THE ECOSYSTEMS CENTER
SAFETY MANUAL
5/22/2006

YOU MUST CALL THE FIRE DEPT AFTER PULLING THE FIRE ALARM. THEY WILL NOT COME JUST BY PULLING THE FIRE ALARMS.

EMERGENCY PHONE NUMBERS:	**From MBL Ext.**	**From Outside Line**
MBL Emergency Number	**7911**	**508-289-7911**
Falmouth Fire And Rescue Department (Fire, Rescue Squad and Ambulance)	**9-911**	**911**
Falmouth Police Department	**9-911**	**911**
Falmouth Hospital	**9-508-548-5300**	**508-548-5300**
Mass. Poison Information Center	**9-1-800-222-1222**	**1-800-222-1222**
Chemical Spills / Radiation Incident	**7424 or 7911**	**9-508-289-7424/7911**
MBL Watch Staff	**7217**	**9-508-289-7217**

ECOSYSTEMS CENTER PERSONNEL QUALIFIED IN CARDIOPULMONARY RESUSCITATION:

Linda Deegan	**EXT. 7487**	**EXT. 7487**
Anne Giblin + 02 administration and standard first aid	**EXT. 7488**	**EXT. 7488**
Charles Hopkinson + standard first aid, NAUI and MBL diver	**EXT. 7688**	**EXT. 7688**
Sam Kelsey + advanced first aid, scuba first aid, DAN 02 provider, SLAM rescue	**EXT. 7735**	**EXT. 7735**
Jane Tucker	**EXT. 7469**	**EXT. 7469**

First Aid Kit with oxygen available. See Anne Giblin or Jane Tucker for assistance.

INTRODUCTION

This document is intended as a general introduction to laboratory safety for employees of the Ecosystems Center. While it has been written specifically for the staff of the Center it is a reference for all who use the chemical laboratory facilities. It contains approved laboratory practices and guidelines to ensure the safety of all employees. If an accident occurs, use the appropriate emergency phone number above and notify the MBL Safety Director — MBL extension 7424. The Analytical Lab has the book "First Aid Manual for Chemical Accidents" which also provides information on applying first aid. When a question arises about what is the proper practice, please ask for clarification. Suggestions for improving the laboratory and this manual are always welcome.

PERSONAL PROTECTION

A variety of laboratory operations require that certain safety equipment be worn or used.

- Eye protection should be worn at all times when in the labs and must be worn when using hazardous materials. Safety glasses are provided for all employees.
- Appropriate footwear must be worn when working in the laboratories; bare feet are not permitted.
- Gloves must be worn when handling hazardous chemicals or handling hot or cold objects. Different types of rubber and cloth gloves are available.
- Dust masks should be worn for those operations producing small particles, such as tissue grinding.
- Mouth pipetting is prohibited. Pipette bulbs are strongly recommended for pipetting all liquids.
- Lab coats or lab aprons are required when using hazardous substances such as strong acids or bases, and when working with radioisotopes.
- Consult the MBL Radiation Safety Manual for information on handling radioisotopes. All users must be properly trained and registered.
- When acids and solvents are hand carried they should be transported in a safety bottle carrier, available in all labs.

FIRE PROTECTION

The best method of fire protection is to prevent fires from occurring by not accumulating combustibles.

- Remove paper and packing materials when no longer needed.
- Do not store large quantities of flammable solvents in the work area. Use approved solvent lockers.
- Be aware that chemical fires can produce toxic gases such as ammonia, hydrogen cyanide, hydrogen chloride, carbon monoxide and sulfur dioxide.
- Know the location and type of fire extinguishers.
- Know the location of the fire alarm stations.
- Consult the fire evacuation memo for procedures to follow in the event of a fire.

IN CASE OF A FIRE

1) Activate nearest alarm.
2) Call 9-911 and 7911

3) If it is a small confined fire, as in a wastebasket, you may then use an appropriate fire extinguisher if you have been properly trained. . We have both dry chemical and halon extinguishers.

When an alarm sounds you must leave the building immediately.

CLASS OF FIRE	**EXTINGUISHER TO USE** (in order of preference)
Class A Ordinary Combustibles Paper, Wood, Cloth, Etc	Water Dry Chemical Foam
Class B Flammable Liquids Oil, Grease, Solvents, Paint	Dry Chemical Halon Carbon Dioxide Foam
Class C Energized Electrical Equipment	Dry Chemical Halon Carbon Dioxide **DO NOT USE WATER**
Class D Combustible Metals* Magnesium, Lithium, Sodium	Special Extinguishing Agents Extinguishers, Buckets, or special Applicators

*** Note**: If you plan on using combustible metals in the Ecosystems center you must plan ahead and notify the Environmental Health and Safety Office **EXT. 7424**. That way the proper Extinguishing Agents can be made available beforehand.

CHEMICALS

The large variety of chemicals used in the labs present a number of hazards. The hazards will be identified and discussed by grouping chemicals into four classes: flammable solvents, corrosive chemicals, reactive chemicals, and toxic chemicals.

A. FLAMMABLE SOLVENTS

Flammable solvents comprise a wide variety of organic structural groups. Typical examples of flammable solvent groups.

Group	**Solvent**
Ketone	Acetone
Amine	Aniline
Chlorinated	Chloroform
Ether	Dioxane
Aliphatic Hydrocarbon	Hexane
Alcohol	Methanol
Nitroaliphatic	Nitromethane
Aromatic Aliphatic	Toluene
Fluorocarbon	Trichloroethane
	Trifluoroethane

Each flammable compound has a set of conditions under which it will be combustible. Some of these conditions include critical temperatures and concentrations. The parameters related to the combustion process are:

Flash Point: Is the lowest temperature at which a fuel-air mixture present above the surface of a liquid will ignite if an ignition source is introduced. Note that a spark from an ordinary refrigerator is a sufficient ignition source.

Ignition Temperature: (Auto Ignition Temperature): The minimum temperature at which a substance will ignite in the air when there is no ignition source. For liquids it is defined as the lowest temperature at which a solvent will ignite spontaneously (measured as the temperature of a hot plate on which solvent ignites when added in drops).

Flammable Limits: The minimum and maximum concentrations of the fuel in the oxidizer that is sufficient to allow burning to occur.

Table 1 shows the critical properties for a select group of flammable solvents.

Handling Procedures:

- Store solvents in cool area (<80 deg F) in approved solvent lockers, but not in normal refrigerators.
- Do not flush flammable solvents down drain.
- Do not use solvents near ignition sources such as open fires, hot plates, motors, bunsen burners.
- Wear rubber gloves and eye protection when transferring solvents.
- Use with adequate ventilation.
- Do not leave bottles on bench exposed to sunlight.
- Recap bottles immediately after use.

Table 1. Hazard information for some common solvents.

	Flash Point[1]		Auto Ignition Temperature[2]		Flammable Limits %[3]		Vapor	Vapor	Evap.
	^{o}F	^{o}C	^{o}F	^{o}C	Lower	Upper	Density[4]	Pressure[5]	Rate[6]
Acetone	32	0	869	465	2.6	12.8	2.0	185	2.1
Carbon Disulfide	-22	-30	257	125	1.3	50.0	2.6	298	1.8
Ether	-49	-56	320	160	1.9	36.0	2.6	442	1.0
Ethyl Acetate	24	-4.4	800	427	2.2	11.0	3.0	73	2.9
Hexane	-7	-21.7	437	225	1.1	7.5	3.0	120	2.3
Kerosene (#1 fuel oil)	100	37.8	410	210	0.7	5	4.5		
Methanol	52	11.1	725	385	6.7	36	1.1	96	6.3
Nitromethane	95	35	785	418	7.3		2.1	29	10
2-Propanol	53	11.6	750	399	2.0	12	2.1	32	11
Toluene	40	4.4	896	480	12	7.1	3.1	22	6
p-Xylene	81	27.2	986	530	1.1	7.0	3.7	7.1	14

[1]Flash Point - Closed Cup
[2]Ignition Temperature
[3]Flammable Limits % by Volume in Air
[4]Vapor Density (Air -1)
[5]Vapor Pressure mm Hg @ 20 deg.C
[6]Evaporation Rate Ether = 1

B. CORROSIVE CHEMICALS

Corrosive materials act on body tissue by direct contact with eyes or skin, inhalation and ingestion. Corrosive substances include liquids, solids and gases.

1. Corrosive Liquids

Corrosive liquids are one of the most important categories since they are involved in the most common type of corrosive injury. A list of typical liquid corrosives frequently encountered in the lab are given below:

Strong Acids
Hydrochloric Acid (HCl)
Hydrofluoric Acid (HF)
Nitric Acid (HNO_3)
Sulfuric Acid (H_2S0_4)
Acetic Acid (CH_3COOH)

Strong Bases (Solutions)
Sodium Hydroxide (NaOH)
Potassium Hydroxide (KOH)
Ammonium Hydroxide (NH_40H)
Quaternary Ammonium Hydroxides (R_4NOH)

Others
Chlorinated Hydrocarbons
Terpenes
Liquified Phenol
Bromine
Thymol Chloride

Handling Procedures:

- Always wear protective equipment - gloves, glasses, and lab aprons.
- If corrosive fumes exist (such as HCl, NH_4OH, HF and others) perform transfers in hood.
- Know where safety showers, corrosive-spill clean-up kits and eye wash stations are located.
- If a corrosive agent contacts body tissue flush injured area with large volumes of water.

2. Corrosive Solids

The effects of corrosive solids depend upon their solubility in skin moisture and the duration of contact. Examples of solid corrosives are given below:

Caustic Akalies

Alkaline Hydroxides (NaOH, KOH)
Alkaline Carbonates (Na_2CO_3)
Alkaline Suffides (NaS)
Alkaline Earth Hydroxide ($Ba(OH)_2$, $CaOH_2$)
Alkaline Earth Carbonates ($CaCO_3$)

Elements and Salts

Alkali Metals (Na, K, Li)
Phosphorus (P)
Antimony Salts (SbX)
Arsenic Salts (AsX)
Chromium Salts (Cr_2O_3, CrX)
Mercury Salts (HgX)
Trisodium Phosphate (Na_3PO_4)
Phenol (C_6H_5OH)

Other hazards of corrosive solids include:

- Solutions of corrosive solids can be absorbed through the skin.
- Contact with corrosive solids can cause a delayed injury since they may not produce an immediate painful reaction.
- Many solids will dust readily and thus inhalation becomes another exposure route.

Handling Procedures:

- Always wear protective equipment - gloves, glasses, lab aprons.

3. CORROSIVE GASES

Corrosive gases present the most serious hazards from corrosive substances. Since they exist in gaseous form, they are readily absorbed into the body through solubility into skin moisture and by inhalation. Gaseous corrosives are generally grouped by their water solubility and their effect on the respiratory system. Examples are given below:

Group I
Very soluble, upper respiratory tract.
ammonia
hydrogen chloride
hydrogen fluoride
hydrogen sulfide
formaldehyde
sulfonyl chloride
thionyl chloride

Group II
Soluble, upper respiratory tract and bronchi.
arsenic trichloride
bromine
chlorine
iodine
phosphorus pentachloride
phosphorus trichloride
sulfur dioxide

Group III
Least soluble, minimal primary irritation, severe systemic effects.
carbonyl chloride (phosgene)
nitrogen dioxide
ozone

Group IV
Locus of action unknown. Toxic activity not directly related to solubility.
acrolein
dimethyl sulfate
mustard gas
chlorinated ethers

Handling Precautions:

- Always wear protective equipment - gloves, glasses, and lab aprons.
- Always use a hood for transfers.
- If exposure occurs, seek immediate medical attention.

C. REACTIVE CHEMICALS

These are chemicals that under certain ambient or induced conditions can react violently with spontaneous production of large quantities of heat, light, gases (flammable or nonflammable) or toxicants, which can destroy equipment or pose a health hazard.

Types of reactive materials include explosive substances, oxidants and reductants, water sensitive compounds, acid sensitive compounds and special organic substances.

1. Explosive Substances

Explosives are materials that under certain conditions of temperature or shock, rapidly release large amounts of gases and heat. Our most common hazard is the formation of peroxides from ethers and other compounds. See Tables 2 and 3 for the types of structures and storage precautions.

Table 2. Peroxide Forming Structures.

C-O | H	Ethers, acetals
C=C	Olefins with allylic hydrogen, chloro- and fluorolefins, terpenes, tetrahydronaphthalene.
C=C=C=C and C=C-C=CH	Dienes, vinyl acetylene
H\ C = C- H/	Vinyl Monomers
Alkali metals	Potassium
Alkali metal alkoxides & amides	Sodamide
C- H	Paraffinic and alkylaromatic hydrocarbons, particularly those with tertiary hydrogen
Organometallic	Grignard reagents
0 || -C-H and O H	Aldehydes, ketones. Anhydrous acetaldehyde will autoxidize at 0 deg;C or below under ultraviolet light catalysis to form peracetic acid which may react with more acetaldehyde to give the explosive acetaldehyde monoperacetate.

|| | -C-C	
OH || | -C-N-C	Ureas, amides, lactams

Table 3. Common compounds that form peroxides during storage.

List A - Red Label	**List B - Yellow Label**	**List C - Yellow Label***
(Three Months) Peroxide Hazard on Storage	(Twelve Months) Peroxide Hazard on Concentration	(Twelve Months) Hazard Due to Peroxide Initiation of Polymerization
Isopropyl ether divinyl acetylene vinylidene chloride potassium metal sodium amide	ethyl ether tetrahydrofuran dioxane acetal methyl i-butyl ketone ethylene glyco dimethyl ether (glyme) dicyclopentadiene diacetylene methyl acetylene cumene vinyl ethers tetrahydronaphthalene cyclohexene methylcyclopentane	styrene butadiene tetrafluorethylene chlorotrifluorethylene vinyl acetylene vinyl acetate vinyl chloride chlorobutadiene (chloroprene)

* When stored as a liquid, the peroxide-forming potential increases and certain of these monomers (especially butadiene, chloroprene, and tetrafluorethylene) should be considered as List A compounds.

Handling Procedures:

- Protect potential explosive substances from shock, high temperature and rapid rises in temperature.
- Date containers so that storage time limits can be observed.
- Store ethers in special lab-safe refrigerators. Note: We do not have lab-safe refrigerators in the labs!
- Do not store large quantities of materials. Have on hand only what you will need for one month.

2. Oxidizers and Reductants

These chemicals generally cause enhanced reactions when they come into contact with normally innocuous substances. Table 4 illustrates some common examples.

Table 4.

Inorganic Oxidizing Agents
Oxygen
Mineral Acids
Perchloric Acid
Halogens
Peroxides
Oxides
Haloates & Perhaloates
Nitrites & Nitrates
Chromates & Dichromates
Persulfates
Ozone
Permanganate

Inorganic Reducing Agents
Hydrogen
Metallic Hydrides
Phosphorus*
Metallic Catalysts
Raney Nickel*
Activated Zinc*
Alkali Metals

Organic Oxidizing & Reducing Agents
Perodixes
Oxides
Hydrides
Nitrates & Nitrites
Peracetic & Peroxy Acids
Ozonates
Butadiene

* These agents are also pyrophoric, i.e., they burn when exposed to air. Pyrophores represent a special class of reactive compounds requiring absolute protection against air.

Handling Procedures:

• Do not store next to organic solvents or other combustible materials.

3. Water Sensitive Compounds

These compounds react with water, steam or moist air to release heat and possibly flammable or explosive gases (H_2). Those chemicals that release heat can raise the temperature above the boiling point of water and therefore cause physical injury from burns. Table *5* shows some typical compounds.

Table *5.*

Only Heat Liberated	**Flammable Gases Liberated**
Strong Acids	Alkali Metals (Li, Na, K, Ce)
Strong Bases	Hydrides
Acid Anhydrides	Nitrides
Sulfides	Carbides
	Anhydrous Metallic Salts

Handling Procedures:

- Store in cool, dry area.
- Isolate from other reactive substances.
- Wear protective equipment - gloves, glasses, and aprons.

4. Acid Sensitive Compounds

These are materials that react with acids to evolve heat, hydrogen and other flammable or explosive gases. Like water sensitive compounds, acid sensitive substances can raise water above its boiling point and cause severe burns. Table 6 lists some examples.

Table 6.

Acid Sensitive Substances

Alkali Metals
Alkaline Hydroxides
Carbonates
Carbides
Nitrides
Arsenic & Related Elements
Structural Alloys
Metals such as Ni, Zn
Cyanides
Sulfides

Handling Procedures:

- Isolate from other reactive chemicals.
- Wear safety equipment - gloves, glasses, and aprons.

5. Special Organic Substances

Many organic substances are unstable and may decompose upon contact with air, water or other reactants or spontaneously to release heat and flammable gases. Table 7 shows several examples.

Table 7.

Special Organic Substances

Diazonium Compounds
Diazomethane
Chlorination Intermediates
Monochloroacetone
Butadiene
Nitration Intermediates
Polymerization Reactions (rapid, uncontrolled)
Highly Nitrated Compounds
Organic Sulfates

D. TOXIC CHEMICALS

Toxic substances are those chemicals that have the potential for injury by direct chemical interaction with body systems. There are two general classes of toxicity: acute and chronic. Acute toxicity is the rapid onset of body dysfunction from a short exposure to a single contact, ingestion or inhalation event. Chronic toxicity refers to a body function effect that is observed after repeated exposures over periods of days to years.

While toxic substances can be introduced into the body via ingestion or inhalation, it is important to remember that many materials are readily absorbed through the unbroken skin, for example, aniline, benzene, carbon disulfide, hexane, mercury, toluene, xylene and others.

Several measures of accessing a chemical's toxicity have been developed including LC-50 and TLV's. LC-50 (lethal concentration, 50% kill) is that concentration of a Chemical when administered to test animals for a specific time causes 50% mortality. TLV (threshold limit value, ppm or mg m^3) is an estimate of the average "safe" concentration that can be tolerated on a repetitive basis (usually an 8-hour period) day after day. TLV's should be interpreted as only a guideline since in many cases they are based on limited experimental data.

Listed below are the TLV's for a select number of substances that we use in our laboratory.

Substances	**TLV (ppm)**
HCN	4.7 as CN (skin)
H_2S	5 (vapor)
benzene	0.5 (vapor)
toluene	50 (vapor)
phenol	*5* (skin)
acetic acid	10 (vapor)
formic acid	5 (vapor)
CS_2	10 (skin)
CO	25 (vapor)
CH_4, $CHCI_3$	5 (vapor)
dichloromethane	50 (vapor)
methanol	200 (vapor)
ethanol	1000 (vapor)
HNO_3	2 (vapor)
Hg	*.025* mg/m^3
$0s0_4$	.0002 (as Os) (vapor)

Handling Procedures:

- Always wear protective equipment - gloves, glasses, and lab coats.
- Always use a hood for transfers.

Further LD_{50} and TLV data for other substances can be found in the following publications available at the MBL Library:

NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. F. W. Mackison (ed.), DHHS (NIOSH) Publication #81-123.

Hazards in the Chemical Laboratory. 3rd edition. 1981. L Bretherick (ed.), Royal Society of Chemistry, London.

WASTE DISPOSAL

Chemical wastes present serious disposal problems and caution should be exercised before thinking about pouring wastes down the drain.

Disposal Procedures:

- In general, laboratory drains should not be used to dispose of any waste chemicals. The MBL Environmental Health and Safety Office has provided Satellite Accumulation Areas (SAA) in all of the labs that produce hazardous waste. Hazardous waste should be put in appropriate and properly labeled containers and stored in these designated areas. When the containers are full or otherwise ready to be taken away, the waste label should be **dated** and then the EH&S Office called to come and take the waste away.
- If there are chemicals that you feel could be safely disposed of in laboratory drains, contact the EH&S Office at x7424 for approval. Only they can make the decision on correct disposal.
- See the MBL Chemical Waste Policy for complete instructions on waste disposal.

Other Disposal Items:

- Used needles and syringes should be broken or made useless before discarding in a labeled sharps container in the labs.
- Broken mercury thermometers and used mercury batteries should be sealed in a plastic bag and taken to the MBL Stockroom for disposal. Label contents and include your name and extension.

COMPRESSED GASES

Compressed gases are supplied in cylinders under high pressure. Each cylinder contains a large amount of energy, which, if released improperly, can cause serious injury. The gases themselves can present other hazards from flammability, toxicity or corrosive properties.

Handling Precautions:

- All cylinders, full or empty, must be firmly supported at all times by securing to a bench or wail.
- Do not expose cylinders to temperatures greater than 100 deg F.
- Protective caps must be kept on whenever a cylinder is not in use.
- Always use a proper hand truck with a strap or chain to transport cylinders.
- Use cylinders in an upright position. Note in particular that acetylene cylinders are designed such that the acetylene is dissolved in an acetone solution inside the cylinder. If the valve is opened when the cylinder is horizontal, liquid acetone may be discharged.
- Use the proper regulator for each gas.
- Stop using a cylinder when the pressure approaches 30 psi and clearly mark as empty.
- Read warning labels on cylinders before using a gas to determine its hazardous properties (flammable, corrosive, etc.) and establish adequate controls.
- Oily fittings should never be used with oxygen, as a spontaneous explosion may result.

CRYOGENICS

Cryogenics refers to the use of liquid gases at low temperatures, -60 deg C or lower. The major hazards are:

- Freezing of tissues from direct contact.
- Pressure buildup. Cryogenic liquids exhibit a large increase in volume (700:1) upon vaporization.
- Embrittlement. Most materials become brittle and can suddenly shatter when subjected to cryogenic temperatures.
- Fire and explosions from flammable gases - liquid hydrogen (LH_2).

Handling Precautions:

- Wear eye protection and loose fitting gloves when handling cryogenic liquids.
- Use only approved cryogenic containers, which must be vented.
- Glass dewars must be protected with electrical tape or other approved cushions to prevent flying glass in case of implosion or explosion.
- Flammable (LH_2) or oxidizer (LO_2) cryogenics must be used in well-ventilated areas to prevent the buildup of flammable gases.

First Aid:

For short contact, flush with large quantities of warm water (110 deg;F, 43 deg;C) to restore the affected tissue to normal body temperature. For eye contact or prolonged contact or if visible tissue damage is present, call the MBL Emergency number (7911 or 7424) for help and seek immediate medical attention.

ELECTRICAL

Guidelines for protection from electrical shocks:

- All current carrying wires on equipment must have sound insulation or be enclosed to prevent contact with live wires.
- Disconnect the plug from the wall outlet before working on electrical equipment. Label plugs and power switches "DO NOT USE OR DO NOT TURN ON" if you have equipment unattended during repair.
- Extension cords must be adequate for the anticipated loads and should be used only temporarily (60 days).
- Ground fault interrupters (GFI) must be used on equipment installed in water or in wet areas.
- If you are not trained to work on electrical equipment, DO NOT attempt to repair.