium gluconate) should have these readily available. All laboratory employees should know the location of these agents as well as proper procedure for administration.

3.3.5 Ventilation Hoods

- I. Hood ventilation systems are best designed to have airflow of not less than 60 ft/min and not more than 120 ft/min across the face of the hood. Flow rates of higher than 125 ft/min can cause turbulence problems and are not recommended. If possible, mark the side of the hood so that the sash can be drawn to a point where 100 ft/min can be achieved.

- II. Avoid creation of a strong cross draft (100 fpm) which can be caused by open doors, windows, air conditioning and/or heating vents, or personnel movement. Drafts will pull contaminants from the hood and into the laboratory.
 - 100 fpm is generally not perceptible (100 fpm is approximately 3 mph, or a normal walking pace). Air conditioning and personnel traffic all create airflow in excess of 200 fpm, often much higher. Therefore, laboratory activity in the hood area should be minimized while the hood is in use.
- III. When not in use, the sash of the hood should be kept closed.
- IV. Work should be performed as deeply within the fume hood as possible.
- V. Only items necessary to perform the present experiment should be in the hood. The more equipment in the hood, the greater the air turbulence and the chance for gaseous escape into the lab.
- VI. The purpose and function of a hood is NOT to store chemical or unused items. Do not store chemicals in a fume hood.
- VII. Hoods shall not be used as a means of disposing of toxic or irritating chemicals, but only as a means of removing small quantities of vapor that might escape during laboratory operations.
- VIII. Always look to insure fan motor power switch is in the “on” position before initiating an experiment.
- IX. Hoods should be appropriate in design and function for the type of experiment being conducted or chemicals used, i.e. spark-proof motors for flammable vapors.
- X. Specialized local ventilation should be provided for some instruments such as atomic absorption spectrophotometers, microscopes or gas chromatographs that emit small quantities of hazardous substances during their use. Manufacturer’s recommendations should be consulted for cubic foot per minute requirements for each instrument.

3.3.6 Flammable Liquid Storage Cabinets

Cabinets designed for the storage of flammable liquids should be properly used and maintained. Read and follow the manufacturer’s information and follow these safety practices:

- I. Store only compatible materials inside the same cabinet.
- II. Do not store paper, cardboard, or other combustible packaging material in a flammable liquid cabinet.
- III. The manufacturer establishes quantity limits for various sizes of flammable liquid storage cabinets; do not overload cabinets.
- IV. Secondary containment within the flammable liquid storage cabinet is highly recommended (i.e. place bottles in plastic tubs filled with vermiculite or whatever is appropriate for the chemical...)

3.4 MATERIAL SAFETY DATA SHEETS (MSDSs)

Material Safety Data Sheets generally have nine parts associated with them. These parts will not necessarily appear in the following order, but should all be present on the chemical manufacturer’s MSDS.

Each laboratory is responsible for maintaining a current MSDS file that should be kept in a centralized location. If new chemicals are introduced to the workspace, their MSDS shall be put into the central folder and all personnel working in that area shall be informed that a new chemical has been introduced to the workspace. Information

regarding its toxicity, spill procedure, personal contact information and any other pertinent information should be explained to all personnel working in the same area. If it is in shared use lab, this information shall be posted on the door (see lab 104 for a very nice example of this)

3.4.1 Information contained in an MSDS

Each worker must be familiar with the MSDS for the chemicals that they work with and the chemicals that are stored in their work area. The information in the MSDS shall provide the outline for safe chemical handling procedures. All MSDS information should be thoroughly explored before beginning work with hazardous material. Any potential problem or discrepancy should be reported to the lab supervisor immediately and before continuing with the work.

- I. Basic information on the manufacturer or distributor and identification of the chemical. This includes trade name, chemical name, any synonyms or other names associated with the chemical, chemical family, CAS name, and the CAS registry number.
- II. The product's hazardous ingredients; whether it is a regulated chemical, the degree of toxicity, and the statement of a permissible exposure level (PEL) or threshold limit value (TLV).
- III. Information in the MSDS on the physical data of the pure chemical and/or mixture includes boiling point, specific gravity, vapor density, volatility, general appearance, pH, melting point, vapor pressure, solubility in water, evaporation point, color and odor.
- IV. Included in the fire and explosion data are flash point, auto-ignition temperature, explosion/flammable limits, fire and explosion hazards, extinguishing media and other special instructions.
- V. The potential reactivity of the product includes instability or incompatibility, potential decomposition products, and/or polymerization data.
- VI. Health hazard information: lethal concentration doses, potential problems of eye and skin contact, inhalation, ingestion and other modes of entry.
- VII. Protection information i.e. is a fume hood required or other protective equipment (respirator, gloves, goggles, aprons, boots, etc.)
- VIII. Procedures for the disposal of the chemical and what to do in case of a spill.
- IX. Additional information not covered in the above sections.

3.5 SAFETY TRAINING

The intent of a laboratory safety program is to provide guidance and training to all laboratory workers who use hazardous substances or engage in potentially hazardous operations.

Educational activities shall be provided for all persons who may be exposed to potential hazards. If other non-lab related offices are nearby, considerations should be given to providing these workers with the necessary knowledge to protect them. This training process shall be a part of a new employee's indoctrination or reassignment.

Institutional safety education programs shall be a regular continuous activity and not just a once-a-year presentation for groups of new students or employees.

BIOS policy now requires laboratories to provide health and safety training programs to their employees. Attendance at these training courses is **mandatory** and shall be

documented. Employees shall also be instructed in how to respond to unsafe conditions or practices and communicate safety concerns to the appropriate individual. This policy shall also extend to student groups and visiting scientists where appropriate.

Where training is provided a written record of the training should be created to include the name of the individual(s) who received the training, the date on which the training took place and this should be signed by the individual(s) receiving the training. This record should be passed to BIOS's Human Resources Department for filing.

3.5.1 Laboratory Chemical Safety Training

- The goal of the program is to educate all BIOS employees who work in a potentially hazardous area on the following issues:
 - The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in their work area.
 - Signs and symptoms associated with exposure to the hazardous chemicals used in their work area.
 - The measures the employees can use to protect themselves from these hazards including specific procedures such as appropriate work practices, personal protective equipment and emergency procedures such as spill cleanup, evacuation in case of fire, etc.

3.5.2 Hazard Communication Training

- The individual's laboratory supervisor, P.I. is responsible for providing employees with information and training to ensure that they are informed of the hazards of the chemicals present in their work areas.
- Such information and training shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.

3.6.1 Chemical Storage

- I. Every chemical in the laboratory should have a definite storage place and should be returned to that location after each use.
- II. Storage must conform to compatibility restrictions as described in the MSDSs. Typically, solvents, acids, bases, reactives, oxidizers, and toxins will be stored separately. Separation refers to physical separation of containers and isolation of potential spills and releases with the goal of preventing chemical reactions. Ideally, separate cabinets or isolated areas within a central storage area should be utilized for segregated storage of incompatibles.
- III. Hazardous chemicals should never be stored on the floor. Containers should be kept on low shelves or in cabinets. The shelves should have a lip on the forward edge to prevent bottles from slipping off. Chemicals tend to "creep" forward and over the edge of a shelf. Shelving units should be securely fastened to the wall or floors. Shelves should not be overloaded.
- IV. Utilize a compatible/suitable container for experiments, stored chemicals and collected wastes. In instances of corrosive wastes or halogenated solvents, the use of metal containers is often unsuitable. Plastic carboys (high-density polyethylene) glass or lined metal containers may be more suitable. See the MSDS for specific information.

- V. There shall be constant vigilance for any sign of chemical leakage. Containers of all types should be free of deformation.
- VI. Caps and covers for containers shall be securely in place whenever the container is not in immediate use. All bottles should be wiped down after pouring.
- VII. Storage areas shall be locked.
- VIII. Chemicals should be stored as close as feasible to the point of use in order to maximize efficiency and minimize transport distance. Chemical storage should be limited only to areas in which the particular chemical is used. Storage locations must be identified on an emergency floor plan posted in each work area. Each floor should be equipped with a minimum of a fire extinguisher, spill kit, eyewash, first aid kit, and telephone or other communication system to allow for adequate emergency notification.
- IX. Small quantities of chemicals can be held at individual workstations if this quantity is to be promptly used in a test and does not compromise worker safety. These containers must be properly labeled.
- X. Only limited quantities of chemicals and solvents should be stored in the laboratory. Large drums or multiple bottles of chemicals should be stored in a centralized chemical storage area.
- XI. Out-of-date chemicals shall be disposed of on a periodic basis to reduce the overall hazard potential and minimize inventory tracking and updating.

3.6.2 Handling and transportation of chemicals

- I. When large bottle of acids, solvents or other liquids are transported within the laboratory a wheeled cart may be used. Carts should be stable under load and have wheels large enough to negotiate uneven surfaces. Incompatible chemicals should not be transported on the same cart.
- II. Special padded or rubber bottle carriers, pails or carts **MUST** be used to prevent breakage by accidental striking against walls or floor and to contain the material if breakage does occur.
- III. Large quantities of concentrated mineral acids shall be kept in storage rooms or cabinets for corrosive substances. Bottles of concentrate acids must be carried from the aforementioned areas in an approved acid bottle carrier.
- IV. Organic solvents shall be stored in specialized flammable storage areas. These solvents shall be transported in approved solvent bottle carriers.

3.6.3 Chemical Waste

The Lab Operations Manager is responsible for coordinating the pickup of waste chemical substances. To assure compliance with regulations, safe handling and efficiency of operations the following standards are applicable to the collections, storing, labeling and packaging of these substances.

UNDER NO CIRCUMSTANCES IS ANY PERSON TO DISPOSE OF A HAZARDOUS SUBSTANCE DOWN THE DRAIN, IN THE TRASH OR BY DUMPING OVERBOARD

If the standard operating procedure or the MSDS prohibit drain or trash disposal, the material or product must be handled as hazardous waste. Lab ops shall not pickup, handle, surplus or hazardous substances that have not been properly identified.

To initiate pick-up of the waste please enter the information on the HAZMAT list found on the BIOS portal. Completing this electronic form will generate a unique number. This number must be attached to the waste to ensure correct identification prior to pick-up.

Visiting scientists and groups are responsible for the hazardous waste they generate while staying at BIOS. It is their responsibility to coordinate special needs with Lab Ops and they are required to dispose of any leftover chemicals or hazardous materials before departure.

Basic Procedures

- I. Collect substances in either their original or other suitable container
- II. Containers shall be in good condition; leaking or damaged containers are not acceptable. Containers shall be equipped with a properly fitting cap or other closure means. Makeshift covers such as tape to hold down a screw cap or a rag stuffed in an opening are unacceptable. If leaking or damaged, either repackage or call the Lab Ops tech to determine the proper packaging for disposal.
- III. Properly label containers as to all contents and hazards. Indicate the strength or concentration of the substance where possible.
- IV. Do not use chemical formulas, chemical symbols, chemical equations or abbreviations on label. Label the contents (i.e., 90% Hydrochloric Acid 10% water).
- V. Many substances are time sensitive, the date of opening or initial accumulation should be included on the label.
- VI. Remove or obliterate any other labels or wording not related to the current substance. Preferably, remove any other labels other than the waste disposal label.
- VII. Do not allow the creation of "unknowns" through lack of secure, readable labeling.
- VIII. Properly store containers in the appropriate storage facility (i.e., acids with acids, solvents with solvents, etc.) until ready for disposal
- IX. Fill out the logbook entry sheet (with all info requested) situated in the waste storage area.

3.6 CHEMICAL HYGIENE PLAN

It is neither feasible nor technically valid to attempt to provide a specific chemical hygiene procedure or protocol in a general safety document. However, individual laboratories and departments should be able to develop their own specific chemical hygiene plan by augmenting BIOS Safety Manual. Therefore, it is the responsibility of the Principal Investigator or Supervisor to incorporate chemical hygiene as part of their standard operating procedures.

3.7.1 Accident Reporting

All accidents, spills, etc shall be reported to your supervisor, safety representative and safety officer. In addition, safety and management personnel should investigate all minor accidents. Taking corrective action as a result of a minor accident may keep a major incident from happening. Employees should understand that the purpose of reporting and documenting accidents is not to affix blame, but instead to determine the cause of the accident so those similar incidents may be prevented in the future.

An accident report form will be available from Reception they are also available on the BIOS webpage and the fileserver (BIOSfs01/Department Data/Public/Human Resources/PPPM Forms).

3.7.2 Exposure Assessments and Medical Consultations upon suspected exposure to a toxic substance

There may be times when employees or supervisors suspect that an employee has been exposed to a hazardous chemical to a degree and in a manner that might have caused harm to the victim. If the circumstances suggest a reasonable suspicion of exposure, the victim is entitled to a medical examination. All medical examinations and consultations shall be provided without cost to the employee, without loss of pay and in a timely fashion.

Criteria for Reasonable Suspicion of Exposure

It is the policy of BIOS to promptly investigate all employee-reported incidents in which there is even a remote possibility of employee overexposure to a toxic substance.

Events or circumstances that might reasonably constitute overexposure include:

- I. A hazardous chemical leaked, was spilled, or was otherwise rapidly released in an uncontrolled manner.
- II. An employee had direct skin or eye contact with a hazardous chemical
- III. An employee manifests symptoms, such as headaches, rash, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgment, etc., and some or all of these symptoms disappear when the person is taken away from the exposure area and breathes fresh air and the symptoms reappear soon after the employee returns to work with the same hazardous chemicals.
- IV. Two or more persons in the same laboratory work area have similar complaints.

Exposure Assessment

Unless circumstances suggest other or additional steps, these actions constitute an exposure assessment.

- I. Interview the complainant
- II. List the essential information about the circumstances of the complaint including:
 - The chemical under suspicion
 - Other chemicals used by the victim
 - All chemicals being used by others in the immediate area
 - Other chemicals stored in that area
 - Signs exhibited or symptoms claimed by the victim
 - How these symptoms compare to symptoms stated in the MSDSs for each of the identified chemicals
 - Were control measures, such as personal protective equipment and hoods, used properly?
 - Were air sampling or monitoring devices in place? If so, are the measurements obtained from these devices consistent with other information?

3.7.3 Medical Consultation/Examination

If an employee feels that they have been exposed to hazardous chemicals, the employee(s) is required to contact their respective supervisor and safety representative who will assist them in arranging for an exposure assessment and medical exam.

Physician is to be provided with:

- The identity of the hazardous chemical(s) to which the employee may have been exposed
- The exposure conditions
- The signs and symptoms the exposure victim is experiencing, if any

Documentation of medical action

- All memos, notes and reports related to a complaint of actual or possible exposure to hazardous chemicals are to be maintained as part of BIOS record.

3.8 CHEMICAL SPILL PROCEDURES

All chemical spills shall be reported in writing to BIOS Safety Committee regardless of size. A report form is available from the Lab Ops Manager they are also posted on the BIOS fileserver.

Although the following tactics are prioritized in terms of usual preferred action sequences, each spill incident is unique and involves persons with varying levels of spill expertise and experience. Thus, for any individual incident, isolation of the spill and/or securing the area might best occur prior to or simultaneously with contacting a member of the safety committee.

3.8.1 Minor Spill-

This could be an unknown substance found in a shared-use area that does not pose an immediate risk (i.e. spilled solids in balance room, etc) or small spill of known substance.

- If you spill a chemical, clean it up immediately following the procedures outlined in the chemicals Material Safety Data Sheet. Be sure to wear the appropriate personal protective equipment (lab coat, gloves, eye goggles, etc.) and dispose of the waste in the appropriate manner.
- If the spilled chemical has occurred in a shared-use area and its origin is unknown, adopt a safe practice by wearing the appropriate personal protective equipment and treat the spill as hazardous using the spill response kits located on your floor.

3.8.2 Major Spill

In the event of a spill that could pose a significant threat to person(s) in the immediate area (i.e. solvent spill, corrosive spill, etc.)

- I. Never clean up a spill by yourself! Send for help first.

- II. If the spill presents an immediate danger, leave the spill and warn others, control the entry to the spill site and wait for an official response from the Lab Ops Manager/Fire Department.
- III. Before any attempt is made to clean up the spill, first protect yourself by donning the appropriate personal safety equipment. Then attend to any persons who may have been contaminated.
- IV. Notify persons in the immediate area about the spill. Evacuate all non-essential personnel from the spill area.
- V. If flammable vapors are involved, do not operate electrical switches unless it is to turn off motorized equipment. Try to turn off or remove heat sources, when and where safe to do so.
- VI. Secure supplies to effect cleanup
- VII. Where the spill does not present immediate personal danger, try to control the spread or volume of the spill.
- VIII. Never assume gases or vapors do not exist or are harmless because of lack of smell.
- IX. Use absorbents to collect substances. Reduce vapor concentrations by covering the surface of a liquid spill with absorbent. Control enlargement of the spill area by diking with absorbent.

Spilled liquids

- I. Confine or contain the spill to a small area. Do not let it spread.
- II. For small quantities or inorganic acids or bases, use a neutralizing agent or an absorbent mixture (i.e. soda ash, diatomaceous earth). For small quantities of other materials, absorb the spill with a non-reactive material (vermiculite, clay, dry sand or towels).
- III. For larger amounts of inorganic acids and bases, flush with large amounts of water (providing that the water will not cause additional damage). Flooding is not recommended in storerooms where violent spattering may cause additional hazards or in areas where water-reactive chemical may be present.
- IV. Mop up the spill, wringing out mop in a pail equipped with rollers.
- V. Carefully pick up and clean any cartons or bottles that have been splashed or immersed.

Spilled Solids

- I. Generally, sweep spilled solids of low toxicity into a dustpan and place them into a container suitable for that chemical. Additional precautions such as the use of a vacuum cleaner equipped with a HEPA filter may be necessary when cleaning up spills of a more toxic nature.
- II. Dispose of residues according to safe disposal procedures. Remembering that personal protective equipment, brooms, dustpans and other items may require special decontamination or disposal procedures.

3.8.3 Neutralization procedures for acids and bases and General Disposal Methods

Neutralization is a simple procedure that is best done by and in the laboratory that uses inorganic acids and bases on a regular basis.

DO NOT neutralize inorganic acids that contain heavy metals (i.e. Atomic Absorption Standards) or the following acids:

- I. Esters of inorganic acids
- II. Chromic acid
- III. Perchloric acid
- IV. Hydrofluoric acid
- V. Organic acids except acetic acid and straight-chain fatty acids
- VI. Large quantities of nitric acid

It is safe to neutralize acid solutions containing sodium, potassium, magnesium or iron as long as the anion is also considered non-hazardous. However, always read the Material Safety Data Sheet for detailed information.

Equipment needed for neutralizing acids/bases

- I. Sodium carbonate, baking soda or diluted inorganic base- for acids. Diluted inorganic acid- for bases.
- II. Polyethylene bucket
- III. Glass rod or other stirring device
- IV. Protective equipment (minimum of gloves, lab coat, goggles, fume hood)
- V. 500 ml beakers
- VI. pH strips or other pH test method

Neutralizing procedure for Acid

- I. Make a saturated solution of sodium carbonate in a beaker or use an inorganic base diluted in water (1:10 ration) - set aside.
- II. Put tap water into the polyethylene bucket
- III. Dilute acid at least 1:10 (1 part acid to 9 parts water) by slowly pouring and stirring the acid into the water. For concentrated acids, neutralization must be done slowly and with vigorous stirring.
- IV. Warning: extreme heat can be produced by this procedure unless it is done very slowly and well diluted. Closely monitor the amount of heat being produced. Use an ice bath if necessary. Also, be aware of the surface under the neutralizing container, as it will be subject to intense heat.
- V. Slowly add basic solution (step a) into the diluted acid while stirring
- VI. Monitor pH. When pH is between 6 and 9, dispose of liquid down the drain with the tap on. A pH nearest to 7 is preferred.

Helpful Hint: When neutralizing an acid, the pH can be tested quickly by the following method. Make a saturated solution of sodium bicarbonate in water. A small amount of sodium bicarbonate solution poured into the acid will make a "fizz." This "fizz" will indicate that the solution is still acidic and needs more base to be added. Always stir the mixture and do a final check of the pH before disposing of.

Neutralizing procedure for Base

- I. Make up a dilute inorganic acid of at least a 1:10 diluted rate. Set aside.
- II. Put tap water into polyethylene bucket.
- III. Dilute alkali wastes at least 1:10 (1 parts alkali to 9 parts water) by slowly pouring and stirring the base into the water. Do this slowly and with vigorous stirring.
- IV. Neutralize the diluted alkali solution with a previously diluted inorganic acid
- V. Monitor the pH. When the pH is between 6 and 9, dispose down the drain followed by excess water. A pH nearest to 7 is preferred.

3.8.4 Spill Report

All spills must be reported to your principal investigator. Many times, minor spills are not reported because they are perceived to be embarrassing or that “careless actions” lead to the accident. However, minor spills can sometimes lead to more serious complications that only become evident later in time. Taking corrective action as a result of a minor accident may keep a major spill from happening. Employees should understand that the purpose of reporting spills is not to affix blame but instead to determine the cause of the accident so that a similar incident may be prevented in the future.

A spill report form is available from the Lab Ops Manager; they are also posted on the BIOS fileserver.

3.9.1 COMPRESSED GAS SAFETY

3.9.1 Identification of cylinders

- I. The contents of any compressed gas cylinder shall be clearly identified for easy, quick, and complete identification by any laboratory worker. If the labeling on a cylinder becomes unclear or an attached tag is defaced to the point where the contents cannot be identified, the cylinder should be marked “contents unknown” and returned directly to the supplier.
- II. All gas lines leading from a compressed gas supply should be clearly labeled to identify the gas and the laboratory served.
- III. Signs should be conspicuously posted in areas where flammable compressed gases are stored.

3.9.2 Handling and Use

- I. Since gas cylinders are tall and narrow, they shall be secured at all times with non-flammable material (such as chain) to prevent tipping.
- II. When new cylinders are received, they should be inspected for leaks and that the proper cap is securely in place. If the cylinder is leaking, contact your safety officer. Under no circumstances should any attempt be made to repair a cylinder or valve.
- III. Cylinders containing flammable gas such as hydrogen or acetylene shall not be stored in close proximity to open flames, areas where electrical sparks are generated, or where other sources of ignition may be present.
- IV. Cylinders containing acetylene shall never be stored on their side.
- V. Oxygen cylinders, whether full or empty, shall not be stored in the same vicinity as flammable gas cylinders. Greasy or oily materials shall never be stored around oxygen, nor should oil or grease be applied to fittings.
- VI. Cylinders should be placed so the valve is accessible at all times. The main cylinder valve should be closed as soon as it is no longer necessary that it be open.
- VII. Cylinder valves should be opened slowly. Main cylinder valves should never be opened all the way.
- VIII. When opening the valve on a cylinder containing an irritating or toxic gas, the user should position the cylinder with the valve pointing away from them and warn those working nearby.
- IX. Connections should be checked with a soap solution to identify leaks.
- X. Never use oil or grease on the regulator of a cylinder valve.

- XI. Piping material shall be compatible with the gas being supplied. Copper piping shall not be used for acetylene, or plastic piping for any portion of a high-pressure system. Do not use cast iron pipe for chlorine; do not conceal distribution lines where a high concentration of a leaking hazardous gas can build up and cause an accident. Distribution lines and their outlet should be clearly labeled as to the type of gas contained. Piping systems should be inspected for leaks on a regular basis.
- XII. To protect the valve during transportation, the cover cap should be screwed on hand tight and remain on until the cylinder is in place and ready for use.
- XIII. Cylinders should never be rolled or dragged.
- XIV. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability.
- XV. Only one cylinder should be handled at a time.

3.10 DISPOSAL OF BROKEN GLASSWARE

Inspect all glassware before use. Do not use broken chipped, starred or badly scratched glassware. If it cannot be repaired, discard it in containers specifically designed for broken glass. All broken glass requires special handling and disposal procedures to prevent injury not only to lab personnel but also to members of the janitorial staff.

- I. Limit quantities to no more than approximately 15 pounds so that lifting of the container will not create a situation that could cause the bag to break or back injury.
- II. Make sure that the bottom of the glass disposal box is firmly taped before starting a new container. This will prevent the bottom from falling out later on.
- III. Glassware that is chemically contaminated deserves special attention and should be decontaminated prior to disposal. If you have special concerns, contact your PI who will instruct you in the best possible way to deal with contaminated glassware.

3.11 SHARED USE EQUIPMENT

The following equipment refers to shared use equipment, which is managed and serviced by Lab Operations or a designated other. If you are not familiar with the operation of any of this shared use equipment ask your immediate supervisor and or the Safety Officer. Logbooks **MUST** be filled out whenever equipment is used as they determine when maintenance is required.

3.11.1 Centrifuge Safety

Centrifuge safety starts before you turn on the machine. The owner's manual should be consulted to insure that the proper tubes have been selected and that suggested weights are not being exceeded.

General Practices

- I. Obtain appropriate instructions on the operation of any centrifuge before using it for the first time. Consult the scientist, instructor, teaching assistant, or technician who is responsible for the instrument **AND** examine the operating manual.

- II. Know the speed limitations of each centrifuge and rotor and do not exceed them.
- III. Use appropriate tubes and tube holders. Tubes should be neither loose nor tight in the holders or rotor. Many tubes and holders require adapters.
- IV. Do not use cracked or otherwise damaged tubes
- V. Do not over-fill any tubes. Do not under-fill ultracentrifuge tubes – they may collapse if there is too little in them.
- VI. Balance all tubes, and, with swinging-bucket rotors, tube-holders and caps as well. Balance the entire assemblage of removable parts. If using a balance tube, fill it with material similar to that in the tube that is being balanced.
- VII. Put the lid on all rotors that have lids.
- VIII. For centrifuges and rotors with sign-up sheets and logbooks, be meticulous about recording the requested information. This information is needed to keep track of rotor usage, since many high-speed and ultracentrifuge rotors will be down-rated after a certain amount of usage has been accumulated.
- IX. Once the centrifuge has started, make sure that the run is proceeding normally before you leave the area.
- X. When the run is done, make sure that the rotor has stopped completely, and that vacuum, if applied during the run, has been released, before opening the centrifuge.
- XI. Check for spills. If a leak or damage has occurred, plan proper decontamination and clean-up. Do not pretend nothing happened.
- XII. Remove your samples and balance tubes from the centrifuge and rotor when your spin is done!
- XIII. Clean up every time you have finished using a centrifuge! Wipe down the inside of the centrifuge. Do not use metal brushes, harsh detergents, or inappropriate solvents to clean rotors. Remove buckets from swinging-bucket rotors, rinse with Q-water, and invert to dry. Rinse all wells of fixed-angle rotors with Q-water, and invert to dry.

3.11.2 Autoclave

Autoclaves sterilize by subjecting material to saturated steam under pressure with high temperatures. If you are unfamiliar with the autoclave, **ASK SOMEONE** to demonstrate its use. This is not a machine to experiment with, although it is quite safe when used correctly.

Monitor the progress of the autoclave every 15 -30 minutes, improper use may melt plastics or ruin buffers. Be sure the items that are to be sterilized are borosilicate glass or autoclaveable plastic. Glass will generally be used for buffers, because repeated autoclaving is rough on most plastics.

Notes:

- Leave at least a quarter of the total flask or bottle volume as free space. This leaves plenty of room for boiling liquids.
- Place items in a shallow metal or autoclavable plastic pan to catch anything that might break.
- Make sure caps are loose to prevent buildup of pressure.

Operation

- I. Check the water reservoir and make sure it is at the correct level, if not, add more Q-water.
- II. Check inside the autoclave chamber to make sure it is clean and empty.
- III. Load the chamber with items to be autoclaved.

- IV. Turn the function knob to the FILL position. Water will slowly enter the chamber; when water covers the 'water level indicator' inside the chamber turn knob to STERILIZE.
- V. Close the door and push lever down to lock the door. The HEAT ON light will illuminate when door is properly locked and closed.
- VI. Set operating temp with the temperature control knob; this will generally 250-260oC. If you require a specific temperature, refer to the autoclave manual.
- VII. Set the timer for the desired sterilization time (~25-30 minutes for most items). The timer will start when the temperature reaches sterilization temperature and pressure (This may take a half hour or longer, be patient!).
- VIII. When the timer returns to zero a buzzer will go off and the STERILE light will illuminate.
- IX. The buzzer will go off until the function knob is turned to VENT. At this point, the pressure will be released and the water in the chamber will return to the water reservoir. Allow at least a half an hour for the chamber to cool and release pressure.
- X. The OPEN DOOR light will illuminate when it is safe to open the door. Depress the OPEN DOOR button and lift the lever at the same time. You may have to do this several times before the door solenoid will engage and open the door. Open the door very slowly, standing back from the door, to avoid contact with any escaping steam. If the chamber has not been allowed to cool and release all pressure opening the door quickly may cause solutions to boil over.
- XI. Allow any items that have condensation on them to dry by leaving the door partially open and leaving the function knob on the VENT position. This will dry your items as well as making it safer for you to remove your items from the autoclave; let things sit for at least 15-30 minutes. To prevent burns when removing items make sure to use the large heavy gloves on top of the autoclave.
- XII. NOTE the heating element will stay on until the knob is in the 'off' position.
- XIII. Log name, items sterilized, and any problems in the logbook on top of the autoclave. Notify Lab Ops of any problems or spills so the autoclave can be properly cleaned for the next user. Cleaning should automatically be done by Lab Ops monthly.

4 Marine Department

4.1 MARINE WAREHOUSE AND DOCK

The marine warehouse is the large warehouse behind the workshop, this area is generally off limits except for marine department employees.

- I. The marine warehouse is an area where machinery is in use for the transport of scientific gear. Caution should be used at all times when in this area.
- II. All storage and retrieval of gear is handled primarily through the Marine Technicians, Ships Ops and Maintenance personnel.
- III. Forklifts are only to be operated by trained certified forklift operators.
- IV. No unsupervised children or pets are allowed at the marine warehouse or dock.

4.2 R/V ATLANTIC EXPLORER

Only those directly involved with the R/V Atlantic Explorer are allowed on board without permission from Marine Operations.

Below is a brief explanation of some basic safety rules related to the vessel. These regulations do not supersede the established policies onboard the vessel. While onboard the vessel all personnel are subject to United States rules and regulations as outlined in the ships safety manual and UNOLS RVSSv9. If you have any questions regarding safety regulations and established policies onboard the vessel contact the marine department for more information.

Orientation

An orientation will be immediately prior to or after departure. It will include the following:

- I. An explanation of the general alarm signals.
- II. An explanation of station bill and bunk cards.
- III. How to don life jackets and survival suits.
- IV. Requirements for hard hats, shoes, and work vests.
- V. When, how, and who to notify for over-the-side research
- VI. Discussion of other matters of general safety interest.
- VII. Shipboard drills.

Deck Operations

Deck Machinery and deck systems are used to launch and recover scientific apparatus. There are inherent hazards of working near tensioned cables and rotating machinery:-

- I. Stay clear of moving equipment such as cranes, frames, and davits.
- II. Keep clear of lines, wires and cables.
- III. Wear hard hats and adequate foot protection.
- IV. Avoid getting hands, feet, or loose clothing caught in wire, cables, or in rotating machinery.
- V. Horseplay is not permitted.
- VI. If you are not a member of the deck operation crew keep clear of deck operations
- VII. Much of research ship time is spent performing science operations over the side or fantail, or placing heavy objects on the seafloor. Nothing goes over the side unless permission from the watch officer is obtained-whether launching scientific gear or disposing garbage.

Laboratory Safety

All BIOS Laboratory practices, spill procedures, and storage procedures will be followed in the laboratories on board the Atlantic Explorer.

In addition to BIOS policy, United States regulations are in full effect onboard the RVAE. All users of the ship are required to read the ships safety manual and UNOLS RVSSv9. All users shall comply with posted information and instructions.

Employees and visiting scientists should make themselves familiar with safety equipment in the laboratories and throughout the vessel. Fire extinguishers, safety showers, eyewash stations, first aid kits, and ventilation hoods are readily available.

4.3 SMALL BOATS

Users of BIOS boats do so at their own risk and in doing so agree to abide by the following rules laid down for their safety and convenience, by both BIOS and the Bermuda Marine and Ports Authority.

4.3.1 General

- i) The small boats fleet is composed of R/V Henry M. Stommel, R/V Rumline, R/V Sea Dance and R/V Twin Vee (Reefrunner)
- ii) All BIOS boats are registered as M-class vessels by the Bermuda Marine and Ports Authority. M-class vessel designation refers to any island boat inspected and thus issued a license to operate for hire or reward (a.k.a. charter vessel).
- iii) BIOS boats operate under individual licensing restrictions and all operators are responsible for familiarizing themselves with said restrictions.
- iv) If a BIOS vessel is working as an island boat for charter it must be operated by a licensed Bermuda Boat Pilot and an assigned deckhand. If a BIOS vessel is not working as an island charter boat it may be operated by a non-pilot, however said operator must be trained and approved by a qualified member of the Boat Department staff or by the DSO (who functions as Boat Department manager)
- v) ALL boat users are required to carry out a maintenance check prior to leaving the dock. This must include at a minimum, a check on oil and fuel levels, presence of required safety equipment and a radio check. Upon return to the dock, users are responsible for refueling and washing down the vessel, then returning it to the mooring.
- vi) Users are prohibited from using the boats without prior authorization from the Boat Department manager in the form of an online booking. Any change in the booking must also be cleared in advance. A float plan must be logged with the boat office prior to the trip, and upon return users are required to fill in the boat activity log sheet.

4.3.2 Regulations for individuals embarking on BIOS vessels

- i) The captain's word is final on matters of safety and boat operation, and in the instance that the captain is incapacitated, this responsibility passes to the designated deckhand.
- ii) All passengers are required to fill out a BIOS waiver form prior to departure and have it filed with the DSO (Boat Department Manager) For diving activities, a SCUBA waiver is also necessary.
- iii) A safety briefing will be given prior to departure detailing the location and use of safety equipment, basic emergency procedures, man-overboard procedure, recall procedures for in-water activities and basic on-board conduct. It is the passenger's responsibility to listen carefully and make it known to a crewmember if they do not understand any part of the safety briefing.
- iv) Nobody is to get off the vessel into the water at any point without express permission to do so from the crew. This includes swimming off the boat when it is at the dock, swimming off the boat when it is at sea or entering the water for a dive.
- v) Nothing shall be put in the water without the full knowledge of the boat crew.
- vi) Unless expressly asked to do so, passengers are prohibited from interfering with switches, valves, dials, radios, GPS systems, sounders etc.
- vii) Alcohol is prohibited on BIOS vessels unless approved of in advance for a specific event. The captain/vessel operator may not consume alcohol at any point while responsible for the vessel.
- viii) Passengers are never permitted on the wheelhouse overhead and foredeck on the R/V Henry M. Stommel.

- ix) Passengers should avoid distracting the captain at all times, and should stand clear of vessel sides when approaching the dock to allow crew to work lines.
- x) Passengers must keep hands, feet etc. inside the vessel at all times when underway.
- xi) Passengers may not disembark from the vessel upon return to the dock until they receive express permission from the boat crew to do so.

4.3.3 In-water safety

- i) No one shall enter the water until express permission is given by a crewmember.
- ii) Qualified personnel must operate boats at all times. If not a designated crewmember, the boat-sitter must possess current First Aid/CPR and Emergency Oxygen Provision certifications, and be familiar with the vessel's basic operation, emergency recall and communication systems.
- iii) The buddy system applies to in-water activities at all times with no exceptions. This includes group leaders/guides.
- iv) Any safety issues particular to an activity or location must be addressed prior to entering the water.
- v) The recall procedure in the event of an emergency consists of sounding of the horn, signaling from the boat and starting of the engine. Moving to help a distressed person or to evacuate an ill or injured person cannot take place until all members of the party are on board.
- vi) Prior to pulling anchor or leaving a mooring, all members of a party must be accounted for by roll call and head count.
- vii) Live- the Diving Safety Officer must approve of boat operations where the boat is not anchored or moored while persons are in the water in advance.

4.3.4 Dock Safety

- i) Smoking is prohibited on all portions of the dock, including the floating dock, as well as docked vessels
- ii) Swimming is prohibited off the dock on weekdays between 8am and 6pm and also after dark.
- iii) Personal recreational vessels are not allowed on the dock during working hours and only with permission of the Boat Department staff at other times.
- iv) Fishing is not allowed from any portion of the dock, docked vessels or moored vessels at any time.
- v) Boarding docked or moored vessels without express permission of the Boat department staff is prohibited.
- vi) Specific care must be taken near fuel pumps, fuel lines, the dive compressor fill station, high-pressure cylinders as well as during ship mobilization/demobilization.
- vii) During dive compressor operation, the use of combustion engines and substances producing fumes of any description must be avoided on the dock.
- viii) Fuel pumps are solely for use by BIOS vessels and vehicles and users must receive instruction on their use by qualified personnel

5 DIVING

5.1 Diving Operations

- i) Diving in any form under BIOS auspices is carried out under the operational control and approval of the Diving Safety Officer. This includes any scientific diving, educational diving, recreational diving or commercial diving undertaken using BIOS facilities or BIOS equipment, funded in any part by direct BIOS funding, or grant overseen by BIOS or a BIOS employee or adjunct.
- ii) All required documentation, plans, certifications and medicals must be submitted to and approved by the DSO prior to any diving activity occurring. It is the responsibility of the individual divers to familiarize themselves with what documentation is required for their particular activity and submit it to the dive office.
- iii) BIOS is an organizational member of the American Academy of Underwater Sciences and as such upholds the AAUS Standards for Scientific Diving and Operation of Scientific Diving Programs <https://www.aaus.org/AAUS>
- iv) Scientific diving is defined as “diving performed solely as a necessary part of a scientific, research or educational activity by employees whose sole purpose for diving is to perform research tasks” (OSHA 29 CFR 1910.402)
- v) All divers wishing to undertake scientific diving at BIOS must complete a registration document and series of medical forms and liability waivers. All of these can be found in the Student Diver Information Packet available on the BIOS website.
- vi) For all other aspects of scientific diving safety, standards and operations please refer to the BIOS Dive Safety Manual ([link](#)).
- vii) BIOS operates as a Professional Association of Dive Instructors dive school and our Educational Dive program is carried out under PADI auspices and safety standards.
- viii) The Educational Diving Program seeks to provide visiting students, scientists and staff to gain experience and further their diving certification process where the activities do not fall under the definition of Scientific Diving (see section 5.1 iv)
- ix) PADI dive training standards and safety standards apply to all Educational Dive Programs
- x) Educational Dive program participants are not allowed to conduct research, collect specimens, nor dive out with scheduled program classes.
- xi) All planning, documentation, certifications and medical information must be submitted to and approved by the DSO prior to any diving activity.
- xii) Educational Dive Program participants are subject to a check out dive with the DSO or designate.
- xiii) Recreational dives for staff or students may be organized by the dive office. All divers must possess certifications applicable to level of diving to be undertaken. The DSO will decide this. Completed waivers and certification cards must be presented to the DSO prior to any recreational diving activity.
- xiv) Recreational divers and participants of Educational dive Programs may not participate in scientific dives nor accompany scientific divers/dive trips.
- xv) All divers must adhere to the buddy system
- xvi) When diving from BIOS vessels, all boating safety rules must be adhered to. Refer to Section 4 of this manual.
- xvii) Plans for any commercial diving activities to be carried out by BIOS employees must be approved by the DSO, even when performed by external contractors.

5.2 SCUBA tank filling and dive compressor

- i) Filling of high-pressure cylinders with breathing gas shall only be carried out by the DSO, or individuals trained and approved by the DSO. Untrained persons may not touch or interfere with any part of the cylinder fill station or the compressor itself.
- ii) Only those tanks that have undergone a hydrostatic test within the preceding 5 years AND a visual inspection within the preceding 12 months shall be filled.

6 Radiation Policy

6.1 ORGANIZATION AND PURPOSE

In setting up rules and procedures to minimize radiation exposure, BIOS calls attention to recognized necessary precautions which, when carried out in the proper spirit, will minimize the probability of an accident occurring. If an accident should occur, the possibility of harmful consequences is expected to be greatly reduced by adherence to these practices.

Three principal factors are considered by the Radiation Safety Officer (RSO) in evaluating the adequacy of the safety risks in a proposed usage: (1) the training, experience, and ability of the individual to cope with the hazards involved in the particular application; (2) the adequacy of the facilities and equipment for the proposed usage; and (3) the thoroughness of the attention given to safety precautions in the proposed experimental manipulations and disposal procedures.

If the Radiation safety officer at any time is not satisfied with the adequacy of safety practices employed in a project, he or she may require cessation of the project until satisfactory procedures have been adopted.

All use of radioisotopes at BIOS falls under a license (Cert No: 15RDC003) granted and approved by the Department of Health in accordance with the Radiation Act 1972. Additionally, under this license, rules and regulation adhere to the Occupational Safety and Health Regulations 2009, and Bermuda Radiation Protection Guidance 13 (refs?). Operating under the license is subject to annual audits by the Bermuda Occupational Safety and Health Officer, which ensures correct compliance for both existing and any new legislation.

The BIOS radiation license allows use and storage of radioisotopes in three specified locations: BIOS Radiation laboratory RC215, the UNOLS radioisotope laboratory van on the R/V Atlantic Explorer, and the radiation storage closet opposite RC215. The use and storage of radioisotopes is strictly limited to these locations with the exception of transport to either of these two BIOS facilities.

At any one time, the combined amount of radionuclides contained at BIOS (RC215) and the R/V Atlantic Explorer (UNOLS laboratory van) will not exceed the quantities allowed by the BIOS license. As of October 2015 the specific nuclides and agreed possession limits are as listed in Table XX1

Radioisotope	Nuclide Symbol	Possession Limit
Hydrogen 3 (tritium)	$^3\text{H}(\text{H-3})$	25 mCi

Carbon 14	¹⁴ C(C-14)	35mCi
Phosphorous 33	³³ P(P-33)	25mCi
Sulfate 35	³⁵ S(S-35)	8mCi
Barium 133	¹³³ Ba(Ba-133)	10mCi
Silicon 32	³² Si(Si-32)	40mCi

Table XX1 – BIOS radionuclide total possession limits

6.2 THE PROCUREMENT AND USAGE OF RADIOISOTOPES AND EQUIPMENT

BIOS requires that every radioactive source on the premises be assigned to a specific individual who shall be responsible for its use though ultimately all sources fall under the authorized user which defaults to the RSO. In certain circumstances, it may be convenient for one person to be assigned responsibility for a departmental inventory consisting of several teaching and/or instrument check sources.

- I. Each sealed source (Ba-133) other than those exempt by size or specific regulation must be swipe-tested for leakage. For both BIOS's Packard 1600 Tri-Carb Liquid Scintillation Counter (LSC) and the UNOLS LSC on the R/V Atlantic Explorer, this will be done during annual service visits by a Perkin & Elmer engineer.
- II. Records will be maintained for each test.
- III. If a newly received sealed source does not have a certificate from a transferor indicating that a leak test has been made within six months prior to the transfer, it shall not be placed into use until tested.
- IV. If a contamination activity of greater than 0.005 microcuries is observed, the source is to be withdrawn from use and the RSO notified immediately.

6.3 SPECIFIC RADIOACTIVITY SAFETY STANDARDS

Maximum Permissible Levels from External Sources in Restricted Areas

- I. The maximum permissible level for total body radiation exposure shall be 1.25 rem per calendar quarter. A calendar quarter shall refer to any of the following periods: January 1 - March 31, April 1 - June 30, July 1 - September 30, October 1 - December 31. This shall not be acquired at a rate greater than 0.1 rem per week except when operating conditions require a higher rate for a special project. When such a higher rate is to be used, a safety officer must be present during the operation.
- II. The maximum permissible level for exposure to a limited portion of the body shall be the same as for whole-body exposure except that the hands, forearms, and feet may be exposed to a maximum of 18.75 rem per calendar quarter where necessary for operational reasons.
- III. No individual under 18 years of age may receive in any one-calendar quarter from radioactive material and radiation producing devices a dose in excess of 10 percent of the limits specified above.
- IV. The lowest possible daily exposure should be striven for in every operation. The exposure limits listed above represent the total additive exposure from all components of radiation involved.
- V. The maximum permissible accumulated dose to the whole body shall be calculated according to the following formula:
- VI. $MPD = 5 (N-18) \text{ rems}$

- VII. MPD = the maximum permissible dose in rems
- VIII. N = individual's age in full years
- IX. The relationship between R, rad, and rem is considered to be as given in the following table. Maximum values of average neutron flux for a 40-hour week exposure are also given.

Type of Radiation	Quality Factor	rem/week	rad/week (Maximum Neutron Flux for 40-hour Week Exposure)
X or gamma	1	0.1	0.1
Beta	1	0.1	0.1
Protons	10	0.1	0.01
Alpha	20	0.1	0.005
Fast neutrons	~15/n/cm ² /sec		
Thermal neutrons	670/n/cm ² /sec		

International System (SI) metric radiation units are used throughout the world. The United States was in a transition period until 1 April 1996 when the U. S. Department of Transportation mandated the exclusive use of SI units on labels and placards. Below is a comparison of radiation units used.

It should be noted that the guidance above is for general occupational radiation workers and not overly specific for BIOS radiation work. Under the current BIOS license, the useable radionuclides are weak beta emitters and the exposure limits listed above are well above any practical dosage expected from working with isotopes under BIOS license. Further, other than P-33 all other BIOS permissible radionuclides have insufficient energy to register on dosimeters.

Former Units SI Units

1 curie (ci) = 37 billion Becquerel (Bq)

1 Bq= 60 Disintegration Per Minute (DPM) – Note DPM is unit measured on the LSC.

1 Roentgen (R) = 2.58 X 10⁻⁴ coulomb per kg of air

1 rad = .01 Gray (Gy)

1 rem = .01 Sievert (Sv)

Equivalents for Conversion

Quantity (Activity)

1 TBq = 27 Ci = 27,000 mCi

1 GBq = 0.027 Ci = 27 mCi = 27,000 uCi

1 MBq = 0.000027 Ci = 0.027 mCi = 27 uCi

1 Ci = 0.037 TBq = 37 GBq = 37,000 MBq

1 mCi = 0.000037 TBq = 37 MBq

1 uCi = 0.037 MBq = 37,000 Bq

1 nCi = 0.000037 MBq = 37 Bq

1 pCi = 0.037 Bq = 37 mBq

Radiation Level (Dose Equivalent Rate)

1 Sv/h = 100 rem/h = 100,000 mrem/h 1 mSv/h = 0.1 rem/h = 100 mrem/h

1uSv/h = 0.0001 rem/h = 0.1 mrem/h

1 rem/h = 0.01 Sv/h = 10 mSv/h = 10,000 uSv/h
1mrem/h = 0.00001 Sv/h = 0.01 mSv/h = 10 uSv/h

To convert a value from the "Customary System of Units" to SI units and vice versa, use the following directions:

- Step 1: On the left side, find the unit you want to convert FROM.
- Step 2: Find the factor in that line for the unit you want to convert TO.
- Step 3: Multiply the original value by the factor and the result will be the measure in the desired units.

Example: Say a package has 20 TBq (=1200 T DPM as measured on LSC) of radioactive material. How many curies does this correspond to?

Answer: Following Step 1, we immediately find 1 TBq = 27 Ci
Following Step 2, we find that the "factor" is 27 Ci
Following Step 3, we multiple 20 x 27 which = 540
Answer is: 540 Ci

6.4 PROTECTIVE CLOTHING

- I. Suitable gloves must be worn at all times whenever using radioisotopes
- II. Rubber gloves shall be worn when handling open vessels containing alpha material or when handling any equipment of comparable hazard.(currently not applicable for BIOS)
- III. Laboratory coats must be worn as additional protection for personal clothing during handling of materials.
- IV. Disposable booties will be used in designated areas.

6.5 CONTAMINATION CONTROL

In addition to health issues, radiation contamination control at BIOS is imperative to prevent the possibility of contaminating scientific work measuring the natural abundance of specific isotopes (e.g., H-3 and C-14). This is mostly an issue with ship users but also a potential problem in the shore side facility and hence most of the stringent contamination control at BIOS is relating to experimental contamination since these levels are much lower than health related limits.

Personnel

All persons while working with radioactive materials wherein hand and shoe contamination is possible, are to:

- I. Accomplish decontamination prior to leaving any designated radiation area.
- II. Do not wear protective clothing outside of the laboratory area. There should be designated protective clothing for the radiation areas.
- III. Utilize the available equipment to assure that decontamination has been effected.
- IV. No work with long-lived alpha and beta-gamma emitters, in any chemical or physical form, is to be performed by a person having break in his skin below the wrist unless suitable gloves known to be clean on the inside are worn.

Areas of Use

- I. All areas in which there is radiation in excess of 0.5 mrem/hr shall be physically isolated and appropriate signs posted to prevent persons from entering the area without being aware of the radiological hazard. Signs having the radiation symbol will be standard for radiation hazards. The symbol will also be used to distinguish radioactive source containers, contamination area, hot sinks, barriers, etc.
- II. All spills of radioactive material must be cleaned up promptly. Cleaning responsibility shall rest on the individual(s) working in the area involved and responsible for the spill, and a survey shall be made after cleaning to verify that the cleaning has removed the radioactive material(s). Cleaning tools shall be assigned to the room in which the work operations are being performed and not removed or used elsewhere under any circumstances. The Safety Committee shall be notified of all spills or incidents involving possible contamination.

Routine Laboratory Surveys by Users

Individuals approved to procure and use radioisotopes are responsible for determining the levels of radiation and/or removable contamination present in facilities and will be subject to review by the RSO. The following minimum guidelines will be observed and will serve as a basis for procedures to be established as a part of the application for permission to procure and use radioisotopes.

- I. Approved individuals are responsible for determining the external radiation levels and/or removable surface contamination levels present in facilities under their supervision.
- II. Maximum permissible removable surface contamination is 10^{-4} microcurie/cm² (or twice the blank) as determined by dry swipe tests using filter paper on a surface area of 100 cm² for low-energy beta emitting isotopes and 1 mr/hr (measured in air at 1-inch from a 2 square inch area of surface). Surfaces indicating activities in excess of the above shall be decontaminated immediately using appropriate procedures.
- III. Areas in which radioisotopes are used on a continuous or regular basis will be surveyed at intervals not to exceed one month using methods appropriate to the isotope(s) in use.
- IV. Areas in which radioisotopes are used on an irregular or intermittent basis shall be surveyed on the above basis during periods of continuous use. Terminal surveys shall be conducted upon cessation of an interval activity.
- V. Authorized users are responsible for the maintenance of up-to-date permanent records of the results of area surveys. Records will be made available to the RSO upon request.

6.6 RECEIPT OF RADIOISOTOPES

- I. Any shipments of isotopes to BIOS must be prior approved by the RSO and further all packages will be shipped to the attention of the RSO.
- II. All isotopes shipped to BIOS will be checked and tested on arrival by an authorized user in consultation with the RSO.
- III. Due care shall be exercised when opening packages of radioactive materials, including the wearing of gloves and other appropriate protective clothing and the use of hoods and other equipment to protect personnel and minimize the possibility of contamination.

6.7 STORAGE, TRANSPORTING, AND HANDLING OF RADIOACTIVE MATERIALS

- I. Quantities of long-lived alpha emitters or similar hazardous substances having an activity greater than 1 microcurie shall be securely covered during storage and kept in an adequately protected location (not relevant under current license)
- II. Any transfer of materials must be done in such a manner as to avoid the possibility of spillage or breakage. Double containment in appropriate storage vessels is mandatory.
- III. Any work with materials susceptible to atmospheric distribution (i.e. dusting, spillage, vaporizing, effervescence of solution, etc.) shall be performed in adequate hoods, unless the safety of other procedures has been established. Suitable instrumentation for each type of material to be used must be available and in operation condition in the area in use. "Suitable" in this case will mean that the instrument will detect maximum permissible levels of contamination, radiation level, air hazard, etc., as are associated with the material(s) involved.
- IV. It is recognized that in the course of some experiments there will be a need for the handling of "hot" equipment or the reworking of "hot" equipment to conform to the requirements of the experiment. Such equipment should not be taken into non-radioactive areas until (a) all personnel within such areas are notified of the intent to bring in the material, (b) complete protective measures have been incorporated to assure minimum contamination to the area and to assure that any atmospheric distribution of the material resulting from the handling or reworking will be below the maximum permissible concentration value for the airborne material. It is apparent that certain equipment will conform to the safe limits associated with fixed concentration (i.e., radiation hazard), but the same material dispersed in the atmosphere would be above the safe concentration values for the material ingested.
- V. All areas where radiation materials and equipment are to be stored must be clearly marked with the radiation symbol and any other pertinent information. Such markings shall be placed in such a position that there will be no radiological risk or hazard to any personnel while reading it.

6.8 DISPOSAL OF RADIOACTIVE WASTE

General

- I. The radioactive wastes that will be produced at BIOS must be stored in either the radiation laboratory (N219) or the Radiation storage closet (N?) for radioactive decay or marked for removal during scheduled visits from the Bermuda Health board.
- II. It is necessary to keep the volume of such waste as small as practicable. In order to make full use of concentrating techniques and of the natural decay characteristic of radioactive substances, it is important that waste be segregated and labeled as far as practical according to type.
- III. It shall be the responsibility of all individuals producing radioactive waste to be aware of disposal limits and to conform to all requirements pertinent to safe disposal. In particular, efforts should be made to limit the volume of radioactive wastes and to furnish information concerning the nature of wastes being collected for subsequent disposal, i.e., (a) isotope(s), (b) estimated activity in waste (mCi), and (c) date of estimation.
- IV. All radioactive waste materials or equipment are to be removed from the working area as rapidly as possible. During the time that these materials or equipment

remain in the working area, shielding should be utilized to minimize the radiological risks and hazards.

Gaseous Wastes and Air Contaminates

- I. If the radioactive waste(s) to be disposed of is (are) in the gaseous state, the concentrations of effluents at all locations to which people have access without time limitation shall not exceed the permissible 24-hour ingestion or inhalation limits for the isotope(s) as given in 10 CFR (Code of Federal Regulations).
- II. The discharge of particulate radioactive contamination is to be avoided by the use of filters or suitable experimental techniques. All operations with radioactive materials and equipment shall be carried out in such a manner as to minimize contamination of the air and keep the operation within the limits given in 10 CFR. See 10 CFR 20.103 for application of this regulation.

Solid Wastes

- I. If the radioactive waste(s) to be disposed of is (are) in the form of a solid, it (they) shall be placed in a properly labeled containers to be stored in a radioactive waste storage area until natural radioactive decay has reduced the contamination to background level or until the waste may be sent to an appropriate waste disposal area.
- II. It is desirable that short-lived materials be kept separate from those of long half-lives where feasible. Whenever possible the nature of the material being disposed of should be fully described on a tag or sticker attached to the container.
- III. Waste containers for solid radioactive waste shall be removed when the maximum safe radiation level or volume is reached. The safe radiation level is defined as the level such that no one can receive an exposure on more than 50 mrem pre 8-hr day to the surface of the container. Typically, for short half-life emitters this is deemed to be seven half-lives.
- IV. All waste packages shall be carefully wrapped to preclude the possibility of external contamination.
- V. For disposal by commercial contractors or decay, contact the RSO for approval forms and instructions.

Liquid Wastes

Liquid waste materials are of such a nature that the responsibility for conforming to safe disposal practices rests on the individual user of radioactive materials. The feasibility of a safe liquid waste disposal program will be based upon the methods used by the individual user of radioactive isotopes to get rid of his waste and a statement of these methods is a required part of the user's standard operating procedure. All liquid waste must use secondary containment. Records must be kept of all liquid waste disposal and reported to the RSO quarterly.

6.9 TRITIUM BIOASSAYS

- I. Personnel using activities in excess of 100 mCi and in the form of water or gas and personnel using activities in excess of 25 mCi in any other form, with the exception of tritiated foil detector devices, will be required to have a urine assay performed within one week of single contact or weekly for repeated use (see below).

- II. Personnel who make repeated use of activities in the range of 5 to 25 mCi in any form other than water or gas will be monitored by quarterly urine assays.
 - III. In these and subsequent statements, "repeated use" is taken to mean operational procedures involving separate contacts with the stated activity amounts which occur at times averaging less than a week apart.
 - IV. Liquid scintillation counting of urine specimens for tritium activity is the accepted bioassay procedure. If tritium levels greater than 25 microcuries / liter are observed in an assay, the person involved will be required to cease all use of tritium pending further investigation. Levels greater than 2.5 microcuries / liter will be considered "cause for concern" and immediate steps will be taken to review the mode of operation.
- Note: Under current BIOS license (as of October 2019), no user will be exposed to H-3 levels requiring urine assays.

6.10 IODINE BIOASSAYS

- I. Personnel performing operations which involve only simple handling and/or dilution of Iodine-125 or Iodine-131 purchased in forms stabilized by the addition of a reducing agent will be required to undergo bioassays upon use of activities in excess of 25 mCi. The assays will be performed within one week of single contact or weekly for repeated use.
- II. Personnel performing iodination operations using Iodine-125 or Iodine-131 activities in excess of 5 mCi will be required to undergo bioassays within one week of single contact or weekly for repeated use.
- III. Bioassays will consist of a gamma count of thyroid activity carried out at a hospital approved by the RSO. A detectable thyroid burden will be treated as "cause for concern."
- IV. The RSO will be furnished a copy within 48 hours of the record of each bioassay showing levels above the limits stated above; a permanent record will be kept of all bioassays even though the results may be negative. Persons performing the bioassays and the method of procedure will have the prior approval of the RSO.

Note: I-123 and I-131 are not permissible under the current BIOS license.

6.11 SURVEY INSTRUMENTS

Applications for permission to use radioisotopes will include a list of equipment available for the detection of radioactivity and a statement of check and calibration procedures to be followed. Survey instruments will be calibrated at least annually. The RSO will ascertain through inspections and by quarterly survey statements of the authorized users that calibrations are maintained for the required survey instruments.

6.12 RESPONSIBILITY FOR TRAINING IN HEALTH PHYSICS

It shall be the responsibility of BIOS Principal Investigators to ascertain that personnel working in radiation areas are instructed in the above-described procedures. Personnel without training in the safety procedures in handling radioactive materials should receive this instruction under the close supervision of an adequately experienced individual. Since 2009, radiation training at BIOS has been provided by the Woods Hole Oceanographic Institute (WHOI) Director of Health and Safety. Further, the BIOS RSO

frequently consults with the WHOI Health and Safety Director on relevant radiation work procedures.

7 Maintenance and Operations Departments

7.1 VEHICLES

All BIOS vehicles are under the control of the Maintenance Department. Only employees approved by the Facilities Manager or Chief Operating Officer are allowed access to the Station vehicles. This includes the PEW warehouse forklift, small trucks and heavy trucks.

On Station Driving

- I. Observe and obey all Station speed limits – Max. 15kph
- II. Be aware of the activities going on around you i.e. other vehicle traffic, children and pets
- III. Always follow the one-way system
- IV. Report all mechanical difficulties to the Facilities Department immediately
- V. Report all accidents immediately to the Facilities Manager and complete and submit an accident report form.

Off Station Driving

- I. Always adhere to Bermuda Traffic Laws
- II. You must have a valid Bermuda driving license of the appropriate vehicle class in order to take a vehicle off Station.
- III. Each vehicle will be maintained in good repair. If a mechanical problem occurs report it immediately.
- IV. Vehicles shall not be loaded in such a manner as to interfere with safe driving or operation of the vehicle.
- V. No person shall ride in an insecure position on any vehicle.

7.2 ELECTRICAL SAFETY

Electricity has three potential hazards

- I. Electric Shock – In the event of an electrical accident where the victim touches a live part the severity of the electrical shock received depends on the quantity of current, this can cause the body to spasm, stop breathing, fibrillation of the heart or destroyed tissue. If severe shock occurs call 911, and begin appropriate first aid (see below).
- II. Burns – Electricity can cause severe burns to the human body. Precautions should be taken when dealing with any electrical appliance. If severe burns occur call 911, and begin appropriate first aid. (See below)
- III. Fire – Is a risk associated with electricity. Make sure all electrical cords and appliances are in good order before leaving any piece of equipment unattended.

Prevention of Electrical Shocks

- I. Using low voltages
- II. Insulating and or enclosing live parts

- III. Preventing conducting parts not normally "live" from becoming "live" by:-
 - Grounding and in severe conditions automatic disconnection
 - Using double insulation
 - By isolating the load conductors from the supply and grounding conductors
 - By limiting the electrical energy.
- IV. Selecting equipment for the environment in which it is to be used
- V. Using equipment as directed in the manufacturers operating manual
- VI. Ensuring that electrical equipment is adequately maintained.
- VII. Avoid the use of electrical appliances around water wherever possible
- VIII. All metallic non-current carrying apparatus enclosures must be connected to the supply ground by means of a grounding conductor.

First Aid for Electric Shock

- I. Call 911
- II. If the victim is held by the current, disconnect the supply if the plug or switch is near at hand or stand on newspapers or dry wood and pull the victim away by means of a piece of dry wood or dry clothing. DO NOT touch the victim's skin/
- III. Check breathing and pulse, commence CPR if required.
- IV. If breathing and pulse are detected, place the individual in the recovery position.
- V. Treat for shock.
- VI. Following the incident complete and submit an accident report form.

7.3 WORKSHOP

Workshop is under the responsibility of the Facilities Manager. Due to inherent hazards of this area, there shall be no unauthorized access.

Power Tools

Only trained and authorized personnel are allowed to use this equipment. The Facilities Manager will determine this.

Appropriate personal protective equipment shall be worn at all times:

- Hard hats, safety goggles and glasses, ear defenders, dust masks and gloves are available in the workshop.
- Fall protection equipment is to be used when working at height and are available in the workshop. Proper training is required.
- Appropriate footwear should always be worn.
- Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.