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Introduction

Thousands of chemicals are used at the Marine Biological Laboratory. Some are relatively harmless and may be used with a minimal number of precautions. Others, such as benzene, formaldehyde, and chloroform are human carcinogens that may require many special precautions. This handbook has been developed as part of the MBL's effort to ensure that its personnel have adequate information and training on chemical hazards. It is difficult for anyone to use chemicals in a responsible manner without basic safety information and training.

Manufacturers frequently report that the toxicological properties of their products have never been fully investigated. Therefore, even when there is no reason to believe that there are substantial hazards, measures must be taken to ensure that chemicals are handled responsibly. Chemical safety precautions are not difficult to follow. The consistent use of eye protection, gloves, lab coats, and other basic laboratory safety practices should protect laboratory personnel from most of the chemical hazards they might encounter.

Accidents are not anticipated events. Chemical safety precautions, like automobile seat belts, are only fully effective when they are used regularly. All personnel are encouraged to incorporate concerns about safety into all of their activities. Safety is not an isolated topic that can be addressed outside of the normal conduct of workplace activities.

Each supervisor has the fundamental responsibility for the safety of the personnel they supervise. Principal Investigators and other senior scientific personnel often act as supervisors and must be aware that they are responsible for the safety of their research personnel and the safety of the students and staff associated with their instructional activities. Supervisors are responsible for educating their personnel about chemical hazards and enforcing chemical safety regulations in their work areas. The supervisory training requirement is particularly important when new chemicals or procedures are introduced. This Handbook establishes minimum safety standards for the MBL. It does not relieve supervisors of their responsibility to establish effective safety procedures for their personnel.

This handbook is not intended to be a comprehensive chemical safety manual. Section 2.0 describes some of the other resources available to assist you in your efforts to learn about workplace hazards. Although this document concentrates on chemical hazards, it is equally important to pay attention to the physical hazards in our facilities. We should be particularly concerned about the potential for electrocutions and falls in our laboratories and other wet locations. The MBL Environmental Health and Safety (EH&S) Office welcomes suggestions on ways we can address these and other safety concerns.

The Occupational Safety and Health Administration (OSHA) is part of the United States Department of Labor. Part 1910.1450 of the OSHA standards, known as the Lab Standard, establishes regulations covering exposure to hazardous chemicals in laboratories. Part 1910.1200, the Hazard Communication Standard, covers MBL employees who are not laboratory workers. Copies of these standards are available in the EH&S Office.

1.0. REGULATORY OVERVIEW

1.1. 1910.1450 - The OSHA Lab Standard

The OSHA Lab Standard regulates all "laboratory use" of hazardous chemicals by MBL personnel. These are the major provisions.

1.1.1. The Lab Standard requires that we have a written Chemical Hygiene Plan (CHP). This handbook has been developed to satisfy many of the program and training requirements contained in our CHP. Copies of the CHP are available from the EH&S Office.

1.1.2. OSHA and the American Conference of Governmental Industrial Hygienists (ACGIH) have established exposure limits for many laboratory chemicals. Information on these limits is available in the EH&S Office. In accordance with the Lab Standard, it is MBL policy to comply with published limits and to limit all chemical exposures to the greatest practical extent.

1.1.3. The Lab Standard establishes a list of circumstances that require us to provide our employees with medical examinations. These are listed in Section 4.5.

1.1.4. The Lab Standard requires the MBL to maintain chemical labels, maintain accessible files of material safety data sheets, and otherwise ensure that chemical hazards are properly identified.

1.2. 1910.1200 - The OSHA Hazard Communications Standard

The Hazard Communications Standard covers chemical use by non-research personnel such as the employees in our Plant Operations & Maintenance and Building Services & Grounds departments. These personnel use chemical products and may also be exposed to research chemicals during their workplace activities.

The Hazard Communication Standard requires development of a written plan and establishes chemical labeling, Material Safety Data Sheets (MSDS), information, and training requirements. Most provisions of the two standards are similar enough to allow one basic chemical safety plan to cover all employees.

1.3. Chemical Safety for Non-Employees

Most personnel who use chemicals in our facilities are not MBL employees and are therefore not subject to the OSHA regulations. Some non-employees, such as Boston University Marine Program personnel, are covered by MBL policies as part of a formal agreement. Summer investigators and other visiting scientists may be covered by safety policies established by their home institutions. OSHA regulations do not apply to our students but as an institution we must accept some responsibility for their safety while they participate in the MBL- sponsored activities.

It is not the intent of the EH&S Office to attempt to identify all of the possible employment and other types of relationships the MBL has with the personnel who use chemicals in our facilities. The manner in which chemicals are used by non-employees may affect the safety of MBL personnel and reflect on our overall commitment to chemical health and safety. For this reason we must insist that all chemicals be used in a responsible manner that is consistent with applicable MBL policies.

1.4 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) was originally passed by Congress in 1976 to address the problem of managing and disposing huge volumes of municipal and industrial solid waste generated nationwide. The Environmental Protection Agency, (EPA),

estimates that 57 million metric tons of hazardous waste is generated each year in the United States.

RCRA establishes standards, which are applicable to generators (MBL-Small Quantity Hazardous Waste Generator), waste transporters, and operators of treatment, storage, and disposal (TSD) facilities. This system allows for the detailed tracking of the waste from it's' point of generation to it's' point of ultimate disposal. This is where the term "cradle to grave" was created.

The focus and scope of RCRA continues to evolve as environmental needs become more defined. The Act has been amended twice since 1976, in 1980 and 1984, and modifications continue to occur. The result has been to vastly expand the EPA's regulatory capabilities. The goals of RCRA are threefold:

1) To protect human health and the environment;
2) To reduce waste and conserve energy and national resources; and
3) To reduce or eliminate the generation of hazardous waste as effectively as possible.

The EPA requires that each state enforce environmental regulations that are at least as restrictive as the EPA's regulations. Each state has the right to be more restrictive than the EPA. In Massachusetts, the Department of Environmental Protection (DEP) enforces these regulations.

What are the primary regulations that affect how we handle and dispose of hazardous waste at the Marine Biological Laboratory?

1) 310 CMR 30.351(5) - hazardous waste may be accumulated (in the Main accumulation Area) for no more than 180 days prior to disposal.

2) 310 CMR 560 (3) - Incompatible wastes or materials incompatible with hazardous wastes shall not be placed in the same container. If mixing or commingling incompatibles occurs, it must not generate any uncontrollable safety hazard or threaten employee or public health or the environment (310 CMR 30.351 (8) (b) (2).

3) 310 CMR 30.341(2) - Markings and Labels shall be placed on the sides of containers so they are clearly visible for inspection.

2.0 CHEMICAL SAFETY INFORMATION

2.1. Material Safety Data Sheets

Material Safety Data Sheets (MSDSs), provided by our chemical suppliers, contain basic information about the physical characteristics and hazards of commercial chemical products. Files are maintained on MSDS Online (link found on the E, H, and S website). Manufacturers send most MSDSs directly to the EH&S Office. If you receive a MSDS please send the original to the EH&S Office so that it can be added to our master files.

MSDSs contain:

a) Substance Identification
b) Ingredients and Hazards
c) Physical Data
d) Fire and Explosion Data
e) Reactivity Data
f) Health Hazard Information
g) Spill, Leak, and Disposal Procedures
h) Special Protection Information
i) Special Precautions and Comments

Well-prepared MSDSs contain extensive information about chemical hazards and safety precautions. Although it appears that liability concerns often cause manufacturers to exaggerate chemical hazards, MSDSs are still a valuable source of information. Even if the recommended precautions appear overly conservative, they are usually easy to observe and they ensure that necessary safety procedures are followed. We should not ignore manufacturer recommendations unless we have clear evidence that our alternative safety precautions are adequate.

2.2. Labels

Most products bear labels that contain information similar to that contained in the MSDSs. For example, labels on Fisher Scientific products contain summaries of health hazards, first aid precautions,
information on protective equipment, National Fire Prevention

Association (NFPA) ratings and storage information. Information on labels is explained in the chemical section of their catalogue. Other manufacturers provide comparable information.

2.3. Other References

The MBL/WHOI library provides many valuable resources. Selected safety references are available in the Grass Reading Room. The NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards are a particularly valuable summary of the hazards of approximately 400 of the most common chemicals.

In addition to MSDS files, the MBL EH&S Office also maintains a large library with many chemical safety references.

3.0. PROGRAM RESPONSIBILITIES AND SERVICES

3.1. General

The primary chemical safety responsibility rests with Principal Investigators and other supervisors. In their supervisory roles, these individuals select chemicals, control resources, and direct the day-to-day activities of other personnel. However, all employees must share responsibility for the safe use of chemicals. The ultimate success of our safety programs depends on the active involvement of all personnel.

3.2. The MBL Environmental Health and Safety Office (Rowe 401)

The EH&S Office provides consultation and provides specialized assistance. EH&S Office services include:

a) maintenance of a reference library and MSDS files,

b) consultation on chemical safety concerns and advice about ways to control hazards,

c) consultation on the selection and use of gloves, respirators, and other personal protective equipment,

d) calibration of fume hoods and assistance with indoor air quality concerns,

e) chemical waste disposal,

f) evaluation of exposures to airborne contaminants,

g) program management, education, and training to assure that we use our chemicals in a responsible manner.

4.0. EMERGENCY INFORMATION

4.1. Emergency Phone Numbers (for use from MBL extensions)

4.1.1. Extension 7911 is the MBL's 24-hour emergency number. During normal working hours, it is answered in the Swope Office. Nights and weekends it is answered by our watchmen.

4.1.2. Extension 7217 - MBL Watchman

4.1.3. Falmouth Fire and Rescue (medical emergencies) - 9-911

4.1.4. Falmouth Police - 9-911

4.1.5. Massachusetts Poison Information Center - 1-800-222-1222

4.1.6. Phone stickers are available from the EH&S Office (Rowe 401).

4.2. Medical Emergencies

Call the MBL emergency number, extension 7911, to report a medical emergency. Please provide your name, your telephone extension, the nature of the emergency, and the exact location where it has occurred. Remain on the line until you are instructed to hang up. The operator or watchman who answers your call will notify MBL emergency response personnel and/or local emergency services as required. Please call 911 direct if it is a life or death emergency.

4.3. Chemical Spills

Chemical spills are a disruptive but unavoidable consequence of any research activity. Emergencies can generally be avoided if personnel evacuate spill areas promptly, attend to their personal decontamination, and seek medical assistance. Most emergencies are caused by ill advised clean up attempts by inexperienced and poorly equipped personnel. The following procedures must be followed.

4.3.1. When There is a Spill With No Personal Contamination

a) Evacuate the spill area. Pause if possible to turn off any apparatus that requires constant attention and to close any open windows.

b) Close doors leading to spill area.

c) Do not open windows. Airflow through open windows is almost always inward and can contribute to the spread of contamination throughout a building.

d) If a building evacuation is desirable, activate the fire alarm.
e) Contact the EH&S Office at extension 7424 or call the MBL emergency number at extension 7911 for assistance.

f) While waiting for assistance, check the airflow around the doors leading to the spill area. If the air is flowing out, seal the doors with wet paper towels or tape.

g) After the initial evacuation, you may reenter a spill area if you are certain there is no risk. This decision should be made at leisure, outside the spill area, not in an area where you may be experiencing anxiety about the accident and the effects of a chemical exposure.

4.3.2. When There is Personal Contamination

a) Remove lab coat, shoes, and outer clothing. Decontaminate using the nearest emergency shower and/or eyewash. If you cannot reach an emergency shower or eyewash, improvise using any available water source. Contaminated eyes must be rinsed for at least 15 minutes.

b) Seek assistance by calling extension 7911. If possible, have someone else make the emergency call and secure the spill area while you proceed with personal decontamination.

c) The EH&S Office has information on chemical toxicity and first aid requirements. Comprehensive emergency information is also available from the Massachusetts Poison Information Center.

d) After personal contamination has been controlled, proceed with the other instructions for managing a chemical spill.

e) Personnel who have been exposed to hazardous chemicals may be required to have a medical evaluation.

4.4. Reporting Accidents

All injuries, no matter how minor, must be reported promptly. Our MBL "Supervisor's Report of Accident", available from the Human Resources Office or the EH&S Office, must be completed. Supervisors are asked to complete this form because they have the primary responsibility for employee safety. Any job related injury or near miss should be reported because it may help us identify a potentially serious safety problem.

4.5. Medical Consultation and Examinations

Employees are entitled to receive medical examinations, at MBL's expense, under any of the following circumstances:

4.5.1. Whenever an employee develops symptoms of exposure to a workplace chemical;

4.5.2. Whenever exposure monitoring indicates that airborne chemical levels routinely exceed legal limits;

4.5.3. Whenever there is an accident resulting in the likelihood of a significant exposure.

4.6. Emergency Showers and Eyewashes

Bold/underlined units are always accessible when the building is open. Others may be in locked laboratories.

4.6.1. Lillie Building

a) Lillie-08 (Stock Room) - Emergency Shower and Eyewash
b) **Outside Lillie-121 (BoP)**
c) **Outside Lillie-218** (General Use Room)
d) **Outside Lillie-319** (Global Infectious Disease Program)
e) **Outside Lillie-331** (Bay Paul Center)

4.6.2. Loeb

a) Loeb-25 (Neurobiology)	Emergency Shower and Eyewash
b) Hallway outside Loeb-26	Emergency Shower
c) Loeb-27	Emergency Shower
d) **Hallway outside Lb-103**	Emergency Shower and Eyewash
e) **Hallway outside Lb-203**	Emergency Shower and Eyewash
f) **Hallway outside Lb-305**	Emergency Shower and Eyewash
g) Loeb-310 (Physiology)	Emergency Shower

4.6.3. Rowe

a) 4th Fl. Hallway	Emergency Shower and Eyewash
b) 3rd Fl. Hallway	Emergency Shower and Eyewash
c) 2nd Fl. Hallway	Emergency Shower and Eyewash
d) All labs	Emergency Eyewash

4.6.4. Ecosystems Center

a) ESC-112	Emergency Shower and Faucet Mounted Eyewash
b) ESC-113	Emergency Shower and Faucet Mounted Eyewash
c) **Hallway outside ESC-114**	Emergency Shower/Eyewash
d) ESC-212/213	Emergency Shower
e) ESC-213	Faucet Mounted Eyewash and Hand Held Hose
f) ESC-214	Emergency Shower and Hand Held Hose
g) **Hallway outside ESC-214**	Emergency Shower/Eyewash
h) ESC-215	Emergency Shower and Faucet Mounted Eyewash

4.6.5. Marine Resources Center

a) **Hallway outside 202** Emergency Shower and Eyewash
b) **Hallway outside 301** Emergency Shower and Eyewash

4.6.6. 15 North Street

a) Cage washing room Handheld drench hose

4.6.7. Starr Building

a) **Outside 124** Emergency Shower and Eyewash
b) **Outside 231** Emergency Shower and Eyewash
c) **Outside 228** Emergency Shower and Eyewash
d) **Outside 331** Emergency Shower and Eyewash
e) **Outside 334** Emergency Shower and Eyewash

5.0. FIRE SAFETY

5.1. Before a Fire Occurs

5.1.1. Locate the nearest alarm pull station. Most MBL alarms are now hard-wired to the Falmouth Fire Department.

5.1.2. Locate the nearest alarm bell.

5.1.3. Identify several possible exit routes.

5.2. When you Discover a Fire

5.2.1. Activate the nearest alarm.

5.2.2. Evacuate, notifying other personnel on the same floor to leave at once.

5.2.3. Call the MBL emergency number, extension 7911, from a safe location. Provide complete information about the nature and location of the emergency. Our emergency personnel will notify the Falmouth Fire Department.

5.2.4. Do not attempt to fight a fire unless you have been properly trained in the use of portable fire extinguishers and can fight the fire without endangering your safety. Never attempt to fight a fire until after the alarm has been sounded, the MBL emergency number has been called, and evacuation is underway.

5.2.5. If possible, remain outside the building and help direct the Falmouth Fire Department to the exact location of the fire.

6.0. MEASURES FOR REDUCING EXPOSURES TO HAZARDOUS CHEMICALS

6.1. Laboratory Hygiene and General Work Practices

6.1.1. Smoking and Alcohol

Smoking and consumption of alcoholic beverages are prohibited in all of our laboratories.

6.1.2. Eating and Drinking

Eating and the use of non-alcoholic beverages in laboratories are not prohibited except in areas where hazardous chemicals or radioisotopes are being used. Separate well-defined areas must be established for the consumption and storage of food and beverages.

6.1.3. General Housekeeping

Work areas should be kept clean and free of obstructions. There is a definite relationship between safety performance and orderliness in laboratories.

6.1.4. Mouth Pipetting

Mouth pipetting is both dangerous and unnecessary. A pipette bulb or an aspirator should be used to provide vacuum. The use of mouth pipetting on "non-hazardous" solutions substantially increases the risk of accidental ingestion of hazardous materials.

6.1.5. Personal Hygiene

Hands should be washed each time you leave the laboratory and after any contact with hazardous materials. Please remove contaminated gloves before leaving the lab also.

6.1.6. Working Alone

Working alone should be avoided for both safety and security reasons. If you must work alone and are conducting a potentially hazardous experiment, you should make arrangements with the watchmen or other personnel to check your laboratory periodically.

6.1.7. Visitors

Laboratory guests, service personnel, summer and part time employees, and visiting scientists must be fully informed about our safety requirements and the hazards of any chemicals to which they may be exposed.

6.2. Personal Protective Equipment

6.2.1. Lab Coats and Clothing

When hazardous chemicals come into contact with the skin, they may cause direct injury or be absorbed into the body. Appropriate protective clothing must be worn whenever hazardous chemicals are used. Lab coats are designed to protect clothing but they may provide sufficient skin protection for many routine chemical operations. Protective aprons should be worn when corrosive or irritating liquids are being handled.

6.2.2. Eye and Face Protection

Eye protection must be worn whenever hazardous chemicals are being handled. Eye protection should be worn at all times while you are in a laboratory. Accidents are rarely anticipated. Routine use of eye protection is the only way to guarantee that protection will be in place when there is an accident.

Ordinary prescription glasses may contain "safety glass" but they do not provide adequate protection. They do not have side shields and they do not offer as much impact protection as proper safety glasses.

Concern about wearing contact lenses has been shown to be overstated and the MBL will allow them in our laboratories when they are used in conjunction with appropriate eye protection. Personnel who wear contacts should be alert to any eye problems that may be caused by their work environment and should make personnel who assist them in an emergency aware of the presence of the lenses.

In addition to proper eye protection, face shields should be worn when maximum protection against flying particles and chemical splashes is required.

Each individual should have his or her own equipment. The MBL Stock Room stocks the following items:

a) Indirectly vented goggles for protection against splashing chemicals.

b) Polycarbonate safety glasses for impact protection against flying particles. Glasses are available in a style that fits over regular prescription glasses. The polycarbonate lens on these glasses provides 99.9% protection against UV radiation up to 385 nm.

c) Face shields made of polycarbonate that offer full face UV and chemical splash protection.

Other products are available on short notice from vendors or on loan from the MBL EH&S Office.

6.2.3. Gloves

Gloves must be worn whenever hazardous materials are being handled. Even when gloves are being worn, it is important to avoid contact with chemicals and to remove and clean or discard any gloves that become contaminated. Many chemicals will penetrate or degrade gloves if contact time is prolonged.

The MBL Stock Room stocks disposable nitrile, latex, and PVC gloves; reusable rubber gloves; and gloves that protect against extreme heat and cryogenic materials. Vendor catalogues include chemical resistance guides and other information to aid with glove selection. Assistance is also available from the EH&S Office.

6.2.4. Shields

Safety shields may be required to protect against possible explosions and severe chemical splash hazards. These risks may seem to be rare in our laboratories but MBL researchers do use picric acid, perchloric acid, sodium azide, 2,4, dinitrophenol, sodium metal and other chemicals that have recognized explosion potentials.

6.2.5. Respiratory Protection

The Occupational Safety and Health Administration (OSHA) has established limits on exposures to a selected group of air contaminants. The American Council of Governmental Industrial Hygienists (ACGIH) also develops recommended airborne exposure limits. It is the policy of the MBL to achieve compliance with these standards without relying on the use of chemical cartridge respirators. Fume hoods, engineering controls, and the substitution of less hazardous chemicals must be used to reduce exposures to acceptable levels.

You must contact the EH&S Office to arrange for a hazard assessment if ongoing or proposed activities involve the use of hazardous chemicals which may become airborne. If the assessment of airborne chemical concentrations indicates that OSHA concentration limits are at risk of being exceeded, chemical cartridge respirators may be worn by trained users as a safety precaution. Respirators may also be used to control exposure to unregulated materials. The EH&S Office maintains a supply of low cost disposable respirators.

6.3. Fume Hoods

6.3.1. General

Fume hoods must be used when volatile hazardous chemicals are being dispensed and when other manipulations are conducted that may create airborne contamination. We do not have hoods in every laboratory but the supply is adequate provided that they are used properly.

Chemicals that are released into fume hoods are discharged to the environment without any treatment or filtration. Chemical releases must be minimized. Waste containers must not be left open to allow chemicals to evaporate.

Fume hoods are maintained by the Plant Operations and Maintenance Department, extension 7333. They are tested on a periodic basis by the EH&S Office.

6.3.2. Fume Hood Instructions

a) Fume hoods are mechanical systems subject to periodic failures. Airflow should be checked prior to each use.

b) A piece of lightweight plastic or paper, such as a Kimwipe, should be taped to the bottom of the sash to indicate airflow.

c) If a hood failure can create an immediate threat to your safety, you must use a hood equipped with an alarm.

d) Hoods function most effectively when the height of the opening of the moveable sash is 12" or less. Do not work with your head inside the hood.

e) Keep the work surface as clear as possible to limit obstructions which can disrupt airflow and create counter currents. Slots on the back inside wall must not be blocked.

f) Hood work surfaces should not be used to store chemicals or equipment. If you must use a hood for storage or permanent equipment installations, please consult with the EH&S Office for advice on arranging materials to minimize their impact on hood performance.

g) Equipment and chemicals should be set back at least 6" from the front edge of the work surface.

h) Hood glass is "safety glass" and should minimize the effect of an explosion but it must not be used as a substitute for a proper explosion shield.

i) Most hood base cabinets are not ventilated and contain ignition sources. For this reason, they are generally very poor areas to use for chemical storage.

6.3.3. Biological Safety Cabinets

Biological safety cabinets and laminar flow hoods are designed to protect workers from infectious materials and to prevent substances in room air from contaminating materials inside of their enclosure. They are not designed for chemical use. Air recirculating inside the cabinets may increase chemical concentrations to hazardous levels. Air from inside the cabinet is discharged into the laboratory after passing through HEPA filters that do not trap volatile chemicals.

6.4. Detecting Chemical Exposures

The most common routes of chemical exposure are inhalation, accidental ingestion, and skin absorption. Skin contact may cause localized injury or internal poisoning via absorption of chemicals through the skin.

Chemicals may be inhaled in the form of dusts, mists, gases, vapors, and sprays. They may affect the respiratory system and also affect other internal organs when they enter the body through the lungs or digestive system.

Some chemicals have characteristic odors that are readily detectable at concentrations below the permissible exposure limits (PELs). If you cannot smell these chemicals, you can be reasonably certain that you are not being over exposed. Other chemicals have odors that are only noticeable at hazardous concentrations or have odors that produce olfactory fatigue. The sense of smell is therefore a valuable but very limited way to

assess chemical hazards. The EH&S Office has information on odor thresholds and the PELs.

Whenever possible hazardous chemical releases must be minimized. This can be accomplished by identifying less hazardous substitutes, minimizing the amount of chemicals used, and by using closed containers to minimize evaporation. Fume hoods and other ventilation controls do not reduce chemical releases but they dilute the chemicals and may discharge them to areas that are not occupied on a regular basis.

Because most chemicals are used intermittently and in relatively small amounts, routine air monitoring is generally not conducted in research laboratories. Monitoring will be conducted if there is any reason to believe that chemical concentrations are approaching legal limits or creating any safety concerns. Monitoring will be continued if initial screening results are significant. The MBL EH&S Office has an instrument which can be used to measure concentrations of known airborne contaminants. Biological assays are also available which can quantify individual exposures to chemicals. These will be made available to employees if there is any reason to suspect that a significant exposure has occurred.

Studies of laboratory acquired infections have found that only 20% of all infections are caused by recognized accidents. It is assumed that a significant percentage of infections are caused by contact with contaminated surfaces or inhalation of aerosols. Knowledge acquired during the studies of laboratory infections can also be applied to chemical safety concerns. It is reasonable to conclude that most chemical exposures take place during routine laboratory operations when there has not been any unusual incident that created recognized hazards. Operations involving highly hazardous chemicals must be carefully reviewed in an effort to identify and eliminate all possible sources of contamination. Excellent laboratory hygiene practices must be followed to reduce individual exposures to chemical contamination.

Experience gained through the use of radioactive materials also serves as a reminder of the importance of using extra care when highly hazardous chemicals are being handled. Despite strict regulations and the extra attention given to radioisotopes, monthly monitoring frequently reveals detectable contamination on equipment and research facilities. We must assume that comparable contamination is created when other, less detectable, hazardous materials are used. When highly toxic chemicals are used, work areas must be decontaminated on a daily basis.

Chemical exposures may produce immediate and obvious symptoms and they may create delayed effects. Health effects may be the first indication that a chemical exposure has taken place. There have been very few symptomatic chemical exposures at the MBL, but you should consider your exposure to chemicals if you develop unusual medical problems or if several people in your laboratory develop similar complaints. MSDS, labels, and other readily available resources contain information about the health effects of chemical exposures.

7.0 CHEMICAL HANDLING, STORAGE, AND DISPOSAL

7.1. Limits on Flammable Storage

The National Fire Protection Association (NFPA) has developed classifications for flammable and combustible liquids and limits on the amounts that should be stored in each research laboratory. Many of our more common solvents such as acetone, acetonitrile, ethanol, ethyl ether, hexane, methanol, toluene, and xylene are Class I flammables. Ignitable mixtures of vapors and air exist above these liquids at room temperatures.

Inventories of low flash point chemicals must be minimized. In most cases, NFPA guidelines require that total amounts of Class I flammables in any single laboratory unit must be kept below four gallons. These chemicals are all available in the Stock Room where they are stored in cabinets that are specifically designed for the storage of flammable liquids. Laboratories that wish to have large solvent inventories may be required to purchase their own flammable storage cabinets. Whenever practical, a quantity of any flammable liquid greater than one quart should be stored in a metal safety can.

7.2. General Chemical Storage Requirements

Extensive information on chemical storage is available in the EH&S Office. The following list covers only a few of the most important considerations.

7.2.1. Chemicals must be stored in secure, well-labeled containers. Original labels must be maintained. Secondary chemical containers, regardless of their contents, must be carefully labeled with the identity of the chemical and appropriate hazard warnings unless the contents are intended for your immediate use. Unlabeled or mislabeled containers can cause accidents and create serious disposal problems.

7.2.2. Inventories must be kept to an absolute minimum. A significant portion of our waste disposal budget is spent on the disposal of pure unused chemicals that are discarded when laboratories close or move to other institutions. This is environmentally irresponsible and a waste of limited research resources. Sharing chemicals among research groups is strongly encouraged.

7.2.3. Mutually reactive chemicals should be stored separately. Unnecessary hazards may be created when chemicals are stored in alphabetical order without regard for compatibility. Most chemical manufacturers provide storage information and color codes on their labels.

7.2.4. Chemicals stored on floors must be placed in plastic tubs to protect against accidental breakage and to contain spills.

7.2.5. Cardboard boxes are not appropriate for the storage or transportation of chemicals.

7.2.6. Unless they are specifically designed and designated as flammable storage cabinets, the cabinets under fume hoods are not suitable locations for storing flammable liquids. They are not ventilated and they contain switches and other electrical equipment that may ignite confined vapors.

7.2.7. Unmodified laboratory refrigerators must not be used for storing flammable liquids. Sparks from a thermostat, fan, or light may ignite vapors that accumulate in the unventilated compartments. Refrigerators used for the storage of flammable liquids must be specially manufactured for that purpose or modified to remove all internal ignition sources.

7.2.8. Peroxide formers such as ethyl ether must be dated when they are received and discarded within one year.

7.2.9. Each laboratory should maintain a chemical inventory and inspect all chemicals on an annual basis to maintain damaged labels and discard surplus and outdated materials.

7.3. Compressed Gases

Compressed gases are ordered through the Purchasing Department and delivered by the Apparatus Department. Apparatus must be notified about any cylinder moves so that they can keep track of our inventory and limit demurrage charges.

All cylinders must be chained or securely tied at all times during storage, use, and transport. “Empty” cylinders must also be secured. They may contain as much as 600 psig of residual pressure. Unused cylinders must be capped. Cylinder carts and clamps are available from the Apparatus Department. Apparatus will not deliver a cylinder to any laboratory unless there is an adequate means of securing it.

The total force on the inside surfaces of a laboratory cylinder may be as much as 28,800,000 pounds. Broken cylinders may cause extensive damage. Regulators are particularly subject to breakage and they must be protected during use and removed during storage and transport. In addition to the physical hazards, stored gases may be toxic, flammable, or act as asphyxiants.

7.4 Cryogenic Liquids

Small amounts of liquid nitrogen are available through the Central Microscopy Facility. Cryogenic liquids such as liquid nitrogen pose numerous handling and safety problems.

Skin or eye contact with liquid nitrogen or cold gas may cause serious frostbite injuries. Objects cooled by liquid nitrogen may freeze to skin if they are handled without gloves.

7.4.1. Appropriate eye protection, preferably a full-face shield, must be worn whenever liquid nitrogen is handled.

7.4.2. Loose fitting heavy leather gloves specifically designed for use with cryogenic liquids are strongly recommended.

7.4.3. Use only with containers that are designed for use with low temperature liquids. Never close N2 containers with tightly fitting stoppers or any other device that will interfere with venting of the gas.

7.4.4. Liquid nitrogen must be stored and used in well-ventilated areas.

7.5. Chemical Waste Disposal

Complete instructions are available in the MBL’s Chemical Waste Disposal Policy. Copies are available in the EH&S Office. You must be familiar with the entire policy if you plan to generate any regulated chemical wastes.

7.5.1 Please call Safety (x7424 or x7192) for pick-up of all surplus chemicals must be brought to the Stock Room for either disposal, or another lab’s use. Waste chemicals should be stored in each lab’s satellite accumulation area (SAC) prior to weekly removal by Safety department personnel. The EH&S Office sorts the chemicals and discards them appropriately. There is no charge for waste disposal.

7.5.2. Hazardous chemicals may not be discarded in regular laboratory trash or discharged down drains. No solutions may be discharged down laboratory drains unless you are absolutely certain that the discharges are both safe and legal.

7.5.3. Non-specific descriptions such as “organic waste,” “fix,” and “EM wastes,” are insufficient. Containers must be labeled with complete chemical contents.

7.5.4. Special labels, available from the Stock Room, must be placed on all waste containers.

7.5.5. Containers must be kept closed when not in use.

7.5.6. Most compatible chemicals may be mixed. The full policy describes special precautions that apply to uranium and osmium wastes.

7.5.7. The EH&S Office maintains a supply of recycled chemical containers that may be used for collecting wastes.

7.6 Satellite Accumulation Areas (SAAs)

7.6.1 Due to the limited amount of space in many of our labs, it is not feasible to set up Satellite Accumulation Areas (SAAs) to collect hazardous waste at the point of generation in every lab. However, we will attempt to set up SAAs where it is feasible and where chemical waste is being produced.

7.6.2 Where feasible, the Safety Services Department will set up a Satellite Accumulation Area (SAA) in order to collect chemical waste at the point of generation. Each SAA will include a secondary containment bin to store hazardous waste, a sign to delineate the location, and a weekly inspection performed by Safety Services personnel. The Safety Services department will keep a master list of each location.

7.7 Other Special Wastes

Further information about these policies is available from the EH&S Office.

7.7.1. Sharps, officially defined as "used and discarded hypodermic needles, syringes, pasteur pipettes, scalpel blades, razor blades, and broken medical glassware," must be placed in an appropriate sharps container prior to shipment to a medical waste incinerator.

7.7.2. Uncontaminated marine animals, collected in Cape Cod waters, should be placed in animal buckets for disposal by our custodians. Terrestrial animals, non-native marine animals, and treated specimens will be commercially incinerated. They must be placed in a freezer located in Loeb-18.

7.7.3. All live cultures and other liquid and solid biological wastes must be decontaminated chemically or thermally prior to disposal. Full biohazard bags may not be placed in regular laboratory trash. Autoclaved wastes that contain sharps must be must be placed in an appropriate sharps container prior to shipment to our medical waste vendor. Other biohazard bags should be emptied into a regular trash receptacle. The empty bags should be taped up into a small bundle or otherwise packaged so that they are not readily identifiable.

8.0. SPECIAL PRECAUTIONS FOR HIGHLY TOXIC CHEMICALS

8.1. Definitions

8.1.1. Highly toxic chemicals are carcinogens, reproductive toxins, and substances having a high degree of acute toxicity.

8.1.2. Carcinogens are substances that induce cancer in humans. Appendices A and B are lists of substances that are either known or reasonably anticipated to be human carcinogens. Formaldehyde is the known human carcinogen most commonly used in our facilities.

8.1.3. Reproductive toxins include mutagens and teratogens. Mutagens are substances that damage the DNA in female or male germ cells. Teratogens are substances that

damage a developing embryo or fetus. Appendix C is a list of substances that may adversely effect reproduction and development. Because there is no single accepted list, information from a variety of sources including MSDSs may be needed to adequately identify reproductive toxins.

8.1.4. An acutely toxic substance can cause damage as a result of a single or short duration exposure. A chronically toxic substance causes damage after repeated or long duration exposures. Acute health effects are effects that appear rapidly. Chronic health effects are effects like cancer that may not appear until many years after an exposure. Chemicals often cause both acute and chronic effects.

8.1.5. Substances with a high degree of acute toxicity are substances having either an LD50 of 50 milligrams or less per kilogram of body weight by ingestion, an LD50 of 200 mg/kg or less by contact, or an LC50 of 200 ppm or less by inhalation. LD50 and LC50 information is available in MSDSs. When human data is not available, results of animal studies will be used. LD50 (Lethal Dose Fifty) and LC50 (Lethal Concentration Fifty) refer to calculated acute doses of a substance that are expected to cause the death of 50% of an exposed population.

8.2. General Precautions for Using Highly Toxic Chemicals

These basic precautions should be adequate for most chemicals that have moderate chronic and high acute toxicity. Precautions listed in Section 8.3. must also be followed when chemicals are handled that have a high degree of both acute and chronic toxicity.

8.2.1. Employees using these substances must be fully informed about their hazards and should be prepared to answer questions about health effects and proper handling methods.

8.2.2. Precautions listed in Section 6.0 must be followed whenever highly toxic compounds are being used. Extra care should be given to glove selection.

8.2.3. A fume hood must be used whenever volatile materials are used and whenever there is a foreseeable risk of aerosol formation.

8.2.4. Work areas and equipment must be protected from spills through the use of trays and absorbent liners.

8.2.5. Emergency procedures must be reviewed. Special first aid supplies or antibodies may be required for some substances.

8.3. Additional Precautions for Substances which have a High Degree of Acute and Chronic Toxicity

Additional precautions will be required when potent carcinogens and certain highly toxic heavy metal compounds are used such as nickel carbonyl and dimethylmercury. Users are strongly encouraged to contact the EH&S Office before these substances are used. Specific written work practices should be developed by the researcher and reviewed by the EH&S Manager. Some research may be inappropriate for our facilities or may require highly specialized containment, such as a glove box.

These are examples of additional precautions that may be required.

8.3.1. A designated area with clearly marked boundaries must be established. This may be an entire lab, a fume hood, or any other clearly definable portion of a lab.

8.3.2. Appropriate warning signs and labels must be readily visible in the work area and on glassware and equipment.

8.3.3. Special considerations must be given to the storage of these chemicals to ensure that they are not released under normal storage conditions and ensure that they are fully contained in the event of a spill. Storage areas must be locked.

8.3.4. Waste must be collected in durable well-labeled containers. Waste containers must be stored and transported in sturdy secondary containers that are large enough to contain wastes in the event of a spill.

8.3.5. Hazardous waste regulations do not allow us to treat wastes to convert highly toxic chemicals into less toxic reaction products. However, treatment may be allowed if it is conducted for safety purposes in accordance with a formal written protocol.

8.3.6. Vacuum pumps must be fitted with high efficiency scrubbers or filters.
8.3.7. Work areas must be decontaminated at the end of each workday. All work areas and equipment must be labeled until decontamination is completed.

8.3.8. Disposable lab coats, available from the Stockroom, must be worn.

8.3.9. The amount of material purchased and the amount used in each experiment must be minimized.

9.0. Shock Sensitive Chemicals

9.1 General

Shock sensitive chemicals may explode with movement, friction or heat. These chemicals have the potential to undergo a rapid reaction that may be violent enough to produce an explosive reaction. Some chemicals are shock sensitive by nature. Others become shock sensitive through drying, decomposition, or slow reactions with oxygen, nitrogen, or the container. Some chemicals that are or may become shock-sensitive will have this hazard noted on their MSDS.

9.2 Strategies to Improve the Management of Shock-Sensitive Chemicals

The two main types of shock-sensitive chemicals that present a hazard are peroxide formers and peroxidizable organic chemicals. The chemistry and management of these and other shock-sensitive chemicals is not well understood. Effective management of these chemicals is a challenge because:

1) There is no absolute answer as to what should or should not be defined as being shock-sensitive.

2) Detection methods for potentially explosive concentration levels are not definitive.

3) Procedures for removing peroxides are not always effective.

4) What Can Happen?

Between 1980 and 2002 there were 167 accidents nationally involving shock-sensitive chemicals that resulted in severe injuries and/or fatalities. Failure to acknowledge that hazards that shock-sensitive chemicals present can result in extreme danger.

Ex.1- A technician used a pair of channel lock pliers to twist the rusty lid off a small, dark green, bottle to characterize the unknown chemicals inside. There was an immediate explosion and glass shards embedded in a nearby chair. Analysis showed that over time the picric acid in the bottle combined with the metal lid to form shock-sensitive metal picrates that lodged in the threads in the neck of the bottle.

Ex.2- A technician was remotely handling an old, opened can of anesthesia grade ethyl ether to add more ethyl alcohol as an inhibitor. Enough inhibitor was thought to be present, so the ether was not considered hazardous. The liquid level in the small metal can was low so the technician tilted the can to pipette out an aliquot for the peroxide test strip. As the technician turned the can upright, an immediate explosion and fireball filled the fume hood. The slight handling of the can was enough of a mechanical shock to cause peroxide crystals in the top portion of the can to explode.

Safe and healthful working environments at facilities that use or store shock-sensitive chemicals can be enhanced by an effective life-cycle management system that includes the following:

- Dating your chemicals and disposing of shock-sensitive chemicals in a timely manner.
- Respect the chemical and the dangers it presents. If you find shock-sensitive chemicals that are outdated or suspect, immediately contact your supervisor and the E, H & S Manager.

9.3 Steps To Be Taken If You Identify a Potential Shock-Sensitive Chemical Hazard

1. DO NOT TOUCH OR MOVE SUSPECT CHEMICALS.
2. When working with shock-sensitive chemicals, closely follow approved work procedures and hazard controls.
3. Study the chemical's MSDS and label. Look for information about the chemical's reactivity, stability and hazards. If there is an NFPA diamond, look for a 2, 3, or 4 in the yellow reactivity section. Also use information from other chemical safety resources.
4. Check with your facility's chemical safety personnel.
5. Use appropriate personal protective equipment (PPE).
6. Protect the chemical from shock, friction or heating.
7. Make sure that you have access to the MSDS, the chemical is labeled as required by your facility.
8. Acquisition control: 1) Prior to procurement – follow criteria in this handbook to identify shock-sensitive chemicals. At procurement – limit to the quantity that can be used before shelf life is reached.
9. Storage: Adhere to the manufacturer's recommendations, noting any precautions on the MSDS and label. Keep the chemical wetted if it is a dry chemical.
10. (E, H, and Safety Manager) Training: Ensure that employees are adequately trained on the hazards, safe working methods, and emergency procedures for shock-sensitive chemicals.
11. (E, H, and Safety Manager) Disposal: Establish criteria and procedures for the safe and timely disposal of shock-sensitive chemicals.

For a comprehensive list of shock-sensitive chemicals and chemical mixtures, please see Appendix D.

10.0. RADIATION SAFETY

10.1 Basic Information for All Personnel

The MBL is licensed to use radioactive materials by the Massachusetts Department of Public Health. Researchers who use radioactive materials must be registered with the Radiation Safety Office and must receive appropriate training. All personnel should be aware of the following basic information about our radiation safety program.

10.1.1. Copies of our Massachusetts license, all pertinent regulations, and documents pertaining to inspections are available for inspection in Rowe 401, the EH&S Office.

10.1.2. "CAUTION RADIOACTIVE MATERIALS" signs are posted on the doors of all rooms where licensed materials are used or stored, regardless of the amount. We do not restrict access to these rooms. The presence of these signs does not indicate that room occupants or visitors are being exposed to harmful levels of radiation.

10.1.3. Areas where radioactive materials are used are surveyed for contamination on a regular basis. Survey results are available for inspection in the EH&S Office. Surveys of any work area will be conducted upon request.

10.1.4. The external exposures of our radiation workers are regularly monitored using film badges. Their exposures rarely exceed those considered acceptable for members of the general public. Upon request, a film badge will be issued to any member the MBL community.

10.1.5. No one is permitted to order radioactive materials or to transport them to or from the MBL without the prior approval of the Radiation Safety Officer (RSO).

10.1.6. All personnel are encouraged to contact the RSO at extension 7424 if they have any concerns or questions about the MBL's use of radioactive materials or perceive any condition that may cause a violation of our regulations or unnecessary exposure to radiation or radioactive materials.