2014

Hazard Awareness Manual

APPENDIX 3

ENVIRONMENTAL EMERGENCY PLAN

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1. PURPOSE

This chapter provides an introduction to the types of hazards, labeling systems and common sources of hazards information in research labs on campus. This information will help you to identify hazards in your laboratory and will provide resources to increase your understanding of those hazards. Additionally, this chapter provides information to researchers to assist in labeling in-house chemical containers and equipment to identify their unique hazards

2. Types of Hazards

2.1.Health Hazards

According to the OSHA Lab Standard,

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "**health hazard**" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system and agents which damage the lungs, skin, eyes, or mucous membranes. Appendix A provides further definitions and explanations of the scope of health hazards covered by this section, and Appendix B describes the criteria to be used to determine whether or not a chemical is to be considered hazardous for purposes of this standard.

Working with chemicals in a research laboratory can expose researchers to health hazards through inhalation, ingestion, skin, eye, or mucous membrane contact or absorption, or injection of chemicals. Chemical exposures may be acute (short term), intermittent, or chronic (long term), they may be reversible or irreversible, and may have local or systemic effects.

The following are brief descriptions of the classes of health hazards included in the Lab Standard definition of ?health hazard? above. Complete definitions are found in the OSHA Lab Standard (29 CFR 1910.1450).

- **Carcinogen:** A chemical which causes or potentially causes cancer according to the International Research on Cancer.
- **Corrosive:** A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.
- **Irritant**: A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
- **Mutagen:** A chemical that damages chromosomes.
- **Sensitizer:** A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.
- **Target Organ Effects**:

- *Hepatotoxins* damage the liver.
- *Nephrotoxins* damage the kidneys.
- *Neurotoxins* adversely affect the nervous system.
  - *Hematopoietic Agents decrease hemoglobin function and deprive the body tissues of oxygen.*
  - *Agents which damage the lung irritate or damage pulmonary tissue.*
  - *Reproductive toxins affect reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).*
  - *Cutaneous hazards affect the skin, or dermal layer, of the body.*
  - *Eye hazards affect the eye or visual capacity.*

- **Teratogen**: A chemical that causes birth defects.
- **Toxic**: A chemical falling within any of the following categories:
  - A chemical that has a median lethal dose (LD50) of more than 50 mg/kg but not more than 500 mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.
  - A chemical that has a median lethal dose (LD50) of more than 200 mg/kg but not more than 1,000 mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
  - A chemical that has a median lethal concentration (LC50) in air of more than 200 parts per million (ppm) but not more than 2,000 ppm by volume of gas or vapor, or more than 2000 mg/m3 but not more than 20,000 mg/m3 of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.
- **Highly Toxic:** A chemical falling within any of the following categories:
  - A chemical that has a median lethal dose (LD50) of not more than 50 mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.
  - A chemical that has a median lethal dose (LD50) of not more than 200 mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
  - A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2000 mg/m3 or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

LD_{50} (oral, rat)	**LD_{50} (skin, rabbit)**	**LC_{50} (rat)**

	(mg/kg)	(mg/kg)	(ppm for 1 hr)	(mg/m3 for 1 hr)
Highly Toxic	≤ 50	≤ 200	≤ 200	≤ 2000
Toxic	50 to 500	200 to 1000	200 to 2000	2000 to 20,000

Table 1 *Toxic and Highly Toxic definitions.*

2.1.1. Toxicity

The following is an excerpt from ***Safety in Academic Chemistry Laboratories*** (American Chemical Society, 2003: pp. 10-11):

Any substance could be harmful to living things. But complex relationships exist between a substance and its physiological effect in humans. The major factors include the dose (the amount of a substance to which one is exposed and the length of time of exposure to the substance), the route of exposure (by inhalation, ingestion, absorption through the skin or eyes, or injection), and myriad other factors such as gender, stage in the reproductive cycle, age, lifestyle, previous sensitization, allergic factors, genetic disposition, and even whether it has been a "good day" or a "bad day" for the victim. These and other factors can affect the severity of an exposure. If you don't know these details, as is often the case, *it is prudent to act as though you could be susceptible to serious toxic consequences and to therefore follow the necessary precautions when working with chemicals in the laboratory.*

The toxic effects can be immediate or delayed, reversible or irreversible, local or systemic. The toxic effects vary from mild and reversible (e.g., a headache from a single episode of inhaling the vapors of ethyl acetate that disappears when the victim inhales fresh air) to serious and irreversible (e.g., birth defects from excessive exposure to a teratogen during pregnancy or cancer from excessive exposure to a carcinogen).

Some important details about toxic effects:

- **Acute poisoning** is characterized by rapid assimilation of the substance. Often, but not always, the effect is sudden and can be painful or severe and even fatal. Normally, a single exposure is involved. Examples: carbon monoxide or cyanide poisoning.
- **Chronic poisoning** is characterized by repeated exposures with a duration measured in months, or years. Symptoms may not be immediately apparent. Examples: lead or mercury poisoning, pesticide exposures.
- **Substances in combination** may result in the synergistic effect. When two or more hazardous materials are present, the resulting effect can be greater than the effect predicted for the individual substances. Example: exposure to alcohol and chlorinated solvents. The opposite is also possible; two poisonous substances can lessen each other's effects, called the antagonistic effect. Example: cyanide and amyl nitrite.
- **Allergens** are agents that produce an immunologic reaction, and you may encounter them in the laboratory. Asthma-like symptoms or dermatitis are typical

allergic reactions. Not everyone is susceptible to allergens. A susceptible individual will not suffer an allergenic reaction unless he or she has been sensitized by at least one previous exposure. For some allergens, an individual must be exposed several times before suffering an allergenic response. Tell your instructor if you know or suspect that you are allergic to a chemical in laboratory or plant.

Except for allergenic exposures, the toxic effects from exposure to a chemical depend on the severity of the exposures. Generally, the larger or more frequent the exposure, the more severe the result. Consequently, you can reduce or even avoid harm by keeping exposures to a minimum.

2.1.2 Routes of Exposure

There are four main routes of exposure for chemicals: inhalation; direct contact (to skin, eyes and or mucous membranes); ingestion; and injection. An understanding of these routes of entries enables one to develop procedures or controls to prevent hazardous exposures to chemicals.

- **Inhalation:** Inhalation of gases, vapors, dusts, fumes or mists is a common route of exposure. Chemicals can enter and irritate the nose, airways and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.
- **Direct (skin/eye) contact and/or absorption:** Many chemicals can injure the skin directly (corrosives), while others may cause irritation or an allergic reaction. In addition to causing local effects, many chemicals may be absorbed through the skin and/or eyes in sufficient quantity to cause systemic effects. The main avenues by which chemicals enter the body through the skin are hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the skin. Direct contact effects and absorption of chemicals through the skin depend on a number of factors, including:
    - Chemical concentration
    - Chemical reactivity
    - Solubility of the chemical in fat and water
    - Condition of the skin
    - Duration of contact
- **Ingestion:** Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Substances can be absorbed into the blood and then transported to the rest of the body.
- **Injection:** Injections can occur through high pressure streams of liquids or gases, needles or broken contaminated glassware.

2.1.3 Physical Hazards

The Chemical Standard defines physical hazard as:

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

The following are brief descriptions of the classes of physical hazards included in the Chemical Standard definition of "physical hazard" above. Complete definitions are found in the OSHA Chemical Standard (29 CFR 1910.1450).

- **Combustible liquid**: Any liquid having a flashpoint at or above 100° F (37.8°C), but below 200° F (93.3°C), except any mixture having components with flashpoints of 200° F (93.3°C), or higher, the total volume of which make up 99% or more of the total volume of the mixture.
- **Compressed gas**: A gas or gas mixture with an absolute pressure exceeding 40 psi at 70°F (21.1°C), or exceeding 104 psi at 130°F (54.4°C), or a liquid having a vapor pressure exceeding 40 psi at 100°F (37.8°C).
- **Explosive:** A chemical that causes a sudden, almost instantaneous release of gas, pressure, and heat when subjected to sudden shock, high temperature or pressure.
- **Flammable:**
  - *Aerosol*: A chemical that can produce a flame or flashback from a valve opening.
  - *Gas*: Any gas at ambient conditions that will cause a flammable mixture with air in concentrations of 13% or less.
  - *Liquid*: Any liquid having a flashpoint below 100° F (37.8°C), except any mixture having components with flashpoints of 100° F (37.8°C) or higher, the total of which make up 99% or more of the total volume of the mixture.
  - *Solid*: A solid that is liable to cause fire through friction, contact with moisture, spontaneous reaction, or retained heat, or which can be readily ignited and burns with enough persistence or violence to cause a serious health hazard.
- **Organic peroxides**: An organic compound with a bivalent O-O structure, which may be considered a peroxide derivative with one or both of the hydrogen atoms replaced with an organic molecule. They present dangerous fire and explosion risks; many are strong oxidizers.
- **Oxidizer**: A chemical that initiates or supports combustion of other materials, causing fire by itself or by the release of oxygen or other gases.
- **Pyrophoric**: A chemical that will ignite spontaneously in air at or below 130°F (54.4°C).
- **Unstable**: Any chemical, which will vigorously decompose, polymerize, condense, or will become self reactive when exposed to conditions of shock, pressure, or temperature.
- **Water-reactive**: A chemical which can react with water or steam to produce a gas which is either toxic or flammable.

2.2 Labeling

Each chemical container must be labeled as to its contents and any applicable hazard categories. Even non-hazardous chemicals should be identified as such to remove any confusion.

2.2.1 Handwritten or In–House Labels

Temporary containers should be labeled so that if an emergency arises, another person can identify what is in the container. For chemical waste, the container should describe the contents with the word "waste" (e.g., "waste acetone," "waste halogenated solvents," etc.). If a label begins to fall off a container or becomes degraded, the container must be immediately relabeled with tape and permanent marker, printed labels, etc.

Chemical names may be abbreviated (such as Ethanol – EtOH) if everyone in the lab is knowledgeable of the abbreviation. Creating a table of common chemical abbreviations for the lab is strongly advised.

2.2.2 Manufacturers' Labels

The label(s) affixed to the container will have information regarding the hazards of a material.

To start with, the original manufacturer's container label must include the following:

- Product Name
- Manufacturer's Name and Address
- Hazards Identification

Some manufacturers use easily recognizable symbols to communicate the hazard(s) of a product.


Corrosive


Explosive


Flammable


Irritant


Oxidizier


Poisonous

Figure 1 Examples of hazard warnings commonly found on labels

2.2.3 Common Labeling Systems

In addition to the icons shown in Figure 2.1, there could be markings from various labeling systems, such as National Fire Protection Association (NFPA), Hazardous Materials Identification System (HMIS) III, Department of Transportation (DOT), or Globally Harmonized Systems (GHS).

2.2.3.1 National Fire Protection Administration (NFPA)

NFPA 704 *Standard System for the Identification of the Hazards of Materials for Emergency Response* provides a readily recognized, easily understood system for identifying specific hazards and their severity using spatial, visual, and numerical methods to describe in simple terms the relative hazards of a material. It addresses the health, flammability, instability, and related hazards that may be presented as short-term, acute exposures that are most likely to occur as a result of fire, spill, or similar emergency.

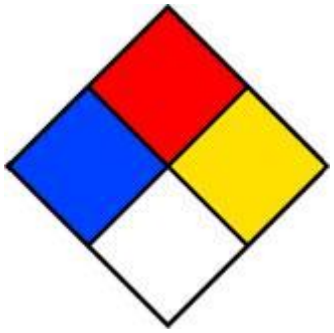

Figure 2 *NFPA Diamond*

The system is characterized by the diamond shape (***Figure 2***). It identifies the hazards of a material and the degree of severity of the health, flammability, and instability hazards. Hazard severity is indicated by a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard. The hazards are arranged spatially as follows: health at nine o'clock position (blue), flammability at twelve o'clock position (red), and instability at three o'clock position (yellow).

Health Materials that, *under emergency conditions*…	**Flammability**	**Instability** Materials that…

0	…would offer no hazard beyond that of ordinary combustible materials	Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone and sand	…in themselves are normally stable, even under fire conditions
1	…can cause significant irritation	Materials that must be preheated before ignition can occur	…in themselves are normally stable but that can become unstable at elevated temperatures and pressures
2	…can cause temporary incapacitation or residual injury	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur	…that readily undergo violent chemical change at elevated temperatures and pressures
3	…can cause serious or permanent injury	Liquids and solids that can be ignited under almost all ambient temperature conditions	…in themselves are capable of detonation or explosive reaction but that require a strong initiating source or must be heated under confinement before initiation
4	…can be lethal	Materials that rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air and burn readily	…in themselves are readily capable of detonation or explosive decomposition or explosive decomposition or explosive reaction at normal temperatures and pressures

Table 2 Explanation of the NFPA numbering system, adapted from NFPA 704.

The six o'clock position on the symbol represents special hazards and has a white background. The special hazards in use are **W**, which indicates unusual reactivity with water and is a caution about the use of water in either fire fighting or spill control response; **OX**, which indicates that the material is an oxidizer; and **SA**, which indicates that the material is a simple asphyxiant, limited to the gases nitrogen, helium, neon, argon, krypton and xenon.

2.2.3.2 Hazardous Materials Identification System (HMIS)

The National Paint & Coatings Association, Inc. (NPCA) developed the HMIS to aid employers in the implementation of an effective Hazard Communication Program. The current version, HMIS III, defines the Health, Flammability and Physical Hazards of different

chemicals with a label that incorporates color-coded fields along with a recommendation for personal protective equipment.

As with the NFPA system, the relative hazard of each category is identified by using a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard. Where applicable, the Target Organs (***Figure 3***) and Physical Hazards (**Figure 4**) will be identified by icons surrounding the label.

In addition to the hazards being identified, appropriate PPE is defined in the last section, by using a single letter (**Figure 5**). For example, the letter "A" corresponds to safety glasses, while the letter "C" would indicate that safety glasses, gloves and a protective apron should be worn.

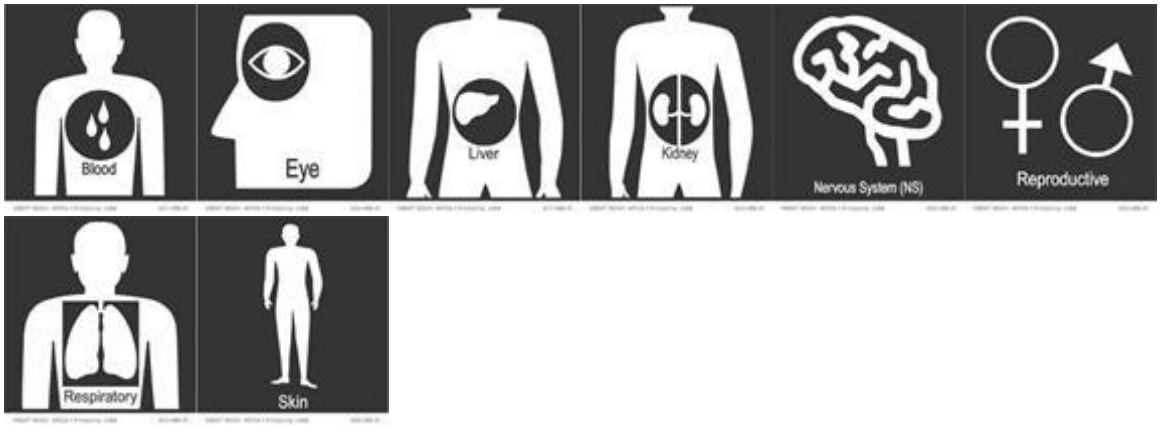

Figure 3 *Target Organ icons used in HMIS III*

Figure 4 Physical Hazard icons used in HMIS III

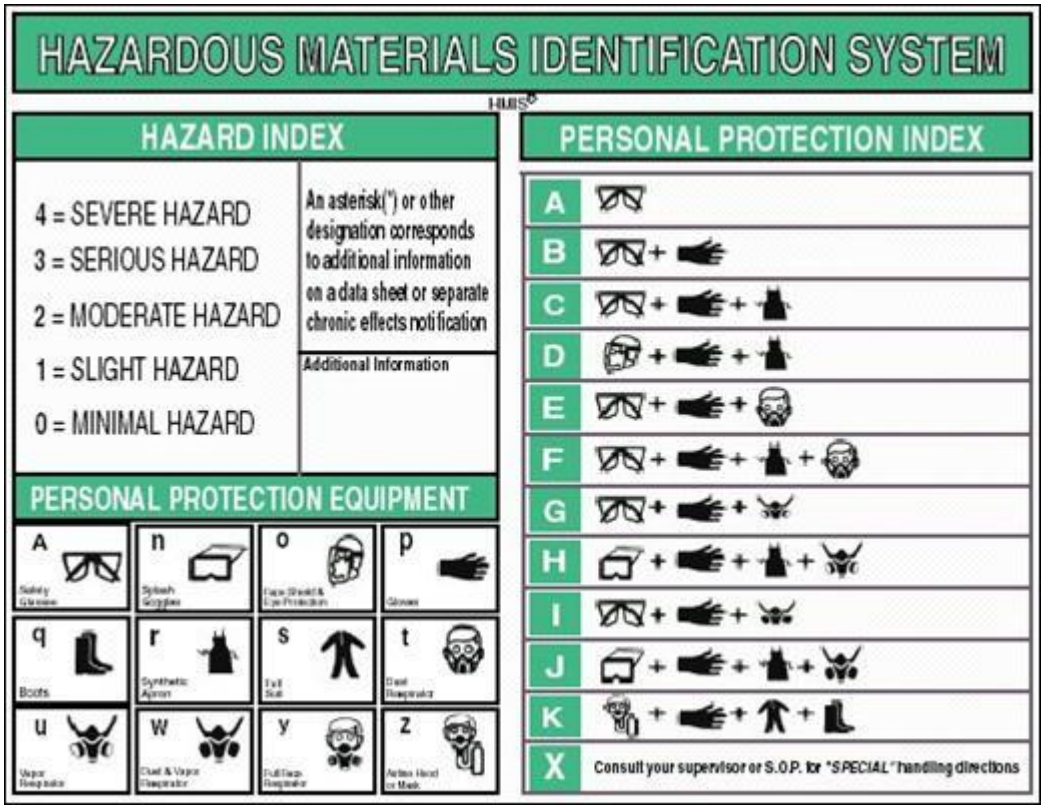

Figure 5: HMIS Key

2.2.3.3 Department of Transportation (DOT)

The US DOT uses hazard classes (1-9). These classes are based on physical and health hazards. When a hazardous material is in transport, it must bear the appropriate label(s). These labels must remain in place until the container is empty.

The nine hazard classes are:

Class 1: Explosives

An explosive is a substance or article, including a device, that is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion, unless the substance or article is otherwise classified under the provision of the regulations.

Class 2: Gases

Division 2.1: Flammable Gas

A flammable gas is any material that is a gas at 20°C (68°F) or less and 101.3 kPa (14.7 psi) of pressure and:

- Is ignitable at 101.3 kPA (14.7 psi) when in a mixture of 13% or less by volume in air.
- Or has a flammable range at 101.3 kPA (14.7 psi) with air of at least 12% regardless of the lower limit.

Division 2.2: Non-flammable, Non-poisonous Compressed Gas

Any material or mixture (including compressed gas, liquefied gas, compressed gas in solution, asphyxiant gas and oxidizing gas) that exerts in the packaging an absolute pressure of 280 kPa (40.6 psi) or greater at 20°C (68°F), or is a cryogenic liquid, and does not meet the definition of Division 2.1 or 2.3.

Division 2.3: Gas Poisonous by Inhalation

A gas poisonous by inhalation is a material that is a gas at 20°C (68°F) or lower and a pressure of 101.3 kPa (14.7 psi) and either:

- Is known to be so toxic to humans as to pose a hazard to health during transportation.
- In the absence of adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals it has an LC50 value of not more than 5,000 ml/m^3.

Class 3: Flammable and Combustible Liquids

A *flammable liquid* is either:

- A liquid having a flash point of note more than 60°C (140°F).

- Any material in a liquid phase with a flash point at or above 37.8°C (100°F) that is intentionally heated and offered for transportation or transported at or above its flash point in a bulk package.

A *combustible liquid* is a liquid that does not meet the definition of any other hazard class and has a flash point above 60°C (140°F) and below 93°C (200°F).

Class 4: Flammable Solids

Division 4.1

- *Wetted Explosives:* Class 1 explosives when dry, other than those of compatibility group A, that are sufficiently wetted to suppress explosive properties.
- *Self-reactive materials:* Materials that are thermally unstable and can undergo a strongly exothermic decomposition even in the absence of oxygen (air).
- *Readily combustible solids:* Solids that can cause fire through friction, such as matches.

Division 4.2: Spontaneously Combustible

- *Pyrophoric materials:* Liquids or solids that can, without an external ignition source, ignite with five minutes after coming in contact with air when tested according to the "UN Manual of Tests and Criteria."
- *Self-heating materials:* Substances that are liable to self-heat when in contact with air and without an energy supply. Materials are classified as Division 4.2 if they exhibit spontaneous ignition or if the temperature exceeds 200°C (392°F) during the 24-hour test period when tested in accordance with "UN Manual of Tests and Criteria."

Division 4.3: Dangerous When Wet

Materials, that by contact with water, are liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1L/kg of the material per hour, when tested in accordance with the "UN Manual of Tests and Criteria."

Class 5: Oxidizers and Organic Peroxides

Division 5.1: Oxidizers

A material that can, generally by yielding oxygen, cause or enhance the combustion of other materials.

Division 5.2: Organic Peroxides

Any organic compound containing oxygen (O) in the bivalent –O-O- structure and that may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

Class 6: Poisonous Materials and Infectious Substances

Division 6.1: Poisonous Materials

A material, other than a gas, known to be so toxic to humans to pose a health hazard during transportation.

Division 6.2 Infectious Substances

Includes materials known to contain or suspected to contain a pathogen. A pathogen is a microorganism (including viruses, bacteria, parasites, fungi, and rickettsiae) or other

agent, such as a proteinaceous infectious particle (prion), that has the potential to cause disease in humans or animals.

Class 7: Radioactive Material

Any material containing radionuclides in which both the activity concentration and the total activity in the consignment exceed the values specified in the table at 49 CFR 173.436 or values derived according to the formula at 49 CFR 173.433.

Class 8: Corrosive Material

Liquids or solids that cause full thickness destruction of human skin at the site of contact within a specified period of time. There is no correlation to pH.

Class 9: Miscellaneous Hazardous Materials

Materials that present a hazard during transportation but do not meet the definition of any other hazard class. This class includes:

- Any material that has an anesthetic, noxious, or similar property that could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties.
- Any material that meets the definition in 49 CFR 171.8 of an elevated temperature material, a hazardous substance, a hazardous waste, or a marine pollutant.

2.3 Material Safety Data Sheets and Safety Data Sheets

Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are common sources of information on hazardous chemicals, as manufacturers are required to provide one for each chemical product sold. For any chemical you receive, the MSDS or SDS must be maintained. To assist with this requirement, DRS maintains a repository of many MSDS and SDS received by the campus. DRS recommends that each lab obtain hard copies of MSDS and SDS from the manufacturer for the products most commonly used. Instructions for electronic access to the DRS repository (for the campus community only) and connections to MSDS and SDS available through the Web can be found on the supply website

2.3.1 Reading a Safety Data Sheet

MSDS and SDS are divided into sections. While the actual format used will vary from one manufacture to another, the MSDS/SDS must include the following:

- **Product Information**
  - Product Name (as on the label)
  - Manufacturer's name, address, and phone number
  - Date of MSDS/SDS
- **Composition/Information on Hazardous Ingredients**
  - Chemical Name and CAS Number
  - Percentage (if mixture)
  - Exposure Limits (if applicable)
- **Physical and Chemical Properties**
  - Boiling Point
  - Vapor Pressure
  - Vapor Density
  - Appearance and Odor
- **Fire and Explosion Hazard Data**
  - Flash Point
  - Extinguishing Media
- **Reactivity Data**
  - Stability
  - Incompatibilities
  - Hazardous Decomposition Products
  - Conditions to Avoid
- **Health Hazard Data**
  - Routes of Entry
  - Health Hazards
  - Signs and Symptoms of Exposure
  - First Aid
- **Precautions for Safe Handling and Use**
  - Spill and Accidental Release Measures
  - Waste Disposal
- **Control Measures**
  - Engineering Controls
  - PPE
  - Work Practices

In addition to the required information, MSDS/SDS may include the following:

- Toxicological Information
- Ecological Information
- Disposal Considerations
- Transportion Information
- Regulatory Information
- Other Information

2.4 Controlling Chemical Exposures

Using the information presented in the earlier sections of this chapter and knowing the specific hazards of the chemicals to be used, one can design procedures to minimize hazards.

The OSHA Permissible Exposure Limit (PEL) or Short Term Exposure Limit (STEL) should not exceeded. These are legal limits established by OSHA to protect all workers. Similarly, Threshold Limit Values (TLVs) from the American Conference of Governmental Industrial Hygienists(ACGIH) should not be exceeded. These values are updated more frequently and are more reflective of the best knowledge available. You may request assistance from DRS at 333-2755 in developing or reviewing procedures to control chemical exposures.

Control techniques fall into three broad classes in order of preference: engineering controls, administrative controls, and personal protective equipment (PPE).

- **Engineering controls:** Options for engineering controls are those that eliminate the hazard through methods such as changing the procedures or substituting less hazardous materials for more hazardous materials. Conducting work with hazardous chemicals in a fume hood or glove box, and providing secondary containment in the event of spills are examples of engineering controls.
- **Administrative controls:** Whereas engineering controls are controls that work passively once they are established, administrative controls require that workers take active steps. Examples of administrative controls are posting hazard signs on laboratory doors, minimizing exposure time when working with hazardous chemicals, restricting access to areas where hazardous chemicals are used, working with highly odorous chemicals during non-office hours, and adopting standard operating procedures.
- **Personal protective equipment:** Personal protective equipment includes items such as gloves, eye protection, suitable clothing, and respirators. Because such equipment is the last line of defense against exposure to hazardous chemicals, these are the options last employed. Note that selection of appropriate PPE is not always straightforward. In the case of gloves, there are a wide variety of types depending on the specific application. Although some types of PPE may be suitable for a wide range of applications, each operation should be assessed individually.