CHEMICAL HYGIENE PLAN & LABORATORY SAFETY MANUAL

Mississippi State University

Environmental Health & Safety

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INTRODUCTION AND SCOPE

The Mississippi State University Environmental Health & Safety Office (EHS) has developed this manual to assist in the recognition, evaluation, and control of hazards associated with laboratory and chemical operations. This manual also meets the requirements of the International Fire Code, 2012 5001.3 general provision for hazardous materials. It is the responsibility of every lab and chemical user to maintain, to the best of their ability, a safe work environment. This manual is intended to establish baseline safety practices for working with chemicals and working in laboratories. Due to the wide scope of activities that occur across the University, each department is responsible for developing department-specific standard operating procedures to supplement this manual for the hazards associated with each department.

There are subject specific manuals for radiological and biological materials that will also need to be incorporated into laboratories utilizing those materials. For more information on these policies and manuals, please consult the list below.

Environmental Health & Safety Office General Information: http://ehs.msstate.edu/

Mississippi State University Biosafety Manual

Mississippi State University Radiation Safety Manual

RESPONSIBILITIES

Responsibility for chemical and laboratory safety rests within every level at the University. It is important that all personnel understand their role and responsibilities for maintaining, to the best of their ability, a safe working environment for themselves and those around them.

Employees and Students

All employees and students are responsible for:

a. Observing all applicable practices and procedures contained within this manual, department specific manuals and standard operating procedures, and other University policies and manuals.
b. Reporting unsafe conditions and safety concerns to their supervisor, EHS, or the MSU ethics point.
c. Participating in all University and department required training and applying the knowledge and concepts gained in the training.
d. Reporting all accidents and near misses to their supervisor.

Principle Investigators (PI) and Supervisors

All PI’s and supervisors are responsible for:

a. Familiarizing themselves with this manual, department specific manuals and standard operating procedures, and all other applicable University policies and manuals and ensuring compliance in their area by all employees, students, and visitors.
b. Developing standard operating procedures specific to the work with potentially hazardous chemicals, equipment, or processes.
c. Selecting and employing safety practices and equipment that reduce the potential for exposure to hazards.
d. Maintaining laboratory equipment and controls in good working order.
e. Training all employees, students, and visitors of the hazards associated with their area and the procedures to be taken to reduce risk of exposure and/or injury.
f. Correcting reported unsafe conditions and safety concerns and contacting EHS for assistance in correcting unsafe conditions and investigating concerns when needed.

Department Heads, Chairs, and Directors

All department heads, chairs, and directors are responsible for:

a. Overseeing the development of standard operating procedures specific to work with potentially hazardous chemicals, equipment, or processes that occur in their department.
b. Familiarizing themselves with this manual and all other applicable University policies and manuals and ensuring compliance by all employees, students, and visitors in their department.
c. Supporting affected employees by supplying the resources necessary to ensure safety compliance. This will include providing training to affected employees and allowing for time away from work for training.
d. Notifying EHS of laboratory relocations, closings, and new lab space assignments.
e. Assigning a responsible party to control, maintain and supervise common use laboratories. This will include shared space, cold rooms, animal rooms, greenhouses, etc. If no person is assigned, the responsibility remains solely with the department head, chair, or director.
g. Reporting unsafe conditions and safety concerns to EHS for assistance in correcting unsafe conditions and investigating concerns when needed.

Environmental Health & Safety Office

The Environmental Health & Safety Office is responsible for:

a. Developing programs based on federal, state, and local rules and regulations, best practices, and University policies to enhance safety.
b. Assisting all MSU personnel in maintaining compliance with all University policies and applicable local, state, and federal regulations.
c. Provide general awareness training of common hazards and safe practices related to chemical and laboratory safety. EHS will maintain the training records of these training sessions.

d. Assist all personnel in correcting unsafe conditions and investigating safety concerns.
e. Conduct laboratory safety audits and hazardous waste satellite accumulation area inspections.
f. Provide guidance as requested regarding the selection and application of controls and development of standard operating procedures.
g. Upon request, investigation of accidents and serious incidents or chemical exposures.

Mississippi State University

Mississippi State University is responsible for:

a. Providing continuing support of chemical and laboratory safety. The University will continue to foster an attitude that promotes safe, productive, quality research.

DEFINITIONS

Autoignition Temperature is the approximate temperature at which a flammable gas-air mixture will ignite without spark or flame. Vapors and gases will spontaneously ignite at lower temperatures in oxygen than in air.

A *Chemical Storage Area* is defined as any location in which hazardous chemicals are stored. Chemical storage areas may include shops, mechanical, and custodial areas.

A *Hazardous Chemical* is defined as any element, chemical compound, or mixture of elements and/or compounds which is a physical and/or health hazard, regardless of quantity.

Hazardous Waste is any waste or combination of waste which because of its quantity, quality, concentration, physical, chemical, or infectious characteristics could cause or significantly contribute to adverse effects in the health and safety of humans or the environment if improperly managed (40 CFR 260-270). Specific definitions of the general characteristics of hazardous waste are found in 40 CFR 261.2. They include any wastes exhibiting a general characteristic of ignitability, corrosivity, reactivity, or toxicity. Also included are all waste specifically listed by the EPA in 40 CFR 261, Subpart D as a toxic or acutely toxic hazardous waste, or waste derived from specific or non-specific sources.

Flash point temperature is the lowest temperature at which sufficient vapor is given off to form an ignitable mixture in air.

A *Laboratory* is defined as, but not limited to, any location where research, diagnostic testing, or teaching is conducted using hazardous chemicals, biohazardous or biological materials, radioactive materials, radiation-producing devices, lasers, and/or related equipment.

Laboratory scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. ``Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

Pilot-Scale (or Pilot Plant) refers to a demonstration unit such as a small industrial system which is operated to generate information about the behavior of the system for use in design of larger facilities. The definition of pilot-scale is provided as a comparison to typically laboratory work/research often referred to as bench-scale.

Satellite Accumulation Area (SAA) is an area designated for hazardous waste collection and temporary storage at or near the point of generation and under the control of the operator generating the waste.

CHEMICAL HYGIENE

There are thousands of different chemical compounds in use across campus. Specific hazards associated with many of these compounds is unknown or little research has been conducted to determine the associated hazards. Consequently, it is impossible for this Chemical Hygiene Plan & Laboratory Safety Manual (CHP) to provide standard operating procedures and information for each specific substance. It is the responsibility of each department to address specific hazards present in their department and to supplement general procedures for work with hazardous substances listed in the CHP.

The CHP guidelines for the safe use, handling, and storage of chemicals covers the minimum required/recommended precautions and procedures for working with chemicals and in laboratories at MSU.

Chemical Classifications

It is essential that employees understand the types of toxicity, routes of exposure, and are familiar with the major hazard classifications of chemicals. There are several different systems that can be used to classify chemicals. The International Fire Code 2012 (IFC) classification of chemicals and the associated definitions are presented below. The 2012 OSHA 1910.1200 (GHS Standard) classification of chemicals is presented in Appendix A and is mandated to be followed by all chemical manufacturers. The Hazardous Materials Information System (HMIS; Appendix B) and the National Fire Protection Agencies 704 Standard (Appendix C) are also given in this Manual as examples of common systems used to quickly identify specific hazards and their severity for chemicals. It is important for all employees to be aware of the differences in classification and hazard rating systems when reading chemical information (MSDS, chemical label, website, etc.) because the commonly used systems in the U.S.A. are not synonymous. For example, an IFC class 4 oxidizer would be a class 1 oxidizer for OSHA.

Classification	Definition
Combustible Liquids II	Liquids having a closed cup flash point at or above 100˚F and below 140˚F
Combustible Liquids IIIA	Liquids having a closed cup flash point at or above 140˚F and below 200˚F

Classification	Definition
Corrosive	A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. A chemical shall be considered corrosive if, when tested on the intact skin of albino rabbits by the method described in DOT 49CFR 173.137, such chemical destroys or changes irreversibly the structure of the tissue at the point of contact following an exposure period of 4 hours.
Explosive	A chemical compound, mixture or device, the primary or common purpose of which is to function by explosion. The term includes but is not limited to dynamite, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, igniters, and display fireworks.
Explosive Division 1.1	Explosives that have a mass explosion hazard. A mass explosion is one which affects almost the entire load instantaneously.
Explosive Division 1.2	Explosives that have a projection hazard but not a mass explosion hazard.
Explosives Division 1.3	Explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.
Explosives Division 1.4	Explosive that pose a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package
Explosives Division 1.5	Very insensitive explosives. This division is comprised of substances that have a mass explosion hazard but which are so insensitive that there is little probability of initiation or of transition from burning to detonation under normal conditions of transport.
Explosives Division 1.6	Extremely insensitive articles which do not have a mass explosion hazard. This division is comprised of articles that contain only extremely insensitive detonating substances and which demonstrate a negligible probability of accidental initiation or propagation.
Flammable Liquids IA	Liquids having a closed cup flash point below 73˚F and having a boiling point below 100˚F

Classification	Definition
Flammable Liquids 1B	Liquids having a closed cup flash point below 73˚F and having a boiling point at or above 100˚F
Flammable Liquids 1C	Liquids having a closed cup flash point at or above 73˚F but below 100˚F
Flammable Solids	A solid, other than a blasting agent or explosive, that is capable of causing fire through friction, absorption of moisture, spontaneous chemical change or retained heat from manufacturing or processing, or which has an ignition temperature below 212˚F or which burns so vigorously and persistently when ignited as to create a serious hazard.
Flammable Gas	A material which is a gas at 68˚F or less at 14.7 psig of pressure which 1. Is ignitable at 14.7 psig when in a mixture of 13% or less by volume with air; or 2. Has a flammable range at 14.7 psig with air of at least 12% regardless of the lower limit.
Highly Toxic	A material which produces a lethal dose (LD50) or lethal concentration (LC50) which falls within any of the following categories: 1. A chemical that has a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to albino rats weighing between 200 and 300 g each. 2. A chemical that has a median lethal dose (LD50) of 200 mg or less per kg body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hrs.) with the bare skin of albino rats weighing between 2 and 3 kg each. 3. A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2 mg/L or less of mist, fume or dust when administered by continuous inhalation for 1 hr. (or less if death occurs within 1 hr.) to albino rats weighing between 200 and 300 g each. Mixtures of these materials with ordinary materials, such as water, might not warrant classification as highly toxic. While this system is basically simple in application, any hazard evaluation that is required for the precise categorization of this type of material shall be performed by experienced, technically competent persons.

Classification	Definition
Organic Peroxide	An organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radial. Organic peroxides can present an explosion hazard or they can be shock sensitive. They can also decompose into various unstable compounds over an extended period of time.
Organic Peroxides Class 1	Describes those formulations that are capable of deflagration but not detonation.
Organic Peroxides Class 2	Describes those formulations that burn very rapidly and that pose a moderate reactivity hazard.
Organic Peroxides Class 3	Describes those formulations that burn rapidly and that pose a moderate reactivity hazard.
Organic Peroxides Class 4	Describes those formulations that burn in the same manner as ordinary combustibles and that pose a minimal reactivity hazard
Organic Peroxides Class 5	Describes those formulations that burn with less intensity that ordinary combustibles or do not sustain combustion and that pose no reactivity hazard.
Organic Peroxides Undetermined	Organic peroxides that are capable of detonation. These peroxides pose an extremely high-explosion hazard through rapid explosive decomposition
Oxidizer	A material that readily yields oxygen or other oxidizing gas, or that readily reacts to promote or initiate combustion of combustible materials and, if heated or contaminated, can result in vigorous self-sustained decomposition.
Oxidizers Class 1	An oxidizer that does not moderately increase the burning rate of combustible materials.
Oxidizers Class 2	An oxidizer that will cause a moderate increase in the burning rate of combustible materials with which it comes in contact.
Oxidizers Class 3	An oxidizer that causes a severe increase in the burning rate of combustible materials with which it comes in contact.

Classification	Definition
Oxidizers Class 4	An oxidizer that can undergo an explosive reaction due to contamination or exposure to thermal or physical shock and that causes a severe increase in the burning rate of combustible materials with which it comes into contact. Additionally, the oxidizer causes a severe increase in the burning rate and cause spontaneous ignition of combustibles.
Oxidizing Gas	A gas that can support and accelerate combustion of other materials more than air does.
Pyrophoric	A chemical with an autoignition temperature in air, at or below a temperature of 130˚F.
Toxic	A chemical falling within any of the following categories: 1. A chemical that has a median lethal dose (LD50) of more than 50mg/kg, but not more than 500mg/kg of body weight when administered orally to albino rats weighing between 200 and 300 g each. 2. A chemical that has a median lethal dose (lD50) of more than 200mg/kg but not more than 1000mg/kg of body weight when administered by continuous contact for 24 hr. (or less if death occurs within 24 hrs.) with the bare skin of albino rabbits weighing between 2 and 3 kg each. 3. A chemical that has a median lethal concentration (LC50) in air of more than 200ppm but not more than 2000ppm by volume of gas or vapor or more than 2 mg/L but not more than 20mg/L of mist, fume, or dust when administered by continuous inhalation for 1 hr. (or less if death occurs within 1hr) to albino rats weighing between 200 and 300 g each.
Unstable (Reactive) Materials	A material, other than an explosive, which in the pure state or as commercially produced, will vigorously polymerize, decompose, condense or become self-reactive and undergo other violent chemical changes, including explosion, when exposed to heat, friction or shock, or in the absence of an inhibitor, or in the presence of contaminants, or in the contact with incompatible materials. Unstable (reactive) materials are divided into 4 classes.
Unstable Class 1	Materials that in themselves are normally stable but which can become unstable at elevated temperatures and pressures.

Classification	Definition
Unstable Class 2	Materials that in themselves are normally unstable and readily undergo violent chemical change but do not detonate. This class includes materials that can undergo chemical change with rapid release of energy at normal temperatures and pressures, and that can undergo violent chemical change at elevated temperatures and pressures.
Unstable Class 3	Materials that in themselves are capable of detonation or of explosive decomposition or explosive reaction but which require a strong initiation source or which must be heated under confinement before initiation. This class includes materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures.
Unstable Class 4	Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures. This class includes materials that are sensitive to mechanical or localized thermal shock at normal temperatures and pressures.
Water Reactive Materials	A material that explodes; violently reacts, produces flammable, toxic, or other hazardous gases; or evolves enough heat to cause autoignition or ignition of combustibles upon exposure to water or moisture. Subdivided into 3 classes.
Water Reactives Class 1	Materials that react with water with some release of energy, but not violently.
Water Reactives Class 2	Materials that react violently with water or have the ability to boil water. Materials that produce flammable, toxic, or other hazardous gases, or evolve enough heat to cause autoignition or ignition of combustibles upon exposure to water or moisture.
Water Reactives Class 3	Materials that react explosively with water without requiring heat or confinement.

Chemical Limits and Fire Zones

Mississippi State University is required to follow the International Fire Code, 2012 which includes classification of chemicals and limits of storage/use for each classification. The code establishes physical areas called fire zones that meet certain structural characteristics. Each fire zone has a limited quantity called the maximum allowable quantity (MAQ) of each classification of chemical that can be stored/used based upon storage containers, fire protection equipment (i.e.

sprinkler systems), and floor level. EHS has established fire zones and MAQ’s for each building on campus. Contact EHS for information specific to your buildings fire zones and MAQ’s.

Chemical Inventory Database

To assist personnel in achieving compliance with fire codes and facilitate maintaining up-to-date chemical inventory for each area, Mississippi State University has purchased a chemical inventory program, EHS Assist. The program also provides a means of controlling excessive inventories of chemicals by facilitating sharing of surplus chemicals resulting in the reduction of purchase and disposal costs. The program will also assist EHS and emergency responders in the event of an incident involving a facility that houses chemicals by providing the most up to date information on the type of chemicals that are likely to be encountered or involved in the incident.

All departments that use chemicals as part of their function are to actively utilize the EHS Assist program as a part of their chemical inventory maintenance. Contact EHS for enrollment in or assistance with the EHS Assist program.

Chemical Storage

Proper chemical storage is of great importance to ensure a safe working environment. The following segregation guidelines meet the requirements of the International Fire Code 2012. In general, chemicals should be stored according to their hazard classification. Material Safety Data Sheets (MSDS)/ Safety Data Sheets (SDS) should be utilized in all instances to determine classification and ensure compatibility with other chemicals in the area. Specific storage and use guidelines for common particularly hazardous chemicals are given later in the Chemical Hygiene section of this manual.

General Chemical Storage Guidelines

1. Solid, liquid, and gas chemicals should be segregated by distance or by compatible physical segregation.
2. Chemicals should be segregated based on chemical classification.
3. Chemicals should not be exposed to sunlight or localized heat.
4. Chemicals should be stored on shelving that is compatible with the class and weight of the class of chemicals. Chemicals should not be stored on shelving that would require the use of a step stool or reaching for chemicals over one’s head.
5. Flammable materials should be stored away from egress pathways and exit doors.
6. Sulfide, cyanide, and hydride chemicals must be stored in a dry location away from sources of water and acids.
7. Water reactive chemicals should be stored in secondary containment and away from all sources of water.
8. Corrosive chemicals not stored in corrosive cabinets should be stored in secondary containment large enough to contain a spill or leakage.

General Classifications for Chemical Segregation

Classification	Recommended Storage Location(s)	Incompatible with
Flammable Liquids	UL approved safety cabinet or can. Intrinsically safe refrigerator or freezer.	Oxidizers, inorganic acids, poisons/toxics
Combustible Liquids	UL approved safety cabinet or can. Intrinsically safe refrigerator or freezer. On laboratory shelving or in cabinets.	Oxidizers, inorganic acids, poisons/toxics, cyanide, sulfide, and hydride chemicals
Organic Acids	Corrosive cabinet. On laboratory shelving or in cabinets in secondary containment (not metal). UL approved flammable cabinet (check MSDS for compatibility with other stored chemicals)	Oxidizers, inorganic acids, bases, poisons/toxics, cyanide, sulfide, and hydride chemicals, flammable liquids, flammable solids.
Inorganic Acids	Corrosive cabinet. On laboratory shelving or in cabinet in secondary containment (not metal).	Organic acids, bases, poisons/toxics, flammable and combustible liquids
Bases/ Caustics	Corrosive cabinet. On laboratory shelving or in cabinet in secondary containment.	Organic acids, inorganic acids, flammable liquids, oxidizers, poisons/toxics
Oxidizers	Oxidizer cabinet. On laboratory shelving or in cabinet (not composed of wood or other combustible materials).	Flammable liquids, flammable solids, organic acids, reducing agents, combustible liquids, organic chemicals
Reducing Agents	On laboratory shelving or in cabinet.	Oxidizing chemicals
Flammable Solids	UL approved flammable cabinet.	Oxidizers, poisons/toxins
Water Reactives	UL approved flammable cabinet, away from water and in secondary containment.	Aqueous solutions, acids, and oxidizers
Poisons/ Toxics	Dedicated, separate, vented, cool and dry area in secondary containment.	Flammable liquids, acids, bases, oxidizers

Classification	Recommended Storage Location(s)	Incompatible with
General Chemicals	General laboratory shelving and cabinets.	See MSDS

Additional information on chemical incompatibilities can be found in Appendix D (Chemical Incompatibility Table)

Hierarchy of Controls

For all chemical and laboratory hazards, steps must be taken to eliminate or reduce the risk to an acceptable level. After identifying the hazard and associated risk, the first step in hazard control is to eliminate the hazard or by replacement with a less hazardous substance or process. If elimination is not possible and/or if hazards still exist, then the hierarchy of controls must be followed to reduce the risk of each hazard.

The hierarchy of controls include 1. engineering controls, 2. work practice controls, and 3. personal protective equipment. The controls must be applied in this order to provide the greatest level of protection to the worker from any hazard.

Engineering Controls

Engineering controls are physical barriers between the worker and the hazard, designed to eliminate, isolate or reduce exposure to hazards. Examples include chemical fume hoods, shields, barricades, and interlocks. Engineering controls should always be used as a primary line of defense against all hazards.

There are many different types of engineering controls and several of the engineering controls that are commonly used to protect workers from chemical and laboratory hazards are discussed below.

Broken Glass Boxes

Broken glassware should be collected separately from other waste to reduce the possibility of individuals being cut by shards of glass while handling waste. Clean, non-contaminated broken glass should be stored in a puncture resistant container with a heavy plastic liner and clearly marked ‘Broken Glass’. Most scientific vendors sell these boxes pre-labeled and with an appropriate plastic liner. The purchased broken glass boxes are the preferred choice of broken glass box on campus.

When the container is nearly full, it should be taped shut and brought directly to a dumpster for disposal. Custodial staff are not recommended to remove broken glass boxes and containers.

Other engineering controls such as tong or a dust pan and broom should be used to pick up broken glass to prevent injury.

Sharps Containers

Sharps are defined as any device having corners, edges, or projections capable of cutting or piercing the skin. Sharps can include needles, scalpels, razor blades, microscope slides, and contaminated glassware and should be placed in puncture resistant containers for disposal.

Sharps that are NOT contaminated with biological, chemical, or radiological materials should be disposed of in a non-red puncture resistant container with no biohazard markings. The container should be labeled as 'Non-Hazardous Sharps Waste' and disposed of in a broken glass box when full.

Sharps that are contaminated or have been used with biohazardous materials must be disposed of in accordance with the OSHA Bloodborne Pathogen Standard. Receptacles containing these materials must be labeled with the universal biohazard symbol and considered to be infectious waste. The container must not be completely filled to allow for proper sealing of the lid, decreasing the chance of a percutaneous exposure.

Sharps that are contaminated with radioactive materials must be disposed of in accordance with the *Mississippi State University Radiation Safety Manual*. The Radiation Safety Officer should be contacted for assistance.

Sharps that are contaminated with hazardous chemicals or drugs should be disposed of in a separate puncture resistant container. The Hazardous Waste Officer must be consulted for proper disposal of the waste. Mixing sharps contaminated with different chemicals is not an acceptable practice.

Laboratory Ventilation

Ventilation systems for laboratories are normally designed to provide 6 - 12 air changes per hour at a slightly negative pressure relative to hallways and office space. It is important to keep lab doors and windows closed at all times to ensure proper pressure balance and ventilation of the lab.

There are several different types of laboratory ventilation that can either protect the worker from hazards and/or the samples/reagents from the workers. For most ventilation equipment, it is essential to place the equipment away from air vents, doorways, windows, and traffic areas in the lab to maintain proper airflow.

To ensure proper functioning of these devices, it is important to evaluate the device before each use. Regular certification of the equipment is strongly recommended to ensure proper functioning and maintenance. EHS schedules the certification of laboratory ventilation equipment with an external certified company. Contact the EHS for more information on the program and to schedule a certification.

The 7 common types of laboratory ventilation and their functions are:

Chemical Fume Hoods

Chemical fume hoods are vital to providing protection to personnel from exposure to hazardous chemicals or otherwise dangerous materials. A common rule of thumb is that a properly functioning and operated chemical fume hood will provide protection for up to 10,000 times the immediately dangerous concentration of a chemical. Chemical fume hoods function as a fire and chemical resistant, 5-sided enclosure that allows large volumes of air to be drawn through the face and exhausted. Chemical fume hoods are NOT intended for the storage of chemicals, even chemicals that are required to be stored in ventilated cabinets. The large amount of power required to run a chemical fume hood makes them extremely inefficient as ventilated storage compared to other local ventilation devices.

General Use Rules for Chemical Fume Hoods:

- Chemical fume hoods should not be used for storage of any kind. Only items **needed** for the work being conducted should be present in the hood. Items needed in the hood should be placed as far back as possible without blocking the bottom baffle. Equipment should be separated and elevated to allow for air to flow easily around all apparatus.
- The sash of the chemical fume hood should remain closed when the hood is not actively being used or attended. When is use, the sash should be as low as possible for each worker to provide maximum worker protection. The chemical fume hood should never be operated with the sash above the minimum working height.
- The chemical fume hood exhaust fans should be left on at all times if possible. Many systems are connected to a single fan and/or building ventilation systems that are designed to be at optimum performance when the hoods are on. Turning off the chemical fume hood may cause disruptions downstream in other hoods or in the building ventilation system. Many chemical fume hoods on campus are designed to go into ‘power saving’ mode when the laboratory is unattended (lights are off) as long as the sash is closed.
- Work should be conducted at least 6 inches behind the sash with ones arms extended under or around the sash with the head in front of the sash. This set up allows the sash to provide a barrier between the person and material being manipulated.
- If bench paper is used in the hood, it is essential to ensure that the paper does not cover or block the lower front airfoil or rear baffles. Bench paper should only be used during a set procedure and removed once the procedure is complete or the paper is contaminated.
- Adjustments to the sash and all movements in the hood should be made slowly as to not increase turbulence and thus reduce the efficiency of the hood.
- Large pieces of equipment should not be used in a chemical fume hood due to the dead space in airflow and reduced efficiency created. If a large piece of equipment emits fumes or produces heat, special-purpose hoods should be designed/installed for that particular device to increase efficiency and decrease energy expenditure.

Biological Safety Cabinets (BSC)

Biological safety cabinets are unique in that they provide protection to the user, the environment, and the materials within the workspace from biological hazards and nano-materials (particulate not gases or vapors). Many of the principles for working in a chemical fume hood are applicable for BSC's, however there are additional protocols that should be used. For detailed information on the different types of BSC's and how to properly work in and maintain a BSC, please refer to Appendix A of the *Biosafety in Microbiological and Biomedical Laboratories*, 5th Ed. available online via www.cdc.gov. Additional information can also be found in the *Mississippi State University Biosafety Manual.*

Gloveboxes

Gloveboxes are fully enclosed small units with multiple openings with arm length gloves mounted to the face. Gloveboxes can operate either under negative (isolate toxic materials from the environment) or positive (protect highly toxic or sensitive materials from atmospheric moisture or oxygen) pressure. Nanoparticles can also be used in a glovebox. Gloveboxes provide protection to the user and the hazardous material. There is very low air flow through a glovebox and the exhaust must be filtered prior to release into an exhaust system. The low air flow also results in minimal dilution of hazardous substances in the air and therefore gloveboxes should be tested routinely for leaks to ensure cabinet integrity. The integrity of the glovebox should be checked prior to each use according to laboratory SOP's specific to the type of glovebox being used.

A Class III BSC is another form of gloveboxes that provide maximum protection for the environment and worker from highly infectious microbiological agents. For more information on Class III BSC's, please refer to Appendix A of the *Biosafety in Microbiological and Biomedical Laboratories*, 5th Ed. available online via www.cdc.gov.

Laminar Flow Hoods

Also known as 'clean benches', laminar flow hoods have horizontal or vertical air flow that *only* protects the materials from the user. **There is NO worker protection with laminar flow hoods and they should NEVER be used to handle any hazardous materials.** Laminar flow hoods are intended for clean activities such as dust-free assembly of sterile equipment or electronic devices or for the preparation of intravenous solutions.

Canopy Hoods

Canopy hoods utilize a large volume of air to 'capture' non-hazardous materials such as heated air or water vapor from ovens and autoclaves. The capture zone of canopy hoods is only a few inches below the opening of the hood.

Downdraft Hoods

Also known as necropsy tables, downdraft hoods are specially designed areas that have ventilation slots on the sides of the work area. Downdraft hoods are useful for procedures such as animal necropsy where access to the materials is needed on more than one side (a chemical fume hood only allows access on one side). Downdraft hoods should only be used for protection from chemicals that have vapor densities heavier than air.

Gas Cabinets

Highly toxic or flammable gases in compressed gas containers too large (larger than lecture size) to be stored and used in a chemical fume hood should be stored and used within UL approved gas cabinets. Gas cabinets are connected to the ventilation system and protect personnel from exposure in the event of a leak or rupture. The IFC 2012 requires that flammable and toxic gases over the maximum allowable quantity (MAQ) for each fire zone must be stored in a gas cabinet.

Work Practice Controls

Work practice controls are precautionary measures that reduce the likelihood of exposure to hazardous substances by altering the way a task or procedure is performed. Work practice controls are the secondary line of defense against all hazards after engineering controls have been applied.

The following items are basic work practice controls that are applicable to all laboratories and chemical work. These items or rules in no way cover all situations and it is essential that hazards and concerns be addressed in each work area. Each department and work area should establish a written set of rules to be followed.

Working Alone

Many organizations and universities state that it is unsafe to work alone in the laboratory or with chemicals and should not be permitted. All efforts should be made to avoid working alone in a laboratory or with chemicals, particularly in an empty building or section of the building. Extreme caution should be taken before working alone in the laboratory.

No work should be conducted unless you are trained and prepared to perform the tasks in the laboratory. Anyone working alone should have prior approval from a supervisor and be experienced in the procedure to be performed. Unauthorized or high risk experiments should not be conducted while working alone.

Emergency procedures should be established and understood prior to the initiation of any work. Personnel should have access to safety equipment such as an eye wash, safety shower, first aid kit, fire extinguisher, and a land-line phone. Emergency contact information should be posted in each laboratory.

Before working alone, it is best to notify someone of your intention to work alone and let them know what you will be doing, where you will be, when you intend to check in or return, and an alternate method to check on you (ex. Lab colleague, MSU police). Again, this is not a recommended practice and should be avoided at all costs.

Food and Beverages in the Lab

Food, beverages, tobacco products, and the application of cosmetics are not recommended to be present or consumed in the laboratory. These products can easily become contaminated by chemical, biological, and radiological hazards by simply being present in the laboratory. Food, beverages, eating utensils, plates, and cups should not be present in locations where hazardous materials are stored or in use. Laboratory glassware should never be used to prepare or consume food or drink, nor should laboratory sinks or drying racks be used to wash utensils, plates and cups.

Laboratory ice machines should never be used as ice for human consumption.

Hand Washing

One of the most important behaviors that all personnel working with chemicals or in laboratories should develop is washing their hands before leaving the work area and after removing gloves. Washing ones hands is vital to reducing the risk of contamination. It is important that there is at least one hand washing sink present in every work area, preferably by the exit door. The sink should contain both hand washing soap and paper towels (or some other method to dry hands).

Laboratory Housekeeping

According to *Prudent Practices in the Laboratory* (National Academy of Sciences, 2022), good housekeeping in the laboratory has many benefits. A well-kept laboratory can reduce the number of chemical hazards in the laboratory and help control the risk from hazards that can't be removed. Proper labeling and storage of materials reduces the risk of mixing incompatible materials. In terms of security, a well-organized laboratory makes it easier to spot out-of-place items. A laboratory with good housekeeping is also more likely to have less scientific error from reduced chances of contaminated samples or equipment and mislabeled reagents. Common injuries in the laboratory such as cuts, slips, trips, falls, and back injuries can also be the result of poor housekeeping.

The following are general housekeeping guidelines:

- Work areas should be cleaned up upon the completion of work or the end of the work day. All items should be returned to the proper storage locations.
- Bench tops and chemical fume hoods should not be used as storage locations.
- Chemical bottles should not be stored on the floor unless in secondary containment. Bottles should not be stored in egress pathways.
- Bench liners, if used, should be changed regularly and after any spill or contamination.
- Bench tops and laboratory equipment should be cleaned and/or disinfected after use.
- The floor should be kept dry at all times. Immediately attend to spills of chemicals or water, and notify other workers of potential slipping hazards.

Proper Lab Attire

The clothing that you wear when working provides a barrier between you and the hazards you are working with (chemical, biological, radiological, and physical). Clothing that leaves large areas of skin uncovered is not recommended in areas where hazardous materials are in use. Adequately covering the skin (long pants or skirt, shoes that cover the entire foot, shirts with sleeves) will delay or prevent the hazardous action of all hazards affecting those areas. Open toed shoes, shorts, short skirts, sleeveless shirts, and sandals are not recommended to be worn in laboratories or when working with any chemical. Very tight or loose fitting clothing, jewelry, and loose hair should be avoided. Tight clothing will hold any spilled material against the skin. Loose clothing, jewelry, and hair can be entangled in machinery, accidently come into contact with hazardous materials, or knock items over.

Additional Prudent Practices

- Know the location and the proper use of the safety equipment present in or near the laboratory or work area (eye wash, safety shower, first aid kit, fire extinguisher, emergency telephone, fire alarm pull stations).
- Wear the appropriate personal protective equipment.
- Utilize all appropriate engineering controls.
- Read the MSDS/SDS, labels, and procedures prior to work.
- Maintain awareness in the laboratory, including the hazards associated with the work that others in the lab are conducting. The use of cell phones and personal music players should be eliminated to maintain situational awareness and prevent contamination.
- Ensure that others in the area are aware of the hazards associated with your work.
- Report all accidents, incidents, injuries, and near misses to your supervisor.
- Dispose of all materials according to University policies, federal, state, and local laws.
- Do not allow visitors or unauthorized people unattended in the work area at any time.
- From a security standpoint, laboratory doors should be kept closed at all times and locked when no one is present in the laboratory.
- Personal protective equipment (gloves, lab coats, etc.) should not be worn in public areas such as cafeterias, offices, and restrooms. Effort should be made to avoid wearing these items in hallways by transporting hazardous materials in secondary or tertiary containment. Gloves should always be removed prior to entering the hallways or touching common items such as door knobs and elevator buttons.

Laboratory Rules

Laboratory and work area rules should be written, provided, understood, and followed by all personnel working in the area. Each department should establish a set of general safety rules, using the following rules as the minimum recommended practices. Some work areas or laboratories with highly hazardous chemicals or procedures should have their own specific rules in addition to the department rules to address those hazards. Laboratory and work area specific rules should be posted on the entry door to the area.

General Safety Rules

1. Appropriate clothing should be worn in the laboratory at all times (full-coverage shoes, pants or long skirt, shirt with sleeves, loose articles of clothing or hair secured).
2. Appropriate PPE should be worn based on the hazards and associated risk in the laboratory.
3. All users should be given a practical orientation for established work practices in which they will be participating. All users will attend any required training and recommended training should be strongly considered.
4. Food, beverages, tobacco products, and cosmetics are not permitted in the laboratory.

5. All users must be made aware of the use and location of emergency equipment such as showers, fire pull stations, fire extinguishers, container grounding equipment, etc. before beginning work or study.
6. All users must be informed of emergency procedures for fire, worker injuries, spills, and alarms before beginning work or study.
7. All chemical users must be informed of the location Material Safety Data Sheets or Safety Data Sheets before beginning work or study.
8. The designated engineering controls should be utilized as instructed.
9. Hands should be thoroughly washed prior to leaving the work area and after contaminated gloves are removed.
10. Laboratory coats should not be removed from the laboratory or taken home for laundering. Gloves should never be worn outside of the laboratory or when touching/handling common objects such as door knobs and light switches.
11. Aisle ways should be clear of all obstructions at all times.
12. Avoid when possible leaving equipment operating while unattended. If equipment or a process must be left unattended, emergency contact information and expected return time should be provided.

Personal Protective Equipment (PPE)

Personal protective equipment, or PPE, is the final step in providing protection to a worker from a hazard. PPE is used to protect workers from hazards that engineering controls and work practices cannot reduce to an acceptable level and should be utilized as the last line of defense. PPE differs from engineering controls in that PPE are items that the worker wears to provide protection and engineering controls create a physical barrier between the worker and the hazard.

The PPE to be worn in each laboratory or work area should be selected based upon the results of a risk assessment completed by the area supervisor. In most cases, all personnel in a set area should be dressed to the highest hazard in the laboratory, not necessarily the hazard they are directly working with. PPE can include items such as laboratory coats, hard hats, hearing protection, steel toe shoes, goggles, respirators, reflective clothing, gloves, aprons, etc.

PPE commonly worn in laboratories or working with chemicals are discussed below.

Gloves/ Hand Protection

It is first important to note that **NO** single glove materials can provide protection for all uses. Multiple types of gloves may need to be available and in some cases, more than one type of glove may need to be worn at the same time to protect the worker.

Permeability, degradation, and dexterity are the three main factors to consider when selecting a glove material. Please view the glove comparison chart below for assistance in selecting the proper material for your use. EHS can assist personnel in selecting the proper glove for hazards and the manner in which the hazard is used.

Most laboratories use latex, nitrile, or neoprene gloves which are not intended for re-use. These gloves should be removed, hands washed, and a new pair of gloves put on after any contamination of the gloves. Latex gloves provide poor chemical durability and some personnel may be allergic or develop sensitivities to latex. Latex gloves are not recommended for most procedures.

When wearing re-usable gloves, be sure to inspect gloves for holes or tears before each use and to appropriately wash the gloves after use. A pair of standard gloves, such as nitrile or neoprene gloves, should always be worn under re-usable gloves to prevent accidental skin contact if breakthrough occurs.

Gloves should be removed prior to entering the hallways or touching common items such as door knobs, keyboards, pens, and elevator buttons to prevent the accidental spread of hazardous substances. If transporting laboratory materials through a hallway, non-contaminated secondary containment and/or carts should be utilized so that gloves are not necessary.

Glove Comparison Chart

Glove Material	**Intended Use**	**Advantages**	**Disadvantages**
Latex	Incidental Contact	-Good for biological and water based materials	-Poor for organic solvents -Little chemical protection -Hard to detect puncture holes -Latex allergies
Nitrile	Incidental and Extended Contact	-Excellent general use glove. -Good for solvents, oils, greases, some acids and bases -Clear indication of tears and breaks	
Butyl Rubber	Extended Contact	-Good for ketones and esters	-Poor for gasoline and aliphatic, aromatic and halogenated hydrocarbons.
Neoprene	Extended Contact	-Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons and phenols. -Good for most hazardous chemicals.	-Poor for halogenated and aromatic hydrocarbons
Norfoil	Extended Contact	-Good for most hazardous chemicals.	-Poor fit.
Viton	Extended Contact	-Good for chlorinated and aromatic solvents. -Good resistance to cuts and abrasions	-Poor for ketones -Expensive

Glove Material	Intended Use	Advantages	Disadvantages
Polyvinyl Chloride (PVC)	Specific Use	-Good for acids, bases, oils, fats, peroxides and amines -Good resistance to abrasions	-Poor for most organic solvents.
Polyvinyl Alcohol (PVA)	Specific Use	-Good for aromatic and chlorinated solvents.	-Poor for water-based solutions
Stainless steel/ Kevlar/ Leather	Cut resistance		
Cryogenic	Cryogenic materials	-Designed to prevent frostbite	
Nomex	Pyrophoric Materials		

It is essential that gloves be properly removed when contaminated or at the end of a procedure to ensure that contamination with the workers skin does not occur. The following pictures demonstrate the proper method to doff (remove) single-use gloves. This method ensures that only gloved hands touch glove and bare hands touch only the inside of the glove and skin.


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Eye and Face Protection

The eyes are delicate organs that are very sensitive to irritants. Most substances when in contact with the eye are painful and irritating, and some can cause considerable damage and loss of vision. It is important to protect the eyes at all times with the appropriate level of eye protection for the hazards associated with the laboratory. Eye protection required for each work space should be available for all workers and visitors at the entrance to the space.

There are several different types of eye and face protection:

- Safety glasses with side shields provide the minimum protection and are acceptable for regular use. Safety glasses should meet the ANSI Z87.1-2003 Standard for Occupational and Educational Eye and Face Protection.
- Chemical splash goggles are more appropriate protection against projectiles, pressurized equipment or parts, potentially explosive compounds, and glassware at high temperatures.
- Face shields only provide splash and projectile protection to the skin of the face and neck. Face shields do not provide any eye protection.
- When there is a risk of splashing of hazardous material or flying particles, both chemical splash goggles and a face shield should be utilized. Both should also be utilized when working with particularly hazardous operations.
- Special glasses or goggles are required for work with lasers and ultraviolet light sources.

Note that prescription glasses do NOT provide adequate protection in the laboratory or against chemical hazards. Safety glasses or goggles must still be worn. Safety goggles or glasses can be purchased with the users' prescription to lessen the discomfort of wearing two sets of glasses.

The use of contact lenses when working with chemicals are not recommended where chemical vapors are present or if chemical splash or dust is possible. If they are to be worn, chemical splash goggles must be worn as well.

Laboratory Coats and Aprons

Laboratory coats should be worn during most, if not all laboratory procedures and come in a variety of styles and fabrics. Despite the style or fabric, all lab coats should be worn fully buttoned or fastened and the sleeves down to the wrist. Laboratory coats should not be taken home for laundering.

Laboratory coats made of cotton will protect the wearer against general laboratory hazards. If working with flammable materials, cotton laboratory coats with a flame retardant treatment are recommended. Laboratory coats made of synthetic fibers will also protect the wearer against general hazards but they may be degraded by certain solvents and will melt upon contact with flames. A detailed risk assessment will assist laboratory workers in determining the type of fabric desired in a laboratory coat.

Laboratory coats with snaps are preferred over buttons for the snaps allow for a quicker removal of the coat in the event of an emergency. Coats with elastic wrist cuffs provide better protection than coats with a standard seam by allowing the hand and forearm to be continuously covered by the gloves and coat.

Laboratory coats can serve four main protective functions: 1. protect your clothing from being damaged, 2. provide an additional layer of material to protect you from spills, splashes and burns, 3. reduce the chance of taking home hazardous materials on your clothes, and 4. protect your samples and reactions from contaminants on your clothes.

An apron is typically made of non-permeable materials such as plastic or rubber. Aprons provide protection to the torso and legs of the wearer. They can be worn in conjunction with a laboratory coat to provide a non-permeable covering to protect against corrosive or irritating chemicals.

Respiratory Protection

When engineering controls (chemical fume hoods, biological safety cabinets, shielding) and work practices cannot reduce the airborne contaminants below an acceptable concentration, then respiratory protection is required. Respirators should be used as a last resort because of the stress they can place on the respiratory tract of the user and they can be cumbersome to wear.

Please note that surgical masks are not considered to be true respiratory protection because they do not protect the wearer from hazards. Dust masks are not considered to be respirators and do not require fit testing or medical evaluations.

Use of any type of respirators must be based upon a risk assessment conducted by the area supervisor and MSU Respiratory Protection Program Manager. Training and fit testing of respirators must be in accordance with the Mississippi State University Respiratory Protection Program through EHS.

Chemical Labeling

Chemical labels serve as an information source for all personnel who will come into contact with the chemical, including emergency and EHS personnel. All chemicals must be properly labeled at all times, from the time they are brought onto campus, to the time they are removed for disposal. Federal regulations require manufacturers to provide vital information such as the chemical name, hazard, and handling information. The manufacturer’s label must not be removed or defaced during the life cycle of the chemical. Chemicals that are transferred to a process container or solutions made within the laboratory or work area must also be properly labeled.

The following provides guidelines for the proper labeling of chemicals from the manufacturer and those made in the work area.

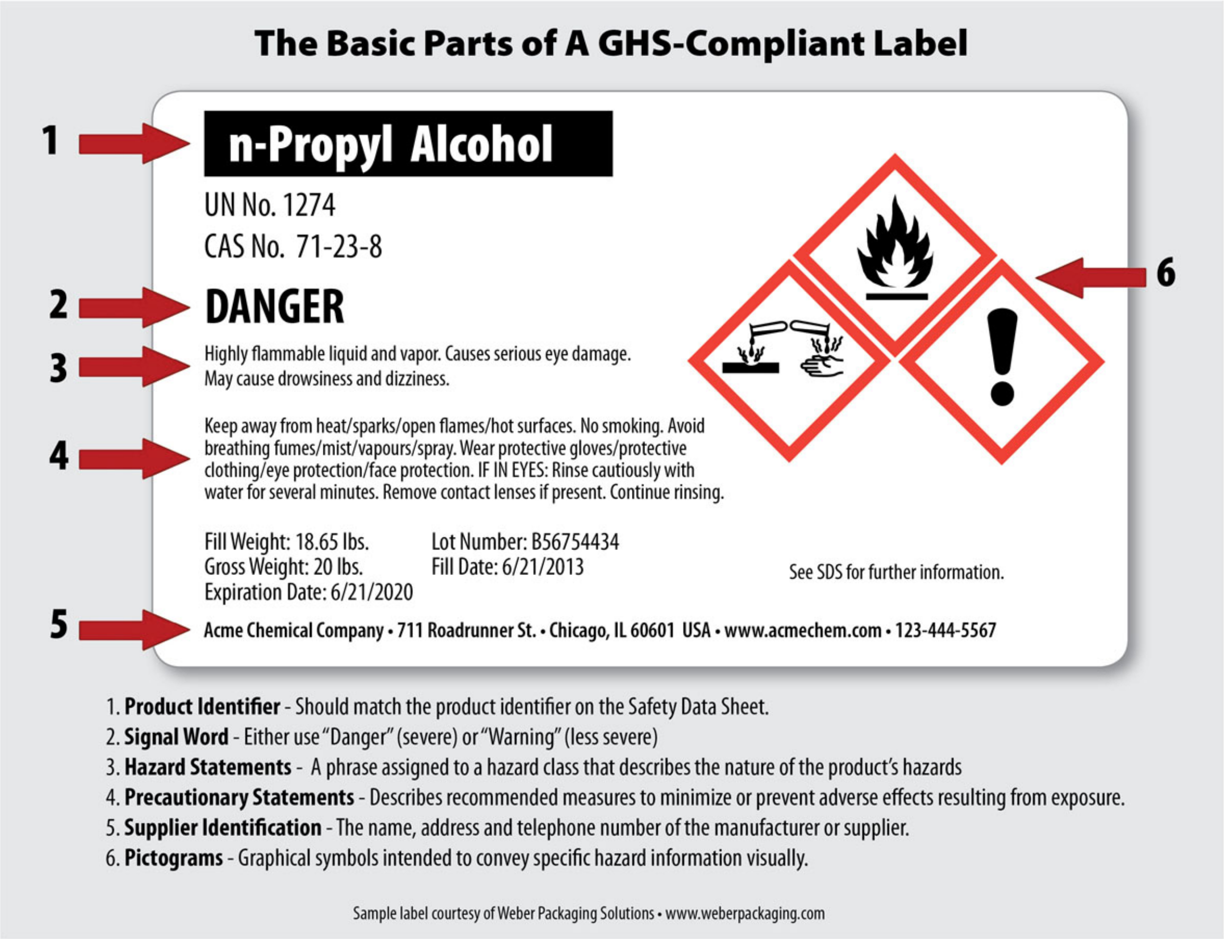
Manufacturer Labels

- No chemical shall be accepted into MSU inventory without an adequate identifying label.
- The manufacturer label must not be defaced during the life cycle of the chemical
- Chemicals should be dated when received, opened, and with an expiration date, if applicable. Dating of chemicals is of particular importance for peroxide forming compounds and other chemicals that become more hazardous over time.
- Damaged labels must be replaced as soon as possible.

- Good laboratory practices recommend including the last name or initials of the responsible party on the label.

The 2012 Hazard Communication (GHS) standard requires manufacturers and distributors of chemicals to provide more detailed labels on all shipped chemical bottles/containers. Chemicals shipped after December 2014 must meet the requirements of this standard. The label must contain 6 components:

1. A **product identifier** used on the Safety Data Sheet
2. **Signal word** of either ‘Danger’ or ‘Warning’, if required by the hazard.
3. **Hazard Statement(s)** inform the user of the specific hazard(s) associated with the chemical.
4. **Precautionary Statement(s)** inform the user of steps to prevent or respond to an exposure, properly store, and dispose of the chemical. Not all information may be listed on the label but will be present in the SDS. This is indicated on the label by the use of ‘***’ at the end of the precautionary statement
5. **Supplier Identification** and Contact Information
6. **Pictogram(s)** for the health and physical hazards associated with the chemical.



The Basic Parts of A GHS-Compliant Label

n-Propyl Alcohol

UN No. 1274
CAS No. 71-23-8

DANGER

Highly flammable liquid and vapor. Causes serious eye damage. May cause drowsiness and dizziness.

Keep away from heat/sparks/open flames/hot surfaces. No smoking. Avoid breathing fumes/mist/vapours/spray. Wear protective gloves/protective clothing/eye protection/face protection. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present. Continue rinsing.

Fill Weight: 18.65 lbs.
Gross Weight: 20 lbs.
Expiration Date: 6/21/2020
Lot Number: B56754434
Fill Date: 6/21/2013

See SDS for further information.

Acme Chemical Company • 711 Roadrunner St. • Chicago, IL 60601 USA • www.acmechem.com • 123-444-5567

1. **Product Identifier** - Should match the product identifier on the Safety Data Sheet.
2. **Signal Word** - Either use “Danger” (severe) or “Warning” (less severe)
3. **Hazard Statements** - A phrase assigned to a hazard class that describes the nature of the product’s hazards
4. **Precautionary Statements** - Describes recommended measures to minimize or prevent adverse effects resulting from exposure.
5. **Supplier Identification** - The name, address and telephone number of the manufacturer or supplier.
6. **Pictograms** - Graphical symbols intended to convey specific hazard information visually.

Sample label courtesy of Weber Packaging Solutions • www.weberpackaging.com

“In House’ Labels

- If a chemical is repackaged into secondary containers, the new container must be labeled with all essential information from the manufacturer’s label [full chemical name, composition of ingredients, CAS #, hazards, date received and opened, and expiration date (if applicable)]. Manufacturer information, catalog number, and lot number may also be included.
- All ‘In House’ labels for solutions and mixtures must contain the following information:
    1. Full chemical name (no abbreviations or structural formulae)
    2. Concentration of ingredients
    3. Date created (not applicable on hazardous waste containers)
    4. Last name or initials of the responsible party

  Additional recommended information for all ‘In House’ labels for solutions and mixtures include:

    1. Hazard information
    2. Hazard pictograms, NFPA diamond, or HMIS rectangle
    3. Storage requirements
- Newly synthesized or experimental materials may not have an understandable name and/or the hazards may not be known. These materials must be labeled with:
    1. Known reactants and possible products
    2. Possible hazardous properties
    3. Date of creation
    4. Name of the researcher

    OR

    1. Location in laboratory notebook with information regarding the reaction
    2. Date of creation
    3. Name of researcher
- All bottles and containers in the workplace must be labeled as to the contents to avoid ‘unknown’ chemicals. This includes items such as distilled water carboys and disinfectant spray/squeeze bottles.
- Damaged labels must be replaced as soon as possible.
- If a chemical is transferred to a process container that will be used within the workday by the person performing the transfer, the process container does not need to be labeled if it is not left unattended.
- Portable containers containing chemicals which are intended for immediate use which will not be left unattended for any length of time do not need to be labeled.
- All information on the labels must be presented in English. Other spoken languages may be added to the label as long as the information is presented in English.

- When labeling samples, the secondary container (box or rack) may be utilized to house the required label information. However, it is vital that the sample could be identified if separated from the secondary container.

MSDS/SDS

OSHA mandates that manufacturers of chemicals provide information to the end users on the hazards associated with each chemical, how to store, properly work with, and dispose of the chemical. This information is presented in Material Safety Data Sheets (MSDS), which are switching to Safety Data Sheets (SDS) with the new hazard communication law by December of 2014.

OSHA mandates that safety data sheets be available to each employee for the hazardous chemicals that they work with or around. The sheets should be available to each employee during their working shift in their primary working area. Electronic copies of SDS's are permitted as long as NO barriers to immediate employee access is created by this option. When work is carried out at more than one geographical location, SDS may be kept at the primary workplace as long as the employees can immediately obtain the SDS in an emergency. SDS may be included in operating procedures and can cover groups of hazardous chemicals, as long as the required information (sections of SDS) is provided for each hazardous chemical and they are readily accessible.

It is strongly recommended that SDS/MSDS be available to all personnel during their working shift for all chemicals that they will work with or around. New SDS do not need to be printed or saved (once available) for each MSDS, but should be printed or saved once the chemical is ordered and possesses the new 'GHS' label. In time, all MSDS should be replaced by SDS.

SDS present in the laboratory should be less than 5 years old (by the revision date) to account for new information acquired related to the hazard information or regulatory changes.

There are 16 mandated sections to a Safety Data Sheet, four of which are regulated by other government organizations. The order and required information of each section is as follows:

1. **Identification:** Product identifier; other means of identification; recommended use and restrictions on use (new); Contact information of responsible party; and Emergency phone number.
2. **Hazard(s) identification:** Classification(s) of the chemical; Signal word, Hazard statement(s); precautionary statement(s); pictograms (optional); hazards not otherwise classified; % of ingredient of unknown acute toxicity (if not otherwise listed in main hazard statement). The additional information that is denoted by an '***' in either the hazard and/or precautionary statement on the chemical label will be listed in this section.
3. **Composition /Information on Ingredients:** Substance name and concentration or concentration range of all ingredients classified as health hazards.

4. **First aid measures**: Description of necessary measures divided by route of exposure; Most important symptoms/effects (acute and delayed); Indication of immediate medical attention and special treatment if needed.
5. **Fire Fighting Measures**: Suitable extinguishing media; Specific hazards arising from the chemical in a fire situation; Special PPE and precautions for fire fighters (new).
6. **Accidental Release Measures**: Personal precautions, PPE, and emergency procedures; Methods and materials for containment and clean up.
7. **Handling and Storage:** Precautions for safe handling, conditions for safe storage, Incompatibilities.
8. **Exposure Controls and Personal Protection:** OSHA permissible exposure limit (PEL), American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV), and any other exposure limit or recommendation by manufacturer/importer/employer; Appropriate engineering controls; PPE.
9. **Physical and Chemical Properties:** There are 18 required physical and chemical properties which must be listed including Appearance, pH, Melting/Freezing Point, Odor Threshold, Flash Point, Flammability, Explosive limits, Pressure and density measures, and Solubility.
10. **Stability and Reactivity:** Reactivity; Chemical Stability; Possibility of hazardous reactions; Conditions to avoid; Incompatible materials; Hazardous decomposition products.
11. **Toxicology Information:** Description of various toxicological (health) effects and the available data used to identify those effects, including: Likely route(s) of exposure; Symptoms; Delayed, immediate, and chronic effects from short- and long-term exposure; Numerical measure of toxicity; Whether the chemical is a carcinogen.
12. **Ecological Information:** (Regulated by EPA). Exotoxicity; Persistence and degradability; Bioaccumulation potential; Mobility in soil; Other adverse effects.
13. **Disposal Considerations:** (Regulated by EPA). Description of waste residues and information on their safe handling and methods of disposal.
14. **Transportation Information:** [Regulated by DOT (US Department of Transportation)]. UN number; UN proper shipping name; Transport hazard class(es); Packing group; Environmental hazards; Transport in bulk; Special precautions.
15. **Regulatory Information:** [Regulated by DOT (US Department of Transportation)]. Safety, health, and environmental regulations specific to the product.
16. **Other Information:** Additional information such as preparation and revision dates of the SDS.

Hazard Specific Recommendations

Most, if not all chemicals pose hazards to the users under certain conditions of use. Chemicals that are particularly hazardous should be considered for special precautions and controls to protect the worker and environment. Specific SOP's must be generated for all procedures, and most importantly, those procedures involving particularly hazardous substances. Engineering controls, work practice controls, and PPE should be considered and applied to all procedures involving particularly hazardous substances to reduce exposure to as low a level as possible.

The following are classifications of chemicals that pose specific hazards to the worker and environment and general steps that should be taken to reduce risk. This is by no means an exhaustive list. MSDS/SDS and best practices should always be consulted in generating SOP's for work with these and all substances. The guidelines listed below are to be used in addition to other guidelines and best practices listed in this manual.

Water Reactive Chemicals

Water reactive chemicals are chemicals such as elementary sodium, potassium and lithium that react violently with water, producing heat and flammable gases.

Storage and handling guidelines for water reactive chemicals include:

- Store in a cool and dry location in secondary containment to protect chemicals from accidental wetting from sources such as sprinkler systems.
- The work area (laboratory) and storage location should be marked as containing water reactive chemicals.
- All work should be conducted in a chemical fume hood or in a glovebox when dry atmospheres are required.

Flammable Chemicals

Flammable liquids and solids are among the most hazardous common chemicals on campus. Precautions must be taken to maintain a safe environment when working with flammable materials.

- Flammable materials should only be handled when no ignition sources are present, including open flames, electrical equipment, hot surfaces, and area's prone to static electricity. The vapor from flammable liquids can travel considerable distances, thus increasing the area at risk of fire.
- Flammable materials should never be heated with an open flame.
- Flammable materials should be handled in a chemical fume hood to prevent an ignitable concentration of vapors.
- Flammable materials cannot be stored in refrigerators or freezers that are not flame-proof or explosion-proof.
- Flammable materials should not be stored in cold rooms or fume hoods.

Peroxide Forming Chemicals

Organic peroxides are liquid or solid organic chemicals which contains a bivalent -0-0- structure where one or both of the hydrogen atoms have been replaced by organic radicals. Organic peroxides are thermally unstable chemicals which may undergo exothermic self-accelerating decomposition and may be liable to burn rapidly, explosively decompose, be sensitive to impact and friction, and/or react dangerously with other substances. Without proper storage and handling, these low stability substances are likely to detonate. Common organic peroxide forming chemicals include diethyl ether, diisopropyl ether, dioxane, cyclohexene, isoproplybenzene, divinyacetylene, decalin, and 2,5-dimethlyhexane.

General precautions for storing and handling peroxide forming chemicals include:

- Store away from heat and light.
- Date containers with the date received and date opened. An expiration date should be assigned based on manufacturer recommendations. If no expiration date is available, EHS recommends all peroxide forming chemicals be disposed of one year after the date they are opened.
- If crystals are visibly present on or in the bottle or lid, DO NOT TOUCH! Contact EHS immediately for disposal.
- Metal spatulas, stir bars, and other metal equipment should NOT be used to reduce the risk of accidental metal contamination, which may lead to unintentional explosive decomposition.

Pyrophoric materials

Pyrophoric chemicals are a special class of reactive materials that spontaneously combust when in contact with air due to very rapid oxidation of the compound. Finely divided metals, metal hydrides, alloys of reactive metals, metal salts, and iron sulfide are pyrophoric.

Guidelines on storage and use of pyrophoric materials include:

- Pyrophoric materials should be stored under inert gas or kerosene as recommended by the MSDS/SDS.
- Pyrophoric materials should NOT be stored with flammable materials or in a flammable cabinet. Pyrophoric materials should be stored in closed secondary containers. Flame- or explosion-proof refrigerators or freezers must be used as opposed to standard refrigerators or freezers.
- Like flammable materials, all sources of ignition should be removed from the storage and handling areas of pyrophoric materials.
- Properly maintained gloveboxes should be used to work with pyrophoric materials if inert or dry atmospheres are required. If chemical fume hoods are to be used, specific work practices must be adopted based upon manufacturer and industry recommendations and standards.
- Flame-resistant laboratory coats must be worn while working with pyrophoric chemicals.

Nanomaterials

Nanomaterials are materials with a typical size in the lower nanometer range and characteristic mesoscopic properties. Nanomaterials can be composed of a wide variety of materials (carbon, gold, silver, and selenium) and shapes (nanotubes, quantum dots, and nanowires). With a size between 1-100nm, the properties of nanomaterials may be vastly different than the bulk material. The risk and toxicity associated with nanoparticles is currently poorly understood or unknown for many substances. With research on the properties and toxicology of nanoparticles ongoing, detailed risk assessments should be conducted to provide protection to the worker and environment from these relatively unknown materials.

General precautions that are to be taken when working with nanomaterials include:

- Materials with a known lower risk should be selected when able over unknown or higher risk materials. Lower risk materials include solid materials with embedded nanostructures or nanostructures affixed to the surface, nanoparticles suspended in liquid, dry dispersible nanoparticles, nanoparticle agglomerates, and nanoparticle aggregates.
- Engineering controls should be utilized to reduce the chance of exposure. Negative pressure gloveboxes, glove bags, hard-ducted BSCs, or chemical fume hoods should be used depending on the type and form of nanoparticle. It is preferred that exhaust from the ventilation equipment be cleaned/scrubbed by filters and released outdoors. HEPA filters should be used to filter air prior to release into the environment.
- At a minimum, non-permeable full-coverage shoes, long pants without cuffs, sleeved shirts, laboratory coats, eye/face protection, and gloves (nitrile at minimum) should be worn for work with nanomaterials.
- Housekeeping practices specific to the type of nanomaterial must be established prior to beginning work.
- All nanomaterials should be considered and disposed of as hazardous waste.

Hydrofluoric Acid

Hydrofluoric acid (HF) is a weak inorganic acid that causes deep, severe burns and toxic effects which if untreated, may be fatal. HF is used to etch glass, clean metal, and as a laboratory reagent. Depending on the concentration, symptoms of HF exposure may be delayed between 1 and 24 hours. When in contact with metals, hydrogen gas is generated, posing an explosion hazard.

Routes and Symptoms of Exposure

Skin Contact: Both the liquid and vapor can cause severe burns that may not be immediately painful or visible. The fluoride ion readily penetrates the skin, causing deep destruction of the tissue. Burns over the body totaling 25 square inches of surface area (approximately the size of the palm of your hand) may also cause hypocalcemia and other fatal toxic effects such as fluoride poisoning. Concentrations over 50% will cause immediate, severe, burning pain, and white discoloration of the skin preceding blister formation. Concentrations between 20-50% will not result in symptoms until 1 to 8 hours after exposure. Concentrations between 0 and 20% will not result in symptoms until up to 24 hours post exposure.

Eye Contact: Contact of liquid or vapor HF can cause irritation, eye burns, and destruction of the cornea.

Ingestion: HF ingestion causes severe mouth, throat, and stomach burns. Ingestion of small, dilute quantities of HF has caused profound and fatal hypocalcemia and systematic toxicity if not immediately treated.

Inhalation: Mild exposure to HF may result in delayed symptoms such as nose, throat, and respiratory system irritation. Severe exposure (LC50 = 5,100 ppm/5 min in rats) causes nose and throat burns, lung inflammation, pulmonary edema, hypocalcemia, and systemic toxicity.

Emergency Response

For all potential and known exposures to HF, immediate medical attention must be sought.

Skin: Remove victim from contaminated area and rinse effected area with copious quantities of water for 5 minutes while removing all effected clothing. Immediately apply 2.5% calcium gluconate gel via continuous massage into the area until medical personnel arrive. Work with hydrofluoric acid is NOT permitted without a readily available supply of 2.5% calcium gluconate gel in the immediate area of use. Immediate medical attention must be sought after exposure or potential exposure.

Eyes: Irrigate eyes in eyewash station for a minimum of 15 minutes. Medical attention must be sought.

Ingestion: Drink large amounts of water, milk, or milk of magnesia. Do NOT induce vomiting. Seek immediate medical attention.

Inhalation: Move victim to fresh air and keep calm while awaiting immediate medical attention. If breathing has stopped, start artificial respiration at once.

Spills: For any HF spills, the area must be evacuated and the spill immediately reported to EHS or MSU Police (after hours).

Guidelines for Storage of and Work with HF

- Regardless of the concentration of the stock solution, an in-date (1 year expiration) 2.5% calcium gluconate gel must be readily available in the HF working area.
- All personnel must be made aware of the hazards associated with HF, proper work procedures for the specific task, and exposure/emergency response (including location of 2.5% calcium gluconate gel, safety shower, and eye wash).
- The MSDS/SDS for HF must be printed off and easily located in the HF work area. The MSDS/SDS must be less than 5 years old.
- SOP’s must be created for all procedures involving HF that include emergency response protocols.

- Work must be conducted within a properly functioning chemical fume hood.
- Non-absorbent, full-coverage shoes, pants, laboratory coat, acid resistant apron, chemical splash goggles, full face shield, and either 2 pairs of nitrile or neoprene gloves for brief use of dilute solutions (under 20%) or nitrile or neoprene gloves under medium or heavyweight (minimum 22mil thickness)Viton, nitrile, or neoprene gloves. The type and amount of gloves required is dependent upon the concentration being used and the task being performed.
- Work must be conducted during normal working hours while other personnel are available to assist in emergency response.
- All HF solutions must be stored in polyethylene, Teflon, or other compatible materials (no glass or metal).
- HF must be stored in a compatible secondary containment tray.

Compressed Gases

All compressed gasses are hazardous and can create very dangerous working environments if not properly stored, handled, and utilized. The quantity of compressed gases should be kept to an absolute minimum and are subject to IFC maximum allowable quantities (MAQ's) for each fire zone.

There are three major types of compressed gases: liquefied, non-liquefied, and dissolved.

1. Liquefied gases are gases that can become liquids at normal temperatures when under pressure in a cylinder. The gases exist in a liquid-gas equilibrium in the cylinder. Liquefied gas cylinders must be stored in an upright position so that the pressure relief valve is in direct contact with the vapor/gas space of the container. Examples of liquefied gases include anhydrous ammonia, chlorine, propane, and carbon dioxide.
2. Non-liquefied gases are gases that do not become liquid at normal temperatures, regardless of the pressure. Common non-liquefied gases are oxygen, nitrogen, helium, and argon.
3. Dissolved gases are gases that are absorbed into a solvent to increase the stability of the gas. The only common dissolved gas is acetylene, which is dissolved in acetone. Dissolved cylinders must be stored in an upright position so that the pressure relief valve is in direct contact with the vapor/gas space of the container. The discharge pressure must be 15psig or less.

Storage Guidelines for Compressed Gases

Compressed gas tanks must be strapped to a stationary object at all times when not in transport.

- Compressed gas tanks should be secured to a fixed structure (wall or lab bench/ cabinet) by a chain or strap capable of holding the weight of the tank. The chain or strap must be located approximately ¾ the way up the tank and tight enough that rocking of the tank is not possible. Two chains or straps, located at the top and bottom of the tank, may be used as long as they prevent rocking of the tank.

- Only items designed and manufactured to store compressed gas tanks or I-hooks drilled directly into a wall stud or properly anchored can be used. C-clamps attached to bench tops are not appropriate for compressed gas storage.
- A maximum of 3 compressed gases can be chained or strapped together. Tanks must be positioned with at least one side touching a stationary object and the other sides touching another tank or secured by a chain or strap. If multiple tanks are chained or strapped together, the chain or strap must be attached to I-hooks properly secured to the wall or other fixed structure or to a compressed gas wall-mounted bracket.
- If a compressed gas tank storage rack is purchased, the number of tanks held within the rack cannot exceed the manufacturers' storage maximum.
- Items such as rope and bungee cords are not appropriate securing materials.
- These requirements apply to compressed gas storage and filling locations.

The protective cap must be in place when the tank is not in use.

- The protective cap or device must be tightly secured to the tank to protect the valve stem when the tank is not in use or in storage. A tank is considered to be in use if it is connected via an appropriate regulator to a piece of equipment or currently connected for use.

Transportation of compressed gases shall utilize a hand cart/ truck or other mobile device designed for the secure movement of compressed gas tanks or cylinders.

- Carts and trucks approved for moving compressed gas cylinders are designed so that the cylinder/tank are secured against dropping and striking against one another or other surfaces.
- The chains or straps on the hand carts or trucks must be utilized and should be tight against the body of the tank.
- Tanks should not be drug, carried, or transported on devices not designed for such use.

Additional information of proper storage locations and positioning of tanks.

- Compressed gas tanks cannot be stored in egress pathways.
- Compressed gas tanks should be segregated from incompatible materials, extreme temperatures (above 125ºF or below sub-ambient), falling objects, sources of ignition, or chemicals which could damage the integrity of the tank.
- Tanks should be stored and used in well ventilated locations.
- If outdoor storage is utilized, tanks must be protected from direct contact with soil or unimproved surfaces. The surface should be graded to prevent the accumulation of water.
- All tanks must be stored in an upright position, unless recommended by manufacturer.
- Full cylinders must be stored separately from empty cylinders. Empty cylinders should be picked up by the distributor as soon as possible.
- Cylinders should be used in the order in which they were received. Only the quantity of cylinders needed for current work should be kept. Unused cylinders and cylinders that have no indented future use must be returned to the vendor.

Cylinder Use Guidelines

- The hazard associated with each gas should be known and understood by all users.
- The hazards associated with using compressed gases with the equipment being used should be known, understood by all users, and written procedures should be followed to mitigate those risks.
- Only the approved CGA regulator for each specific gas may be used. Regulators must be attached prior to opening the gas cylinder valve.
- Do not force cylinder valve connections that do not fit. Thread sealer, Teflon tape, etc. must not be used on valve fittings.
- Open the cylinder slowly after being connected to the process. Check for leaks via an appropriate bubbling solution or gas detector.
- ‘Hard’ piping made of materials such as copper or stainless steel should be used whenever possible. Cast iron pipe and fitting should never be used.
- Teflon tape should be used only on pipe threads where the seal is made at the threads.
- If flexible tubing must be used, the tubing must be compatible with the properties of the gas in use and the tubing must remain ‘in sight’ (not through walls or ceilings). Flexible tubing cannot be used with toxic gases.

Compressed Gas Cylinder Information and Labels

- The shipping label on the shoulder of the tank must indicate the shipping name and identification number. Pure products will also have the grade assigned to the gas on the shoulder.
- The applicable DOT hazardous material placard(s) must be present on the label at all times.

Cryogenic Liquids

Cryogenic liquids, or cryogens, are gases at normal temperatures and pressures but liquids at low temperatures. Cryogens have a temperature roughly below –150°C and very low boiling points. When vented from compressed gas cylinders, cryogens release very cold vapors that condense into highly visible fog. Very small quantities of cryogens ‘boil off’ into very large volumes of gas.

There are four main hazards associated with cryogens.

1. Physical hazards such as contact burns and asphyxiation are prevalent when working with cryogens.
    - Contact burns are similar to heat burns in which contact can locally freeze and tear or remove skin and damage eye tissue. Due to the nature of cryogens low viscous nature, they will easily penetrate woven and other porous clothing material much faster than water. Touching materials that are kept at these low temperatures can also cause contact burns. The

following PPE should be worn while working with cryogens: full-face shield over safety glasses, loose-fitting thermal insulated (cryogenic) gloves, long sleeve shirt and/or laboratory coat, pants without cuffs, and full-coverage non-absorbent shoes. Cryogenic gloves are only intended for short-term contact, not immersion.

- Cryogens rapidly boil off at room temperature producing large quantities of gas relative to the liquid volume. The gas produces a fog cloud where the vapor is still cold, but expands far beyond the fog cloud. This large and rapid out-put of gas can easily cause asphyxiation of any personnel in the area, especially if the area is not well ventilated. Some gases will displace oxygen in the air. Cryogens should only be released in well ventilated areas.

Liquefied Gas	Boiling Point Centigrade	Volume Expansion to Gas (L)
Helium-3	-269.9	757 to 1
Helium-4	-268.9	757 to 1
Hydrogen	-252.7	851 to 1
Neon	-245.9	1438 to 1
Nitrogen	-195.8	696 to 1
Argon	-185.7	847 to 1
Oxygen	-183.0	860 to 1
Methane	-161.4	578 to 1
Nitrous oxide	-89.5	666 to 1
Carbon dioxide	-78 5(b)	553 to 1

2. Some cryogens are flammable gases, such as hydrogen, methane, and acetylene, and the flammable concentration of the gas can easily be reached when boiling-off if proper ventilation is not used. Liquid oxygen quickly creates oxygen-rich environments that can cause organic materials to react explosively in some situations. Flammable cryogenic gases and liquid oxygen must be used in intrinsically safe rooms with no flammable or combustible materials. Contact EHS for assistance in working with cryogenic oxygen and/or flammable gases.
3. Cryogens are under high pressure like all other compressed gases. It is vital that the pressure relief valve is working properly to allow venting of off-gases

produced during storage. On average, a 160 liter tank will vent ~2 liters of liquid a day, depending on storage conditions. Excessive venting or ice-build up on vessel wall may indicate an issue with the pressure relief valve. In this instance, the area should be evacuated, marked as hazardous, and the distributor should be contacted to remove the tank.

4. Due to the low temperatures, many materials cannot be used with cryogens. Rubber, plastic, and carbon steel become brittle and can break with minimal stress applied after being exposed to cryogens. Only use materials that are certified by the manufacturer for use with cryogenic materials. All cryogenic material containers must be properly ventilated.

CHEMICAL WASTE MANAGEMENT

Waste Management Responsibility

Hazardous waste may be generated from laboratory operations, construction, maintenance, and renovation activities, photo processing, and a variety of other activities at the University. The proper disposal of waste chemicals is of serious concern, and every effort must be made to do it safely and efficiently. The responsibility for the identification and proper management of waste chemicals within the University prior to pick-up by EHS rests with the individuals who have generated the waste.

Training

Annual training on hazardous waste management is required for all personnel that generate hazardous waste and/or are responsible for hazardous waste generation areas.

The P.I. is responsible for ensuring that all employees that generate hazardous waste receive the training annually.

EHS provides hazardous waste training in live sessions and online via MyCourses. Scheduled live sessions may be viewed and enrolled in at ehs.msstate.edu.

Procedures for Hazardous Waste Generators

The following summary provides a general overview of regulatory requirements applicable to hazardous waste generators.

1. **Waste Identification:** Hazardous waste includes materials that possess hazardous characteristics (e.g. toxic, ignitable, corrosive or reactive), or substances that are listed as hazardous waste by the Mississippi Department of Environmental Quality and the Environmental Protection Agency. EHS should be contacted if any questions arise as to whether a substance is regulated.
2. **Containers and Labeling:** Separate containers must be used for different types of chemical wastes and the container must be compatible with the waste contained. Only

compatible wastes can be consolidated. Empty containers in the lab can be reused for collecting hazardous waste provided that:

1. No material remains in the container that may be incompatible with the waste to be added.
2. The material of construction of the container is compatible with the waste to be added.

Any old label or marking on the container not indicative of the waste to be added should be completely removed or, at minimum, taped over or rendered illegible. Any chemicals spilled on the outside of the container must be immediately cleaned off. Containers that store hazardous waste must be properly and clearly labeled. Labels must include:

1. The words "Hazardous Waste";
2. The chemical names of constituents written-out with no abbreviations (e.g. "ethanol").

Accumulation & Storage

The U.S. Environmental Protection Agency (EPA) and the state of Mississippi regulations allow for two types of hazardous waste management areas: less than 90-day storage areas (90-day areas) and satellite accumulation areas (SAA). The 90-day storage areas are managed and maintained by EHS.

SAA must be established at or near the point of generation and remain under the control of the person generating the waste. SAAs must be clearly defined and posted with the sign “Hazardous Waste Satellite Accumulation Area.” EHS has “Hazardous Waste Satellite Accumulation” signs available upon approval of the proposed area and located in Appendix F. The following are requirements for SAA:

- A maximum of 55 gallons of hazardous waste or 1 quart of acutely hazardous waste (P-coded) may be accumulated at each SAA. Only one in-use container is allowed per type of waste. Hazardous waste containers must be tightly closed unless waste is actively being added to the container.
- If possible, hazardous wastes with liquids should be kept within secondary containment. In addition, containers of incompatible wastes must be kept segregated and stored in separate secondary containers.
- Bulk containers are available from EHS for cost efficient disposal of large quantities of waste. Containers in size ranging from 5 to 55 gallons are available upon request. Bulk containers will be properly labeled by EHS staff and the label must not be defaced or edited in any way by other MSU employees.
- Hazardous waste containers in SAAs must be labeled as described in the previous section (Procedures for Hazardous Waste Generators).
- Once a hazardous waste container is filled, the container must be removed from the satellite accumulation area within three business days. A bulk container is considered

full when the waste is 2 inches from the top of the container. EHS provides a hazardous waste pick-up service for waste ready for disposal. Hazardous waste pick-up can be requested online at: ehs.msstate.edu or by calling the Environmental Health & Safety Office at (662-325-3294). An account number to which disposal cost will be charged must be submitted with the pick-up request.

Hazardous Waste Site Inspections

Hazardous waste areas (satellite accumulation areas and 90-day storage areas) must be inspected on a weekly basis. Personnel managing satellite accumulation areas are responsible for conducting their area's weekly inspections. EHS personnel will conduct unannounced inspections of SAA.

Guidelines for Waste Reduction

A plan for the disposal of all waste should be developed and approved prior to purchasing chemicals or the initiation of a project. Disposing of large quantities of waste can be very costly. It is in everyone's best interest to keep quantities of waste to a minimum.

The following suggestions may help to reduce the quantity of waste:

- Order only the amount of material you need for your project or experiment even if you can get more quantity for the same money.
- Use only the amount of material that is needed for conclusive results.
- Avoid storing excess material, particularly if it is an extremely toxic or flammable material, as this often only adds to the waste stream. The most common laboratory waste from MSU is unopened/ unused chemicals.
- Before disposing of unopened, uncontaminated chemicals check with others in your department and with EHS for assistance in finding others who may be able to use them.
- Upon termination of a research project or completion of a thesis/dissertation, all unused chemicals that have no intended use should be disposed of as hazardous waste.
- Make sure all samples and products to be disposed of are properly identified, labeled with its chemical name or contents, and containerized. Do not leave them for others to clean up after you.

Empty Containers

Empty metal or plastic chemical containers may be disposed of as ordinary trash or empty glass chemical containers may be disposed of in a broken glass box if:

- All material has been removed.
- A container which held a potential P-coded (acutely hazardous) waste must be triple rinsed or cleaned by a tested, approved method.

- Pesticide containers must be triple rinsed before disposal. The pesticide rinsate may be tank mixed and applied as a form of disposal. If application is not an option, the rinsate should be collected and disposed of as a hazardous waste.
- Containers that contained corrosive materials must be rinsed prior to disposal.

Disposal Procedures for Specific Materials

- **Gas cylinders** are to be returned to the supplier. Some small lecture bottles are non-returnable, which become a disposal problem when empty or near empty with a residual amount of gas. The Environmental Health & Safety Office will arrange for disposal of lecture bottles. However, the Principal Investigator/Lab Group is responsible for the cost of disposal.
- **Controlled drugs** to be discarded ***cannot be disposed of as hazardous waste.*** The handling and records of controlled drugs are the responsibility of the Department, Laboratory, or Center involved operating within the Drug Enforcement Agency (DEA) regulations. However, the Environmental Health & Safety Office will provide assistance with the disposal process.
- **Broken glass or sharp objects** that do not contain radioactive materials, bio-hazardous materials, or regulated chemicals should be placed in a puncture-resistant disposal box. When the box is full, the lid should be taped shut and can then be disposed of as ordinary trash in a MSU owned dumpster. Laboratory personnel are responsible for carrying the box to the dumpster. These boxes should not be placed in the hallway for custodial staff to handle.
- **Used Oil** is oil that is not contaminated with regulated RCRA materials and that is free of PCB materials. Used oil refers to used petroleum products and includes motor oil, hydraulic fluid, vacuum pump oil, etc. It should be placed in a container that must be tightly sealed and labeled “Used Oil”. Containers of 5 gallons or less will be collected by EHS personnel and disposed of at no charge. Containers larger than 5 gallons will have disposal fees associated with their disposal. Users generating large quantities of used oil may utilize drums or tanks for collection that must be labeled “Used Oil”. All used oil containers must be keep closed at all times unless oil is being added. The area around these drums or tanks must be keep clean at all times and any spillage of used oil must be cleaned up immediately. It is recommended that drums be stored in a covered area if outside, to prevent rainwater from accumulating in the drum. Used oil recyclers will not accept used oil that has become mixed with water and the drum or tank would then be considered and be disposed of as hazardous waste. It is recommended that tanks utilized to collect used oil be less than 660 gallons. If tanks larger than 660 gallons are needed, EHS personnel must be contacted for additional regulations.

Universal Waste Disposal

Universal waste materials are common commercial items that contain hazardous materials and must be disposed of properly in accordance with RCRA regulations. Following are the two common universal waste streams on campus:

- **Batteries (excluding non-rechargeable alkaline batteries)** Batteries subject to the universal waste regulations include lead-acid (Pb-acid) batteries, lithium (Li-ion) batteries, nickel-metal hydride (NiMH), silver oxide batteries, nickel-cadmium (NiCd) batteries and mercury-containing (Hg) batteries. Batteries are recycled by a third party.
    - For disposal of batteries contact the Environmental Health & Safety Office. You can do this by submitting an online hazardous waste pickup request ehs.msstate.edu or calling the office at (662-325-3294).
- **Fluorescent bulbs that contain mercury vapor** Bulbs that have green tips or green writing are mercury-free and can be disposed of as ordinary trash. Older fluorescent lamps (i.e., without green tips or green writing) and high intensity discharge (HID) lamps will containing mercury vapor and must be disposed of as universal waste.
    - For disposal of fluorescent bulbs please contact MSU Facilities Management at (662-325-2005).

LABORATORY SAFETY REVIEWS

Each laboratory should be reviewed annually by the laboratory PI and staff or in conjunction with EHS staff. The reviews help PI's ensure that prudent controls are in place for the hazards present in their laboratories in order to provide a safe working environment. The laboratory safety reviews cover prudent practices, fire code regulations, and recommendations based on other government safety agencies. A brief list of items that are included in the safety reviews are included below. The full laboratory safety review checklist and details on all recommendations can be found at ehs.msstate.edu.

- Engineering controls such as chemical fume hoods, BSCs, glove boxes, and laminar flow hoods should be inspected and certified on a periodic basis.
- Ventilation equipment should not be used for storage of any kind while in use.
- A broken glass box should be present and properly utilized in all laboratories that work with glassware.
- A sharps container should be present and properly labeled utilized in all laboratories that work with or produce sharps.
- MSDS/SDS should be present and readily available in all laboratories that contain or work with chemicals.
- Chemical bottles must be properly labeled at all times.
- Chemical bottles must be securely closed when not in use.
- Flammable materials should be stored in a UL approved safety cabinet or can.

- Flammable and explosion proof refrigerators and freezers must be used to store flammable and explosive materials that are required to be stored at low temperatures.
- Chemicals are stored based on chemical compatibility and in appropriate locations.
- There is a clear area of 18” around sprinkler heads or 24” from non-sprinkled ceilings.
- Fire and smoke doors are kept closed unless held open by alarm deactivating magnets.
- Egress pathways are maintained and the floors are clear of any slip, trip, and fall hazards.
- Clean up supplies for spills likely to occur in each laboratory are present.
- A first aid kit is present and up to date in each laboratory.
- Emergency contact information is posted on each laboratory door.
- Eyewash and emergency showers are present, labeled, tested, and easily accessible.
- Food and drink are absent from all laboratory areas.
- Laboratories are clean, uncluttered, and well organized. Garbage is properly disposed of.
- Compressed gas cylinders are secured to stationary objects and are segregated from other chemicals and incompatible gases.
- The proper PPE for the hazards in the laboratory are readily available and laboratory personnel are trained on their use.

EMERGENCY RESPONSE

Accidents can happen at any time and to anyone when working with or around hazardous materials. It is important that all personnel be aware of the proper emergency response procedures. All personnel should know how to report an incident, the location and proper use of safety equipment (safety showers, eye washes, fire extinguishers, and first aid kits), the location of spill kits/control supplies, rally points during building evacuations, and all available exits for evacuation purposes. The following equipment should be present in or near all areas that work with or store hazardous chemicals and other pertinent hazards:

- **Emergency Safety Shower and Eyewash Station:** Safety showers and eyewash stations must be present in any location in which the eyes and/or body of any person may be exposed to injurious chemicals. Safety showers and eyewash stations must be present on the same level as the hazard and the path of travel must be free of obstructions and within 10 seconds (immediate access). If a door is between the hazard and the shower, the door must open in the same direction of travel or it is considered to be an obstruction. An area no less than 36 in^2 (3 ft$^{2)}$ must be clear of all obstructions around the safety shower and eyewash station. The area(s) must be well lit and labeled via a highly visible sign.
    - Emergency safety showers should be used for chemical contact or fire to the body. Affected clothing must be removed as soon as possible.
    - Emergency eyewash stations should be used for any foreign material (solid, liquid, vapor, or mist) in the eye. Eyelids must be lifted and kept open while the victim moves the eyeballs around to ensure adequate washing of the eye. This

must occur for a minimum of **15 minutes**. Portable eyewash bottles are only meant to provide extra time for the victim to reach a plumbed eyewash station.

- **First Aid Kit:** A first aid kit should be present in each work area to address minor cuts, scrapes and other injuries. A basic first aid kit should include: absorbent compress, adhesive bandages, adhesive tape, antiseptic, sterile pads, triangular bandages, and gloves. No expired materials or ingestible medications are permitted to be located in a first aid kit.
- **Small-Spill Containment/Clean-Up Kit**: Each area should have materials present to assist in containing and cleaning up small spills. Only trained personnel should clean up spills and EHS should be notified of all chemical, biological, and radiological spills. Clean-up and containment materials must be disposed of according to hazardous waste procedures outlined in this manual. Items for the spill kit can include items such as paper towels, hand broom and dust pan, and tongs or forceps.

TRAINING

Training is a critical component of working safely with and around chemicals in any setting. There are two levels of training: general awareness and area/task/chemical specific. General awareness training is available from Environmental Health & Safety; area/task/chemical specific training should be completed by the supervisor prior to work or potential exposure. Additional training should be provided to all affected employees when a new hazard or increased hazard is introduced to the work area. All training events should be documented (See Appendix E for sample area/task/chemical specific training forms). Supervisors are responsible for maintaining training records of area/task/chemical specific training. EHS is responsible for maintaining training records of all general awareness training sessions. Employees may view their EHS training records at *ehs.msstate.edu* .

Required general awareness training includes Hazardous Waste Training (see Chemical Waste Management, Training on page 35). Recommended general awareness training for:

- Laboratory Workers:
    - Introduction to Laboratory Safety
    - Hazard Communication
    - Risk Assessment & Management Workshop
    - Laboratory Safety Refresher (Annual)
- Chemical Users:
    - Hazard Communication
    - Risk Assessment & Management Workshop

Additional information and dates for all EHS general awareness training courses is available at www.ehs.msstate.edu.

DEPARTMENT AND LABORATORY SPECIFIC SOP'S

Standard Operating Procedures (SOP's) are a set of written instructions that document a routine or repetitive activity followed by a group. SOP's detail regular work processes to facilitate consistent conformance, minimize variation, and promote quality. The benefits of well written and followed SOP's include reduced work effort, improved comparability, credibility, and legal defensibility. Work with all hazardous materials should be outlined in SOP's that cover the associated hazard, procedures in which the hazard is involved, mitigation steps, emergency response, and procedure details. SOP's should be written by individuals' knowledgeable with the activity, University policies and recommendations, and the risk associated with the hazard. The SOP must contain enough detail so that someone with a basic understanding of the procedure or hazard could successfully reproduce the procedure safely and unsupervised.

Periodic review of SOP's is required to ensure that the information is up-to-date and that appropriate steps have been taken to mitigate risk. Review and revisions of SOP's should be recorded on the SOP. Checklists may be developed to as a part of the SOP to assist users in completing long or complex procedures. Each individual who performs a procedure should document or sign that they are aware and understand the procedure detailed in the SOP.

SOP's are not intended to be used as a substitute for training or mentoring. They are to be used to establish baseline behaviors and enhance consistency and safety when working with hazardous substances.

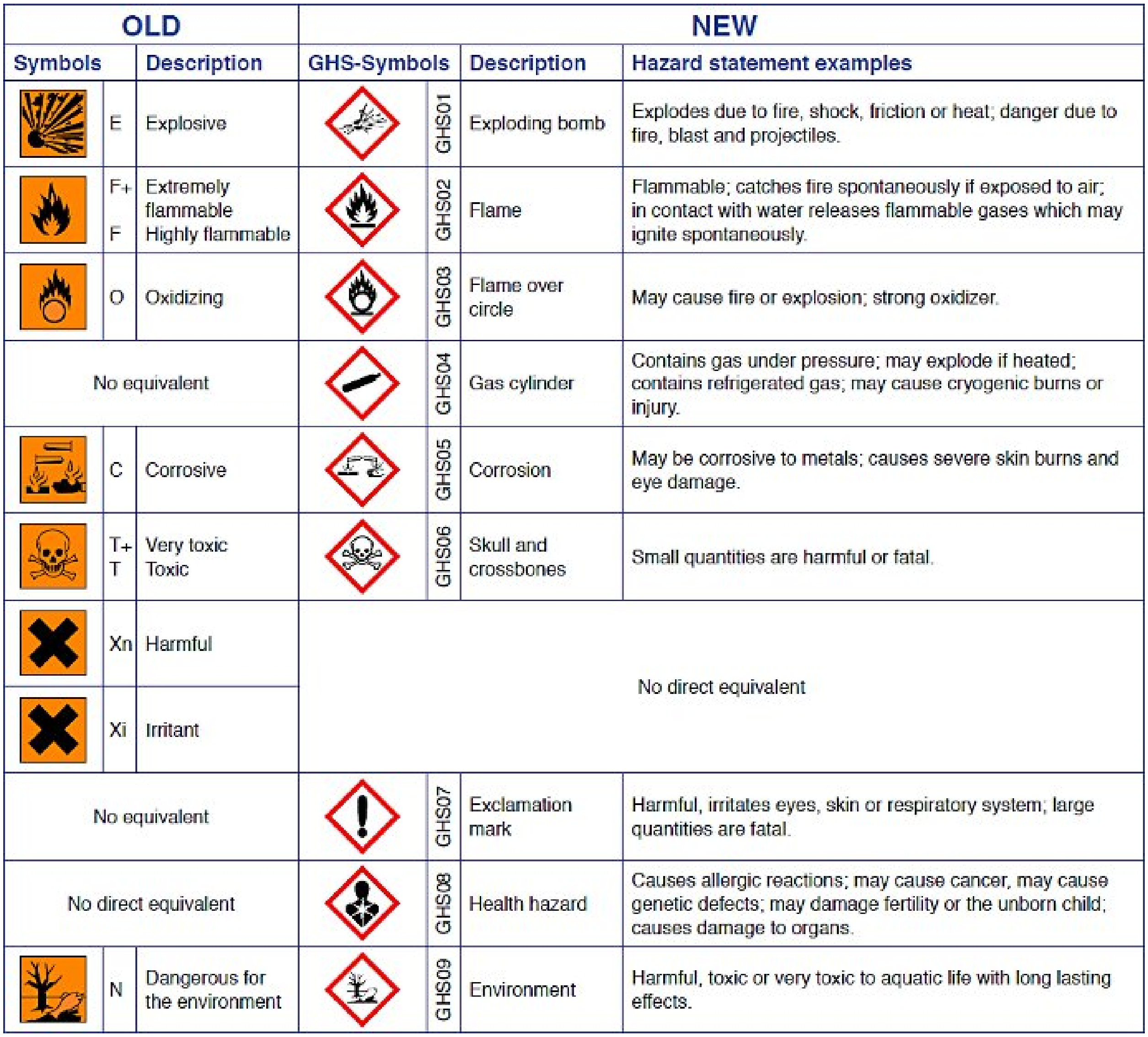
Departments and individual laboratories should develop SOP's for the specific hazards in their work areas to be used as a part of the guidelines and regulations defined in this manual. EHS can assist personnel in conducting risk assessments and developing SOP's.

APPENDIX A

The Globally Harmonized System of Classification and Labeling of Chemicals

Global Harmonization System (GHS) Hazard Symbols

In 2012, OSHA adopted the Globally Harmonized System of Classifying and Labeling of Chemicals (GHS) Standard which provides a harmonized system of classifying and labeling chemicals and consistency in Safety Data Sheets. The chart below shows the 'old' OSHA chemical symbols (orange hazard squares) and the new 'GHS' symbols. Manufactures have until December 2014 to ship chemicals with the new chemical labels.



OLD			NEW			
Symbols		Description	GHS-Symbols		Description	Hazard statement examples
	E	Explosive		GHS01	Exploding bomb	Explodes due to fire, shock, friction or heat; danger due to fire, blast and projectiles.
	F+ F	Extremely flammable Highly flammable		GHS02	Flame	Flammable; catches fire spontaneously if exposed to air; in contact with water releases flammable gases which may ignite spontaneously.
	O	Oxidizing		GHS03	Flame over circle	May cause fire or explosion; strong oxidizer.
No equivalent				GHS04	Gas cylinder	Contains gas under pressure; may explode if heated; contains refrigerated gas; may cause cryogenic burns or injury.
	C	Corrosive		GHS05	Corrosion	May be corrosive to metals; causes severe skin burns and eye damage.
	T+ T	Very toxic Toxic		GHS06	Skull and crossbones	Small quantities are harmful or fatal.
	Xn	Harmful	No direct equivalent			
	Xi	Irritant				
No equivalent				GHS07	Exclamation mark	Harmful, irritates eyes, skin or respiratory system; large quantities are fatal.
No direct equivalent				GHS08	Health hazard	Causes allergic reactions; may cause cancer, may cause genetic defects; may damage fertility or the unborn child; causes damage to organs.
	N	Dangerous for the environment		GHS09	Environment	Harmful, toxic or very toxic to aquatic life with long lasting effects.

All of symbols are the same or similar with the exception of the orange and black hazard X which has been discontinued. Denoting health hazards other than acute toxics (skull and crossbones pictogram) is now denoted by the exclamation mark (mostly reversible damage) or the health hazard pictogram (non-reversible damage).

The GHS standard divides chemical hazards into two main groups: health hazards and physical hazards. Presented below is the classes and categories for the health hazards and physical hazards. Descriptions of each class, category, and pictogram (if applicable) are included.

Health Hazards

Hazard Class	Hazard Category			
Acute Toxicity	1	2	3	4
Skin Corrosion/ Irritation	1A	1B	1C	2
Serious Eye Damage/ Eye Irritation	1	2A	2B	
Respiratory or Skin Sensitization	1A	1B		
Germ Cell Mutagenicity	1A	1B	2	
Carcinogenicity	1A	1B	2	
Reproductive Toxicity	1A	1B	2	Lactation
STOT – Single Exposure	1	2	3	
STOT – Repeated Exposure	1	2		
Aspiration	1			
Simple Asphyxiants	Single Category			

Acute Toxicity

Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance or multiple doses give within 24hr or an inhalation of 4 hrs. Acutely toxic chemicals are allocated into 4 categories (see chart below) based upon the LC50 (Concentration in air (inhalation) in which 50% of the experimental animals died) or LD50 (Concentration via oral or dermal exposure that 50% of the experimental animals died). All categories, 1-3, have the ‘Skull and Crossbones’ pictogram. Category 4, the least severe, has the ‘Exclamation Mark’ pictogram.

Table A.1.1: Acute toxicity hazard categories and acute toxicity estimate (ATE) values defining the respective categories

Exposure route	Category 1	Category 2	Category 3	Category 4
Oral (mg/kg bodyweight) *see: Note (a)* *Note (b)*	≤ 5 ☠	>5 and ≤ 50 ☠	>50 and ≤ 300 ☠	>300 and ≤ 2000 ❗
Dermal (mg/kg bodyweight) *see: Note (a)* *Note (b)*	≤ 50 ☠	>50 and ≤ 200 ☠	>200 and ≤ 1000 ☠	>1000 and ≤ 2000 ❗
Inhalation - Gases (ppmV) *see: Note (a)* *Note (b)* *Note (c)*	≤ 100 ☠	>100 and ≤ 500 ☠	>500 and ≤ 2500 ☠	>2500 and ≤ 20000 ❗
Inhalation - Vapors (mg/l) *see: Note (a)* *Note (b)* *Note (c)* *Note (d)*	≤ 0.5 ☠	>0.5 and ≤ 2.0 ☠	>2.0 and ≤ 10.0 ☠	>10.0 and ≤ 20.0 ❗
Inhalation – Dusts and Mists (mg/l) *see: Note (a)* *Note (b)* *Note (c)*	≤ 0.05 ☠	>0.05 and ≤ 0.5 ☠	>0.5 and ≤ 1.0 ☠	>1.0 and ≤ 5.0 ❗

Skin Corrosion/Irritation

Skin Corrosion is defined as the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis following the application of a test substance for up to 4 hours. A chemical is defined as a category 1A skin corrosive if an exposure of 3 minutes or less results in observed damage within 1 hour. A category 1B skin corrosive is an exposure between 3 minutes and 1 hour that results in observed damage in less than 14 days. Category 1C are chemicals that when exposed to the skin for between 1 and 4 hours result in damage in less than 14 days. Categories 1A – 1C are represented by the ‘Corrosive’ pictogram.

A **Skin Irritant**, or Category 2 Skin Corrosion/Irritant, is defined as the production of reversible damage to the skin following the application of the test substance for up to 4 hours. It is represented by the ‘Exclamation Mark’.

Serious Eye Damage/ Eye Irritation

Serious Eye Damage and Eye Irritation are very similar to Skin Corrosion and Irritation. **Serious Eye Damage,** Category 1, is defined as the production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not reversible within 21 days. **Eye Irritant** is defined as the production of changes in the eye following the application of a test substance which are reversible within 21 days (Category 2A). Category 2B indicates damage to the eye that is fully reversible within 7 days. Both Category 1 and 2A are represented by the ‘Corrosive’ pictogram and category 2B has no pictogram.

Respiratory or Skin Sensitization

A **Respiratory Sensitizer** means a chemical that will lead to hypersensitivity of the airways following inhalation. A **Skin Sensitizer** means a chemical that will lead to an allergic reaction following skin contact. For both respiratory and skin sensitizers, Category 1A indicates a high frequency of occurrence in humans or the probability of occurrence based on animal and other tests. Category 1A is represented by the ‘Health Hazard’ pictogram. Category 1B indicates low to moderate frequency in humans or the probability of occurrence based on animal and other tests. Category 1B is represented by the ‘Exclamation Mark’ pictogram.

Germ Cell Mutagen

Germ Cell Mutagens are represented by the ‘Health Hazard’ pictogram. A **mutagen** is defined as a permanent change in the amount of structure or genetic material in a cell. This hazard class is primarily concerned with chemicals that may cause mutations in germ cells of humans that can be transmitted to the progeny. However, mutagenicity/genotoxicity tests *in vitro* and tests in mammalian somatic cells *in vivo* are also considered in classifying substances in this class. Class 1A are substances known to induce heritable mutation in the germ cells of humans. Class 1B are substances which should be regarded as if they induce heritable mutations in the germ cells of humans. Class 2 are substances which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans.

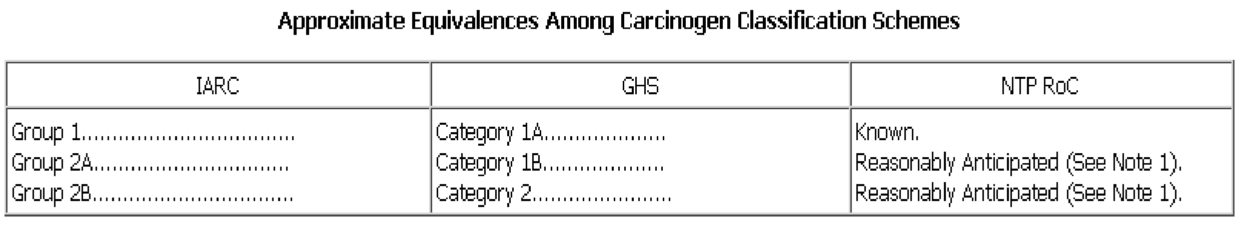
Carcinogen

A **carcinogen** is defined as a substance or a mixture of substances which induce cancer or increase its incidence. The categories for cancer are unlike the other health hazard classes in which they only define if the substance poses a cancer hazard, not the severity of the cancer risk.

Category 1A are known or presumed human carcinogens based largely on human evidence. Category 1B are known or presumed human carcinogens based largely on animal evidence. Category 2 carcinogens are suspected to be human carcinogens.

All three classes are represented by the ‘Health Hazard’ pictogram.

There are several entities that have ratings for carcinogens that you may be more familiar with: the International Agency for Research on Cancer (IARC) and the National Toxicology Program’s Report on Carcinogens (NTP RoC). This chart shows all three grouping systems, at least in part. For the most part, the ranking systems are similar in their classifications and the hazard communication standard recommends that manufacturers refer to both IARC and NTP RoC for guidance on classifying carcinogens.



Approximate Equivalences Among Carcinogen Classification Schemes

IARC	GHS	NTP RoC
Group 1...................................	Category 1A...................	Known.
Group 2A................................	Category 1B...................	Reasonably Anticipated (See Note 1).
Group 2B................................	Category 2......................	Reasonably Anticipated (See Note 1).

Reproductive Toxins

Reproductive toxicity includes adverse effects on sexual function and fertility in adult humans as well as effects on development of offspring. Category 1A are known human reproductive toxicants. Category 1B are presumed human reproductive toxicants. And Category 2 are suspected human reproductive toxicants. All three classes are represented by the 'Health Hazard' pictogram. The GHS standard added a new category, Lactation. Chemicals are listed as a lactation hazard if the chemical is absorbed by women and have been shown to interfere with lactation or may be present (including metabolites) in breast milk in sufficient amounts to cause concern for the child. There is no pictogram for lactation.

Specific Target Organ Toxicity

Specific Target Organ Toxicity Single Exposure (or STOT-SE) means specific, non-lethal target organ toxicity arising from a single exposure to a chemical. Specific Target **Organ Toxicity Repeated Exposure (or STOT-RE)** means specific target organ toxicity arising from repeated exposure to a substance or mixture. There are 3 categories for STOT-SE chemicals and 2 for STOT-RE chemicals. Category 1 for both classes are defined as substances that have produced significant toxicity in humans, or that, on the basis of evidence from studies in experimental animals can be presumed to have the potential to produce significant toxicity in humans following exposure (single or repeated). Category 2 for both classes are defined as substances that, on the basis of evidence from studies in experimental animals can be presumed to have the potential to be harmful to human health following exposure (single or repeated). Both Categories 1 and 2 are represented by the 'Health Hazard' pictogram. Category 3 is for STOT-SE only and indicates that the substances adversely alter human function for a short duration after exposure and from which humans recover in a reasonable period of time without leaving significant alteration in structure or function. Category 3 chemicals include those with narcotic effects and respiratory tract irritation and are represented by the 'Exclamation Mark' pictogram.

Aspiration

Aspiration means the entry of a liquid or a solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system. Aspiration toxicity includes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. This may have consequences for labeling, particularly where, due to acute toxicity, a recommendation may be considered to induce vomiting after ingestion. However, if the substance/mixture also presents an aspiration toxicity hazard, the recommendation to induce vomiting may need to be modified. Aspiration hazards are represented by the 'Health Hazard' pictogram.

Simple Asphyxiant

Simple asphyxiant means a substance or mixture that displaces oxygen in the ambient atmosphere, and can thus cause oxygen deprivation in those who are exposed, leading to unconsciousness and death. There is no pictogram for asphyxiants.

Physical Hazards

Hazard Class	**Hazard Category**						
Explosives	**Unstable Explosives**	**Div 1.1**	**Div 1.2**	**Div 1.3**	**Div 1.4**	**Div 1.5**	**Div 1.6**
Flammable Gases	**1**	**2**					
Flammable Aerosols	**1**	**2**					
Oxidizing Gases	**1**						
Gases under Pressure Compressed Gases Liquefied Gases Refrigerated Liquefied Gases Dissolved Gases	**1**						
Flammable Liquids	**1**	**2**	**3**	**4**			
Flammable Solids	**1**	**2**					
Self-Reactive Chemicals	**Type A**	**Type B**	**Type C**	**Type D**	**Type E**	**Type F**	**Type G**
Pyrophoric Liquids	**1**						
Pyrophoric Solid	**1**						
Pyrophoric Gases	**Single category**						
Self-heating Chemicals	**1**	**2**					
Chemicals, which in contact with water, emit flammable gases	**1**	**2**	**3**				
Oxidizing Liquids	**1**	**2**	**3**				
Oxidizing Solids	**1**	**2**	**3**				
Organic Peroxides	**Type A**	**Type B**	**Type C**	**Type D**	**Type E**	**Type F**	**Type G**
Corrosive to Metals	**1**						

Explosive

An **Explosive** is a solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature, pressure, and speed as to cause damage to the surroundings. There are 7 categories of explosives. Unstable explosives are explosives which are thermally unstable and/or are too sensitive for normal handling, transport, or use. Division 1.1 explosives have a mass explosion hazard and Division 1.4 present only a small hazard in the event of ignition or initiation. Unstable explosives to Division 1.4 are represented by the 'Explosive' pictogram. Division 1.5 and 1.6 and are classified as Very and Extremely Insensitive, respectively, and have no pictogram.

Flammable Gases

Flammable Gases are gases that have a flammable range at normal temperatures and pressures (NTP; 68^{0}F and 14.7psi). Category 1 are gases at NTP are ignitable in a mixture of 13% or less by volume in air or the flammable range is at least 12% points. Category 2 flammable gases are gases, other than Category 1, which at NTP have a flammable range while mixed in air. Category 1 is represented by the 'Flammable' pictogram; Category 2 has no pictogram.

Flammable Aerosols

Flammable Aerosols, also represented by the 'Flammable' pictogram, are any non-refillable receptacle containing flammable gas which are compressed, liquefied, or dissolved under pressure, and fitted with a release device allowing the contents to be ejected as particles in suspension in a gas, or as a foam, paste, powder, liquid or gas. Category 1 contains 85% or more flammable components. Category 2 contains 1% or more flammable components.

Oxidizing Gases

Oxidizing Gases, represented by the 'Oxidizer' pictogram, are any gas which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does.

Gases Under Pressure

Gases Under Pressure are gases which are contained in a receptacle at a pressure of 200kPA (29psig) or more or which are liquefied and/or liquefied and refrigerated. All are represented by the new 'Gas Cylinder' pictogram.

Flammable Liquids

It is important that we understand flash points to understand the definition of flammable liquids. A **flash point** is the lowest temperature in which sufficient concentration of vapors are given off to form an ignitable mixture in air near the surface of the liquid. In the chart below, flash point is represented by 'FP' and boiling point is represented by 'BP'.

OSHA defines **flammable liquids** as liquids having a flash point of not more than 199.4˚F and have divided flammable liquids into 4 categories. Like all of the other hazards, a rating of 1 is the most hazardous and the severity of the hazard decreases as the number increases. This is important to note because another system that is very commonly used for flammability (among other ratings) is the National Fire Protection Association (NFPA) hazard diamond which has a rating of 4 being the most hazardous and 0 as the least hazardous. The International Fire Code (IFC), which MSU falls under, is also another commonly used rating system for chemicals. Due to the fact that all 3 systems are or will be commonly used, all three systems are discussed in terms of flammable liquids because they differ the most for flammable liquids.

OSHA Category 1 flammable liquids have a flash point less than 73.4˚F and a boiling point less than or equal to 95˚F. OSHA Category 1 is equivalent to NFPA rating 4 and IFC IA. OSHA Category 2 flammable liquids have a flash point less than 73.4˚F and a boiling point greater than to 95˚F. This is equivalent to NFPA 3 (depending on flash point and boiling point), and IFC IB. OSHA Category 3 flammable liquids have a flash point greater than or equal to 73.4˚F and less than or equal to 140˚F. Category 3 is equivalent to NFPA 3 or 2 (depending on flash point), and IFC IC or II (Category II is a 'combustible liquid'). OSHA Category 4 flammable liquids have a flash point greater than 140˚F and less than or equal to 199.4˚F and is equivalent to NFPA rating 2 and IFC IIA. There is no OSHA equivalent to NFPA rating 1 or IFC IIB, but they are equivalent to each other. OSHA Category 1-3 are all represented by the 'Flammable' Pictogram.

It is of vital important to remember that the severity of the fire hazard is dependent upon the organizations' category being used in each situation. Other chemical classifications such as oxidizers and water reactive chemicals have similar discrepancies between hazard rating systems. It is critical to take note of the system being used when evaluating hazards.

Flammable Liquid Comparison Chart

Hazard Category	GHS/OSHA	NFPA 	IFC
1	FP < 73.4˚F & BP ≤ 95˚F 	FP >200˚F	**IA:** FP < 73˚F & BP ≤ 100˚F **IB:** FP <73˚F & BP ≥ 100˚F **IC:** FP ≥73˚F & <100˚F
2	FP <73.4˚F & BP > 95˚F 	FP ≥100˚F & ≤200˚F	**II:** FP ≥100˚F & <140˚F **IIA:** FP ≥140˚F & <200˚F **IIB:** FP ≥200˚F
3	FP ≥73.4˚F & ≤ 140˚F 	FP <73 ˚F & BP ≥100˚F **OR** FP ≥73˚F & <100˚F	
4	FP > 140˚F & ≤199.4˚F	FP < 73 ˚F & BP ≤ 100˚F	

Flammable Solids

Flammable Solids are solids which are readily combustible or may cause or contribute to fire through friction. They are categorized based on a burning rate test in which a Category 1 solid has a burning time greater than 45s or a burning rate greater than 2.2mm/s, is not stopped by wetting, or is a metal powder with a burning time less than or equal to 5 minutes. Category 2 solids have a burning time greater less than 45s or a burning rate greater than 2.2mm/s, burning is temporarily stopped by wetting, or is a metal powder with a burning time between 5 and 10 minutes. Both categories are represented by the ‘Flammable’ pictogram.

Self-Reactive Chemicals

Self-Reactive Chemicals are thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen/air. There are 7 categories of self-reactive chemicals:

Type A will detonate or deflagrate rapidly as packaged and is represented by the ‘Explosive’ pictogram.
Type B possesses explosive properties when the chemical as packaged cannot detonate, deflagrate, or undergo a thermal explosion in that package and is represented by both the ‘Flammable’ and ‘Explosive’ pictograms.
Type C – F are represented by the ‘Flammable’ pictogram and continue to decrease in explosive properties and power.
Type G has no pictogram and in laboratory testing, will not detonate in its current state, has no explosive power when heated under confinement.

Pyrophoric Liquids and Solids

Pyrophoric liquids and solids are able to ignite within 5 minutes after coming into contact with air, even in small quantities. Pyrophorics are represented by the ‘Flammable’ pictogram.

Self-Heating Chemicals

Self-Heating Chemicals are liquid or solids, other than a pyrophoric chemicals, which by reaction with air and without energy supply, are liable to self-heat. These differ from pyrophorics in that large amounts of the material are needed and it takes long periods of time for the reaction to produce heat. The 2 Categories are based upon testing procedures; Category 1 yields positive heating results with a much smaller sample (25mm cube) than Category 2 ($3m^3$). Self-heating chemicals are represented by the ‘Flammable’ pictogram.

Chemicals which, in contact with water, emit flammable gases

Chemicals which, in contact with water, emit flammable gases are what is commonly referred to as ‘water reactive’ chemicals. These are liquids or solids that by interaction with water, are liable to become spontaneously flammable or to give of flammable gases in dangerous quantities. All 3 categories are represented by the ‘Flammable’ pictogram. Category 1 is any chemical which reacts vigorously with water at ambient temperatures and demonstrates a general tendency for the gas produced to ignite spontaneously, or which reacts readily with water at ambient temperatures such that the rate of evolution of flammable gas is equal to or greater than 10L/kg of chemical over any one minute. Category 2 is similar to that of Category 1 with the exception that it does not react vigorously and emits flammable gases at a slower rate (20L/kg of chemical/hr.). Category 3 react slowly with water at ambient temperatures and the maximum rate of flammable gas emitted is greater that 1L/kg of chemical/hr.

Oxidizing Liquids and Solids

A **Oxidizing liquid or solid** is defined as a chemical, while in itself is not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material. The category of oxidizers is determined by the burning rate of cellulose when an equal mass of the chemical is added. The faster the burning rate the lower the rating (1). All 3 categories are represented by the ‘Oxidizer’ pictogram.

Organic Peroxides

Organic peroxides are liquid or solid organic chemicals which contains a bivalent -0-0- structure where one or both of the hydrogen atoms have been replaced by organic radicals. Organic peroxides are thermally unstable chemicals which may undergo exothermic self-accelerating decomposition and may be liable to burn rapidly, explosive decomposition, sensitive to impact and friction, and/or react dangerously with other substances. The categories of organic peroxides are much like that of self-reactive chemicals.

Type A, as packaged, can detonate or deflagrate rapidly and is represented by the ‘Explosive’ pictogram.

Type B possesses explosive properties when the chemical as packaged cannot detonate, deflagrate, or undergo a thermal explosion in that package and is represented by both the ‘Flammable’ and ‘Explosive’ pictograms.

Type C – F are represented by the ‘Flammable’ pictogram and continue to decrease in explosive properties and power. Type C – F are represented by the ‘Flammable’ pictogram and continue to decrease in explosive properties and power.

Type G has no pictogram and in laboratory testing, will not detonate in its current state, has no explosive power when heated under confinement.

It is important to store organic peroxides properly and not keep them for periods longer than what is listed on the safety data sheet (usually 6-12 months from the date opened, if not sooner).

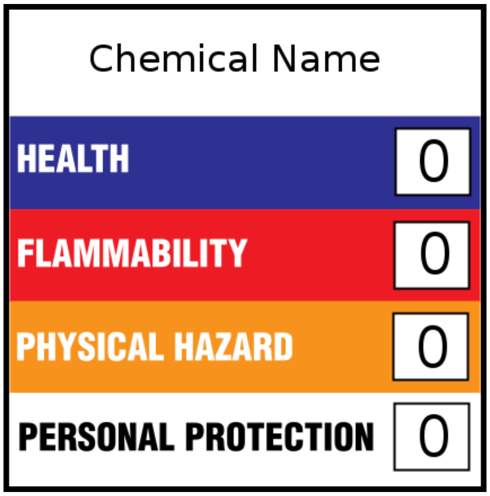
Corrosive to Metals

Corrosive to Metals are chemicals that by chemical action will materially damage or destroy metals and is represented by the ‘Corrosive’ pictogram. This is the only time you will see the ‘Corrosive’ pictogram for a physical hazard; all other times it represents health hazards.

APPENDIX B

Hazardous Materials Identification System (HMIS) Rectangle

The HMIS rectangle was developed by the National Paint & Coatings Association (NPCA) to help employers comply with OSHA's Hazard Communication Standard (HCS; 29 CFR 1910.1200). HMIS® attempts to convey full health warning information to all employees about the health, flammability, and physical hazards associated in working with chemicals and the PPE that should be utilized. HMIS uses 4 colored bars to create an easily recognizable and understandable system for employees to utilize. HMIS is excellent in identifying the personal risks associated in working with chemicals and identifying the PPE that should be utilized. However, in particular, the PPE system can be difficult to understand, particularly to new workers or visitors.



Health (Blue)

The health section conveys the health hazards of the material. If an asterisk is present next to the number, it means there is a chronic health hazard (long term exposure of the material) associated in working with the material. Heath Ratings:

0: No significant risk to health.

1: Irritation or minor reversible injury possible.

2: Temporary or minor injury may occur.

3: Major injury likely unless prompt action is taken and medical treatment is given.

4: Life-threatening, major or permanent damage may result from a single or repeated overexposures.

FLAMMABILITY (Red)

The flammability criteria are defined according to 1994 OSHA Hazard Communication standards, however the ratings are the same as NFPA diamond ratings. (Please note that the OSHA definition of flammable materials changed in 2012 with the adoption of the GHS standard).

Flammability Ratings:

0: Materials will not burn.

1: Materials must be preheated before ignition will occur. Flash point above 200°F.

2: Materials must be moderately heated or exposed to high ambient temperatures before ignition will occur. Flash point above 100 °F but below 200 °F.

3: Materials are capable of ignition under almost all normal temperature conditions. Flash point is between 73 °F and 100°F.

4: Flammable gases or very volatile flammable liquids with flash points below 73 °F. Materials may ignite spontaneously with air.

PHYSICAL HAZARD (Yellow)

Reactivity hazards are assessed using the 1994 OSHA Hazard Communication Standard criterion of physical hazards in which seven hazard classes are recognized: Water Reactive, Organic Peroxides, Explosives, Compressed Gases, Pyrophoric Materials, Oxidizers, and Unstable Reactive.

Physical Hazard Ratings:

0: Materials that are normally stable, even under fire conditions, and will not react with water, polymerize, decompose, condense, or self-react. Non-explosives.

1: Materials that are normally stable but can become unstable (self-react) at high temperatures and pressures. Materials may react non-violently with water or undergo hazardous polymerization in the absence of inhibitors.

2: Materials that are unstable and may undergo violent chemical changes at normal temperature and pressure with low risk for explosion. Materials may react violently with water or form peroxides upon exposure to air.

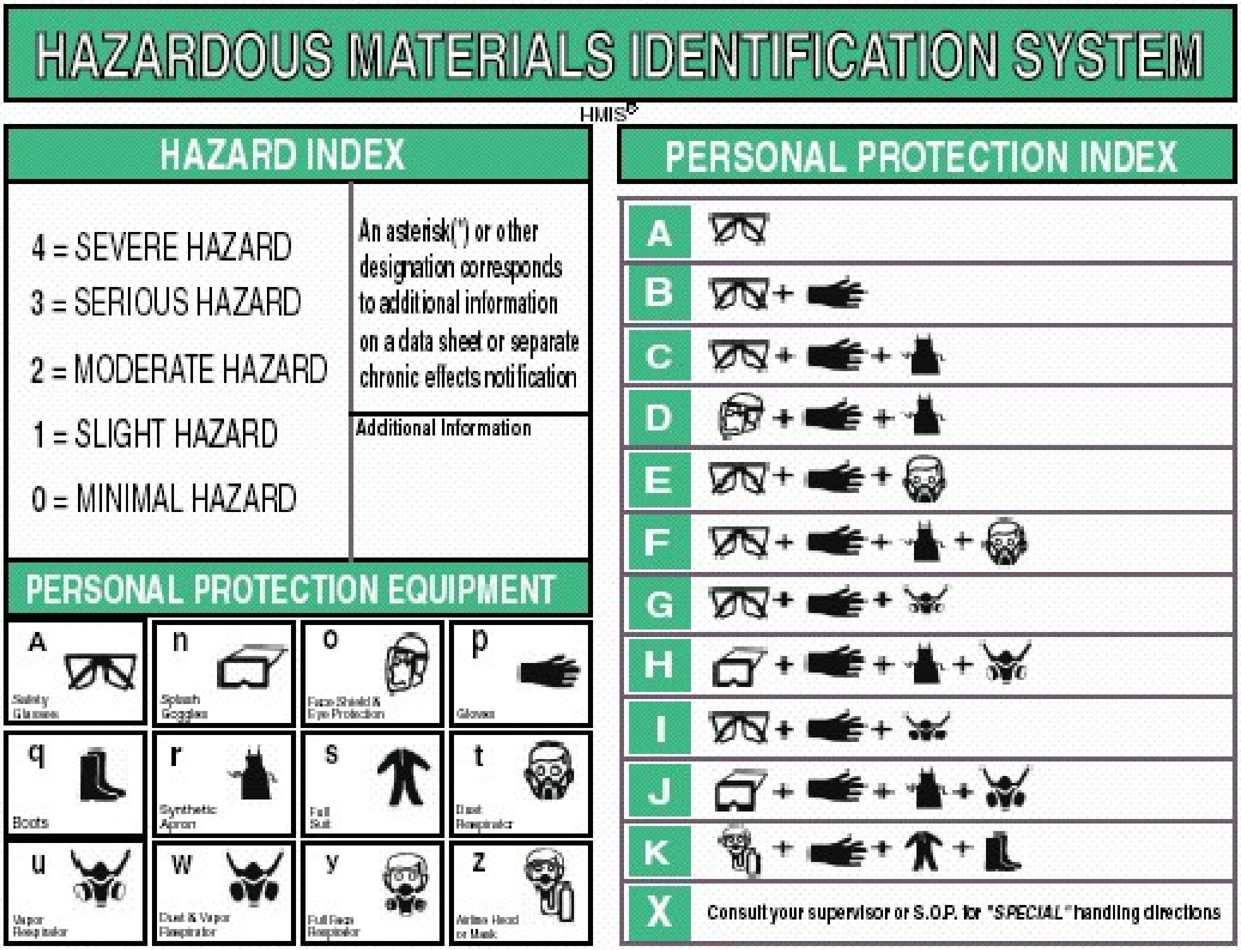
3: Materials that may form explosive mixtures with water and are capable of detonation or explosive reaction in the presence of a strong initiating source. Materials may polymerize, decompose, self-react, or undergo other chemical change at normal temperature and pressure with moderate risk of explosion.

4: Materials that are readily capable of explosive water reaction, detonation or explosive decomposition, polymerization, or self-reaction at normal temperature and pressure.

PERSONAL PROTECTION (White)

HMIS uses a letter coding system to indicate which piece(s) of PPE should be used when working with materials.

Alphabetical Coding System:



HAZARDOUS MATERIALS IDENTIFICATION SYSTEM

HMIS®

HAZARD INDEX

4 = SEVERE HAZARD
3 = SERIOUS HAZARD
2 = MODERATE HAZARD
1 = SLIGHT HAZARD
0 = MINIMAL HAZARD

An asterisk(*) or other designation corresponds to additional information on a data sheet or separate chronic effects notification

Additional Information

X Consult your supervisor or S.O.P. for "*SPECIAL*" handling directions

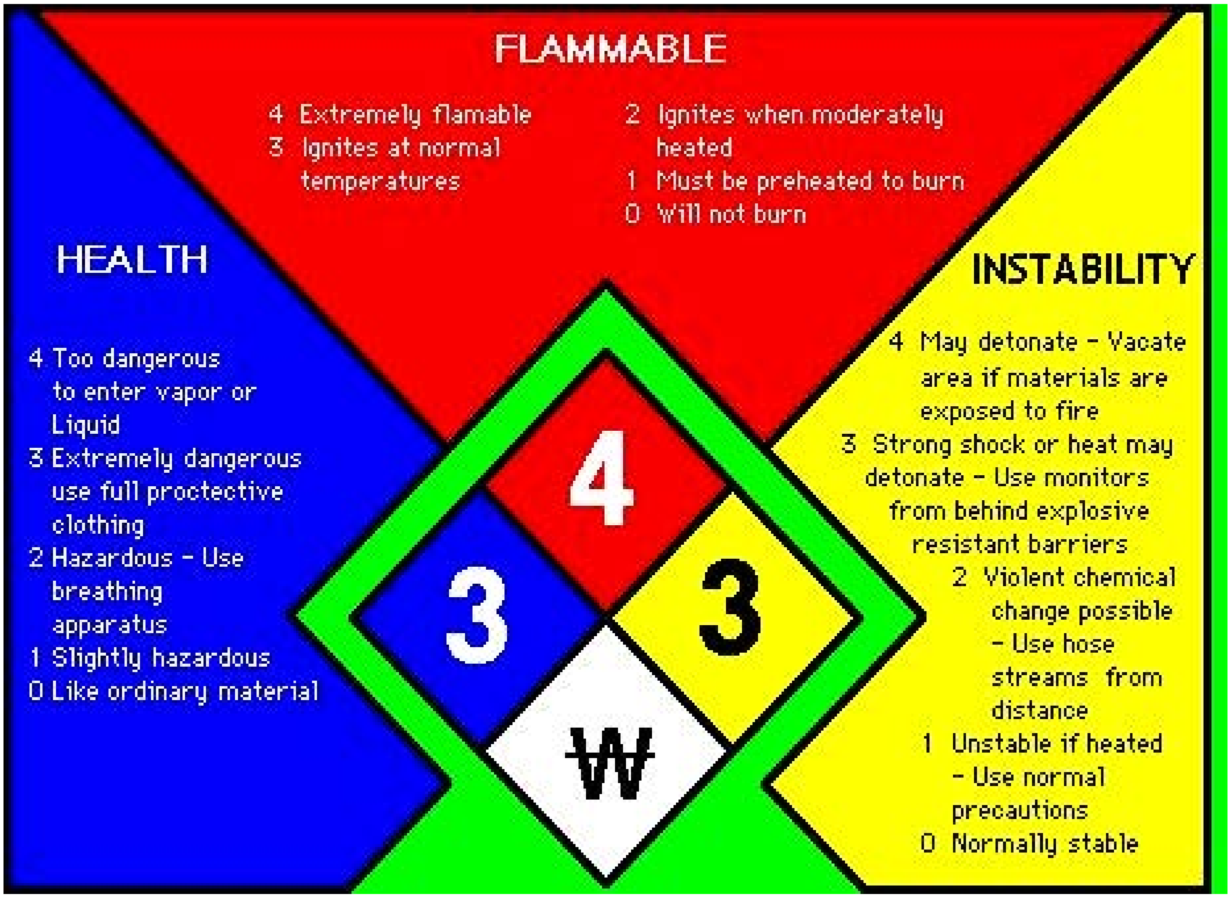
From: http://www.paint.org/hmis/index.cfm

APPENDIX C

National Fire Protection Agency (NFPA) Diamond

The NFPA Standard 704 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.

The system was designed for fire fighters and other emergency personnel. The ratings for chemicals are more geared towards firefighting and less towards personnel risk when working with the chemicals.



Health (Blue Diamond)

0: ‘Non-hazardous’. Note that no chemical is without some degree of toxicity.

1: Slightly toxic material. May cause irritation, but only minor residual injury even without treatment.

2: Moderately toxic material. Intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.

3: Seriously toxic material. Short term exposure could cause serious temporary or residual injury even though prompt medical treatment is given. Known or suspect animal carcinogens, mutagens, or teratogens.

4: Highly toxic material. Very limited exposure could cause death or major injury even though prompt medical treatment is give. Known or suspect human carcinogens, mutagens, or teratogens.

Flammability (Red Diamond)

0: Materials which will not burn.

1: Slightly combustible. Materials that require considerable preheating before ignition can occur.

2: Combustible. Materials that must be moderately headed before ignition can occur. Includes liquids having a flash point above 100 °F and solids that readily give off flammable vapors.

3: Flammable. Liquids and solids that can be ignited under almost all ambient temperature conditions. Included liquids with a flash point below 73°F and a boiling point above 100°F, solid materials which form coarse dusts that burn rapidly without becoming explosive, materials which burn rapidly by reason of self-contained oxygen (i.e. organic peroxides), and materials which ignite spontaneously when exposed to air.

4: Extremely flammable. Materials which will rapidly vaporize at normal pressure and temperature and will burn readily. Includes gases, cryogenic materials, any liquid or gaseous material having a flash point below 73°F and a boiling point below 100°F, and materials which can form explosive mixtures in air.

Reactivity (Yellow Diamond)

0: Materials which are normally stable, even under fire conditions and which are not reactive with water.

1: Materials which are normally stable, but which can become unstable at elevated temperatures and pressures, or which may react with water with some release of energy, but not violently.

2: Materials which in themselves are normally unstable and readily undergo violent chemical change, but do not detonate. Includes materials which may react violently with water or which may for potentially explosive mixtures with water.

3: Materials which in themselves are capable of detonation but which require a strong initiating source or heating. Includes materials that are shock sensitive at elevated temperatures and react explosively with water without requiring heat.

4: Materials which in themselves are readily capable of detonation or explosive decomposition at normal temperatures and pressures. Includes materials that are shock sensitive at normal temperatures and pressures.

Special Notice (White Diamond)

OX: Denotes materials that are oxidizing agents. These compounds give up oxygen easily, remove hydrogen from other compounds or attract negative electrons.

~~W~~ : Denotes materials that are water reactive. These compounds undergo rapid energy releases on contact with water.

APPENDIX D

Chemical Incompatibility Table

The following table is another resource for determining chemical incompatibilities. This list is in no way complete and references such as MSDS/SDS should always be used to determine chemical compatibility. (From Manufacturing Chemists' Association, *Guide for Safety in the Chemical Laboratory*, pp. 215–217, Van Nostrand Reinhold, 2nd Edition.)

CHEMICAL	KEEP OUT OF CONTACT WITH
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates and other oxidizers
Acetone	Concentrated nitric and sulfuric acid mixtures, and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Same as chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid	Ammonia, aqueous or anhydrous, bases and silica
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, and oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate and perchlorate	Sulfuric and other acids
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides	Reducing agents

APPENDIX E

Training Log Examples

Laboratory Training Verification Form

Trainee Name: ______________________

Supervisor/ PI: ______________________

Laboratory Location: ______________________

	Date	Trainer Initials	Trainee Initials	Comments
Lab Rules				
Location of MSDS				
Location of 1st Aid Kit				
Location of Eye Wash/Shower				
Lab PPE Policy				
Disposal of Lab Waste				
Emergency Response				
Proper Chemical Handling				

Laboratory Training Verification Form

Trainee Name: ____

PI/ Supervisor Name: ____

Laboratory Location: ____

Assay/ Procedure: ____

Date	Description of Training/ Comments	Trainee Initials & Date	Trainer/Supervisor Initials & Date

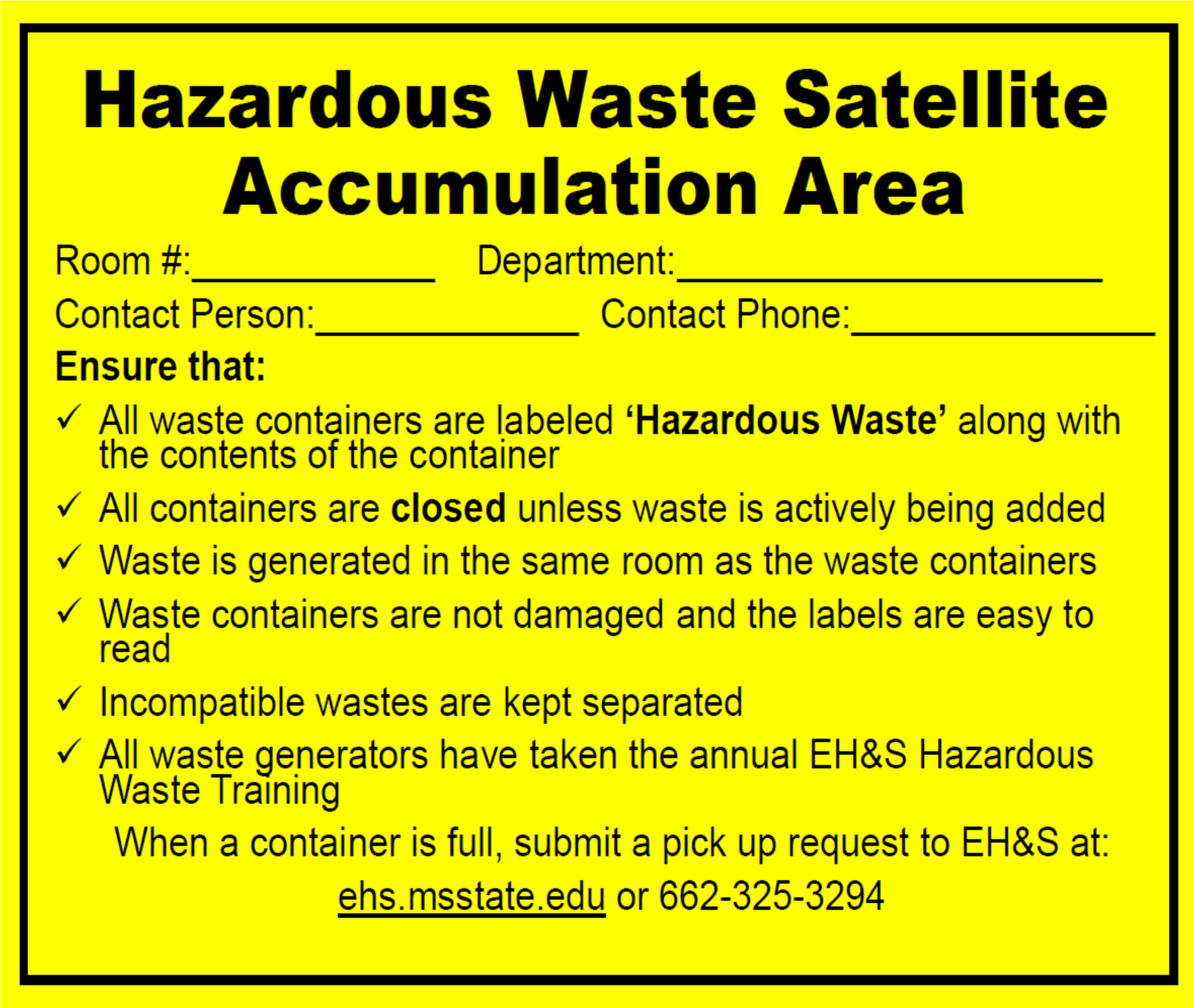
I, certify that ____ has successfully completed the hands on training for ____ and is able to work independently.

_____________________________________ _______________________________

Trainer Signature Date

APPENDIX F

Satellite Accumulation Area Sign



Hazardous Waste Satellite Accumulation Area

Room #:____________ Department:_____________________

Contact Person:_____________ Contact Phone:_______________

Ensure that:

- ✓ All waste containers are labeled **‘Hazardous Waste’** along with the contents of the container
- ✓ All containers are **closed** unless waste is actively being added
- ✓ Waste is generated in the same room as the waste containers
- ✓ Waste containers are not damaged and the labels are easy to read
- ✓ Incompatible wastes are kept separated
- ✓ All waste generators have taken the annual EH&S Hazardous Waste Training

When a container is full, submit a pick up request to EH&S at:

ehs.msstate.edu or 662-325-3294

APPENDIX G

Abbreviations

BSC	Biological Safety Cabinet
CGA	Compressed Gas Association
CHP	Chemical Hygiene Plan & Laboratory Safety Manual
DEA	U.S. Drug Enforcement Agency
EHS	Environmental Health & Safety Office
EPA	U.S. Environmental Protection Agency
F	Degrees Fahrenheit
ft2	Feet squared
g	Grams
GHS	Globally Harmonized System for Labeling and Classifying Chemicals
HF	Hydrofluoric Acid
HMIS	Hazardous Material Information System
hr/hrs	Hour(s)
IARC	International Agency for Research on Cancer
IFC	International Fire Code
in2	Inches squared
Kg	Kilogram
kPA	Kilopascal
L	Liter
LC50	Lethal Concentration 50
LD50	Lethal Dose 50
m3	Meters cubed
MAQ	Maximum Allowable Quantities
MDEQ	Mississippi Department of Environmental Quality
mg	Milligram

mm	Millimeter
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Agency
NTP	Normal Temperature and Pressure
NTP RoC	National Toxicology Program’s Report on Cancer
OSHA	U.S. Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PI	Principle Investigator
PPE	Personal Protective Equipment
ppm	Parts per million
psi	Pound per square inch
psig	Pound per square inch gauge
RCRA	Resource Conservation and Recovery Act
s	seconds
SAA	Satellite Accumulation Areas
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
UL	Underwriters Laboratory

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