LESSON 01: CHEMICAL SAFETY
Unit 01: Hazard and Its Classifications

Introduction:

"Safety First". This is a slogan that can usually be seen in workplaces which signifies the need to prioritize safety above anything else in the work environment. The safety of the working individuals is very important because it is directly related to the productivity of not just the workers but of the institution. In addition, a safe workplace also entails reduction on costs related to the decrease in working capacity and/or to the increase in accidental insurance. Above all, human life is essential; it must be taken care of.

As future engineers, the workplace is where most of the day is spent and it is where exposure to different types of hazards may be experienced and many will be work as leaders who are to oversee the safety of his or her subordinates. With this, a basic knowledge on how safety protocols work is needed, as part of protecting ourselves and others.

Chemical safety refers to the condition of being safe from undergoing hurt or harm during an occurrence of chemical incident. A chemical incident is an unintentional event that may threaten to expose or do expose members of the public to a chemical hazard.

Learning Objectives:

After successful completion of this lesson, the students are expected to:

1. Demonstrate "Chemical Safety" and discuss its importance.
2. Differentiate the terms "hazard" and risk".
3. Enumerate, discuss and give examples of different hazard classifications.

Course Materials:

What is a hazard?

Hazard is defined as any source of potential harm, damage or adverse effect on someone of something. For instance, (1) a fast-running vehicle is a hazard to a person who is crossing the same road the vehicle is moving on; (2) a poorly treated industrial wastewater is a hazard to the body of water where the wastewater is being dumped; (3) an x-ray radiation is a hazard to a radio technologist operating the machine.

Risk, on the other hand, is the probability that a person or a thing is harmed or damaged when exposed to a hazard. It talks about (1) the chance of the person crossing a road be hit by a fast moving vehicle, (2) the chance of the body of water to be polluted from the harmful substance present in the wastewater and (3) the chance that the radio technologist get a disease caused by his exposure to the x-ray radiation. The higher the risk, the higher the probability of getting harmed from the exposure to the hazard.

How are hazards classified?

1. ***Physical hazards*** are factors within the environment that may cause harm on the body even without touching it and they are generally discernible and perceptible. Examples are slippery floors, poor lighting, and excessive noise.

2. ***Chemical hazards*** refer to the chemical substances that may cause harm upon exposure to them. Examples are gases, fumes and liquids.

3. ***Ergonomic hazards*** are physical factors in the environment that may cause problems on the musculoskeletal system. Examples are poor workstation design, repetitive movements and poor workflow.

4. ***Radiation hazards*** are the factors in the environment that causes exposure to the emission of electromagnetic waves. Examples are x-rays, ultraviolet rays and lasers.

5. ***Psychological hazards*** are the aspects of the working environment that may affect the mental health of the individuals such as workload, stress and discrimination.

6. ***Biological hazards*** are biological substances that may threat the health of living organisms exposed to it such as viruses, bacteria and animals.

What are Hazardous Substances?

According to Occupational Safety and Health Administration (OSHA) of the United States of America, a ***hazardous substance*** is any chemical that presents physical or health hazard.

Under OSHA's Health Communication Standard (HCS), ***physical hazard*** means a chemical that is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive. Physical hazards are classified as fire hazard, reactive hazard and explosion hazard.

On the other hand, ***health hazard*** means a chemical that may cause acute or chronic health effects to exposed personnel. They are classified as either systematic effect or target organ effect.

According to Republic Act 6969, a substance is hazardous when it present either a short-term acute hazard or long-term chronic toxicity. ***Acute hazards*** are those that have obvious and immediate impact while ***chronic hazards*** are those that have more hidden, cumulative and long-term impact.

Activities and Assessments:

1. In your own words, define what chemical safety is and state its importance to your life as (1) a member of the community, (2) a student of Chemistry for Engineers who is to undergo laboratory classes; and (3) a future professional working in the engineering field.
2. Cite the difference between "hazard" and "risk" by giving an example.
3. Imagine yourself to be a medical practitioner in a hospital that caters Covid-19 pandemic patients. Name a hazard under each classification that you are exposed to.
4. How would you determine if a substance is hazardous or not?
5. What is the difference between a physical from chemical hazard? Between chronic and acute hazard?

LESSON 01: CHEMICAL SAFETY
Unit 02: Hazard Communication: GHS Labeling

Introduction:

Hazardous substances are those that cause harmful or adverse effects to those that they are exposed to. However, these can be minimized, if not prevented, through their proper and appropriate handling which can be done by proper communication using standard chemical labels.

In this part of the lesson, you will be introduced to the GHS labelling which is the standard means of communication on hazardous substances that is being used around the world as established by the United Nations.

Learning Objectives:

After successful completion of this lesson, the students are expected to:

1. Explain what does “GHS” stands for and its importance.
2. Enumerate and discuss the different elements that compose the GHS label template.
3. Identify the type of hazard(s) that is (are) being represented by the different GHS pictograms.

Course Materials:

The GHS Labels

Adapted from “Globally Harmonized System of Classification and Labelling of Chemicals” by the United Nations.

One of the administrative controls being employed is the proper handling of chemicals through proper chemical labeling. It must be recalled that a “chemical” is a substance that is used or is produced in a reaction involving changes of atoms and molecules. Adding labels to the chemicals will the user the idea on how to properly handle or use it.

GHS stands for Globally Harmonized System of Classification and Labeling of Chemicals. It is an internationally agreed-upon system created by the United Nations that requires manufacturers, importers and downstream users and distributors of chemical substances and mixtures.
GHS was started to be adopted in June 1, 2015. The establishment of GHS had an objective of unifying the communication on hazardous products and of replacing the specific regulations in countries around the world.

The ***GHS label template*** has the following standardized elements according to "Globally Harmonized System of Classification and Labeling of Chemicals (GHS)" by the United Nations.

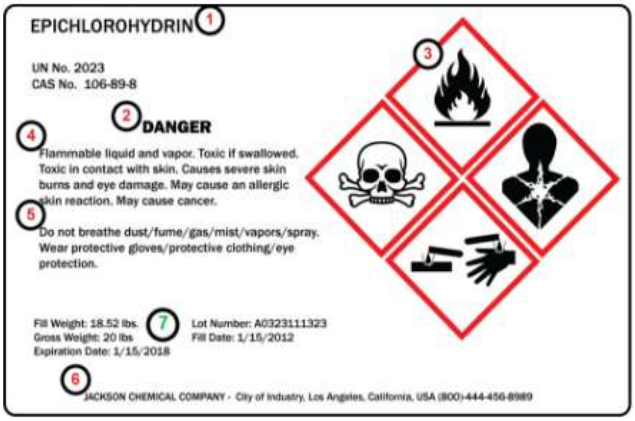

Figure 1: GHS Label Template [Image source: www.nicelabel.com]

1. ***Product Name or Identifier***: This is the name of the substance contained inside the labeled container.

2. ***Signal word***: This is a single word which can either be "Warning" or "Danger". It is used to indicate the relative severity of the product wherein "Danger" indicates more severe hazards and "Warning" for less severe hazards.

3. ***Precautionary symbols or pictogram(s):*** Show(s) a representation of the classification of chemical hazard the product has to expose to its user.

4. ***Physical, Health and Environmental Hazard statements***: Standardized and assigned phrases that describes the hazard based on its classification.

5. ***Precautionary measures:*** Provides the measures to be undertaken to minimize the effect from product exposure. This include the first aid measures that are needed to be undertaken and the appropriate personal protective equipment to be used when dealing with it.

6. ***Supplier identification:*** Gives the name, address and contact details of the manufacturer.

7. ***Supplemental Information***: Includes additional information that the customer requests to include.

The GHS Pictograms and Their Representations

Physical hazards	Fire hazards	Oxidizing solids Oxidizing liquids Oxidizing gases	
		Flammable solids Flammable liquids Flammable gases Flammable aerosols Substances which in contact with water, emits flammable gases Pyrophoric solids Pyrophoric liquids	
	Reactive hazards	Self-heating substances	
		Self-reactive substances Organic peroxides	 
		Corrosive to metals	
	Explosion hazards	Explosives	
		Gases under pressure	

Health hazards	Systemic effects	Skin corrosion	
		Skin irritation Eye irritation Serious eye damage Dermal sensitization	
		Acute toxicity	
	Target organ effects	Carcinogenicity Respiratory sensitization Reproductive toxicology Target organ systemic toxicity Germ Cell Mutagenicity Aspiration toxicity	
Environmental Hazards	Acute aquatic toxicity Chronic aquatic toxicity		

Oxidizers can either be solids, liquids or gases. They are materials that are not necessarily combustible but may generally yield oxygen which may contribute to or cause combustion reactions.

Flammable solids can either be readily combustible or may cause or contribute to fire through friction. They can be in the form of granules, powder and pastry which is easily ignited when come into contact with an ignition source.

Flammable liquids are liquids with flash points of not more than 93°C.

Flammable gases are gases with flammable range in air at 20°C and at standard pressure of 101.3kPa.

Flammable aerosols are any gas that (1) was compressed, liquefied or dissolved under pressure within a non-refillable container that was made up of metal, glass or plastic and (2) contains any component classifies as flammable solid, liquid or gas.

Emits flammable gas are substances that can either solids or liquids that are liable to become spontaneously flammable or to give off flammable gases when get in contact with water.

Pyrophorics are substances which can either be solids or liquids that are liable to ignite within five minutes after having been in contact with air even at very small quantities.

Self-heating substances are solid or liquid substances that are not classified as pyrophorics but is liable to self-heat when comes in contact with air even in the absence of energy.

Self-reactive substances are either (1) thermally unstable liquids or (2) solids that may undergo strong exothermal decomposition even in the absence of the participation of oxygen but (3) are not classified as corrosives, explosive or organic peroxides under the GHS.

Organic peroxides are either solid or liquid substance that contains bivalent O-O structure. These substances may be liable to explosive decomposition, burn rapidly, be sensitive to impact or friction or react dangerously to other substances.

Corrosive to metals are substances that materially damaged metals through chemical reaction

Explosives are substances or mixtures of substances that can either be solids or liquids which in their selves are capable to produce a gas, by a chemical reaction, at such speed as to cause damage to the surroundings.

Gases under pressure are gases that are contained inside a receptacle with a pressure of not less than 280 Pascal at 20°C.

Substances labelled with ***skin corrosion*** are substances that cause irreversible skin damage following an application of a test substance for four (4) hours.

Skin irritation is the label being considered when the substance causes a reversible damage to the skin following an application of a test substance for four (4) hours.

A substance causes ***eye irritation*** if it causes changes in the eye after an application of a test substance to the front surface of the eye, but are fully reversible twenty-one (21) days after the application.

Serious eye damage pertains to the production of eye tissue damage or serious physical decay of vision that is not reversible twenty-one (21) days following the application of the substance.

Dermal sensitization is caused by substances that induce allergic reaction following contact to the skin.

Acute toxicity are substances assigned to the Five Toxicity Categories on the basis of LD50 (oral and dermal) and LC50 (inhalation.)

Acute toxicity	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Category 5
Oral (mg/kg)	≤ 5	> 5 ≤ 50	> 50 ≤ 300	> 300 ≤ 2000	Criteria: • Anticipated oral LD50 between 2000 and 5000 mg/kg; • Indication of significant effect in humans;* • Any mortality at class 4;* • Significant clinical signs at class 4;* • Indications from other studies.* *If assignment to a more hazardous class is not warranted.
Dermal (mg/kg)	≤ 50	> 50 ≤ 200	> 200 ≤ 1000	> 1000 ≤ 2000	
Gases (ppm)	≤ 100	> 100 ≤ 500	> 500 ≤ 2500	> 2500 ≤ 5000	
Vapors (mg/l)	≤ 0.5	> 0.5 ≤ 2.0	> 2.0 ≤ 10	> 10 ≤ 20	
Dust & mists (mg/l)	≤ 0.05	> 0.05 ≤ 0.5	> 0.5 ≤ 1.0	> 1.0 ≤ 5	

Source: A Guide to the Globally Harmonized System of Classification and Labelling of Chemicals", by United Nations

Carcinogens refer to the chemical substances that induce cancer or increase its incidence.

Respiratory sensitizers are chemical substances that cause the airways to be hypersensitive after inhalation of the substance.

Reproductive toxicity may cause infertility, adverse effects on sexual functions and/or developmental toxicity on the offspring.

Target organ systemic toxicity may cause either reversible or irreversible damages on specific body organs which affects their functions.

Germ Cell Mutagenicity may cause gene mutations of organisms to occur.

Aspiration toxicity includes severe acute effects of varying degrees of pulmonary injury or death following aspiration.

Acute aquatic toxicity causes injury to aquatic organisms after a short-term exposure to the substance.

Chronic aquatic toxicity causes adverse effects to aquatic organisms during exposures based on the organism's life cycle.

Activities and Assessments:

1. What does "GHS" means and why is it important?
2. Look for an available GHS-compliant label of hydrogen sulfide, identify the type of hazards of the substances and the necessary measure(s) if someone inhales it.
3. Look for an available GHS-compliant label of n-propyl alcohol, identify the type of hazards of the substances and the necessary measure(s) if it gets to your eyes.

LESSON 01: CHEMICAL SAFETY
Unit 03: Hazard Communication: NFPA Diamond and SDS

Introduction:

The communication on hazardous substances does not stop with the GHS label template. The NPFA diamond is also included which a quick visual representation of the substance's hazards. A standard document that bears a more detailed information on the product's identity, hazards, exposure prevention measures and appropriate response in various situations is also available. It is known as the GHS Safety Data Sheet (SDS). It is used as a primary reference material of individuals who are dealing closely with the chemical as it provides procedures on how to use, store, handle and transport the substance safely.

Learning Objectives:

After successful completion of this lesson, the students are expected to:

1. Interpret the NPFA Hazard Identification System.
2. Demonstrate the knowledge on the use of the Safety Data Sheet.

Course Materials:

NFPA Hazard Identification System

The National Fire Protection Agency Hazard Identification System is a quick visual representation of a chemical substance in terms of its reactivity, flammability, health hazard and special hazards.

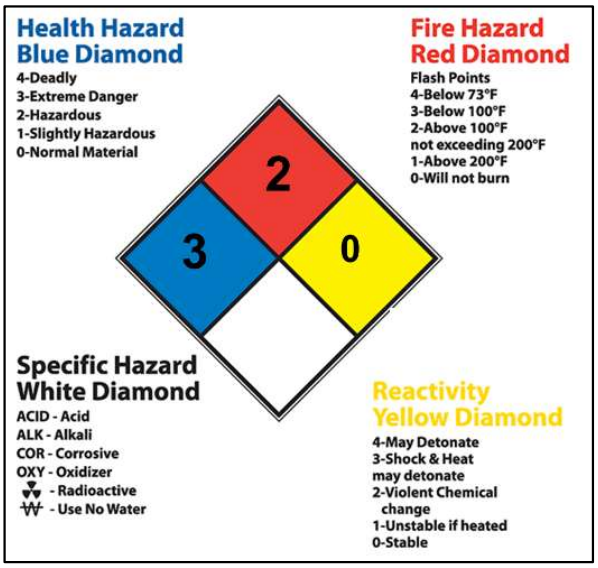

Figure 2: NFPA Hazard Identification System

GHS Safety Data Sheet

Adapted from "Globally Harmonized System of Classification and Labelling of Chemicals" by the United Nations.

The GHS Safety Data Sheet (SDS) provides comprehensive information on the chemical substance being handled. It comprises of the following minimum elements:

1. ***Identification of the substance or mixture and of the supplier***
   Includes the GHS product identifier and other means of product identification, recommended and restricted uses of the product and the supplier's information details.

2. ***Hazards identification***
   Includes the GHS classification of the substance or mixture, GHS label elements and precautionary statements and other hazards that are not covered by GHS.

3. ***Composition or information of ingredients***
   For substances, this include the substance's chemical identity, CAS number, EC number, impurities and stabilizing additives. For mixtures, the chemical identity and concentration of the ingredient(s) which is (are) identified us hazardous, the cut-off levels of reproductive toxicity and, carcinogenicity, mutagenicity and other hazard classes.

4. ***First aid measures***
   Provides description of necessary measures to each of the different routes of exposure (inhalation, skin contact, eye contact and ingestion), the most important symptoms and indications when medical attention or treatment is needed.

5. ***Firefighting measures***
   Provides a list of suitable distinguishing media, the specific hazards arising from the chemicals and the proper protective equipment and precautions needed during firefighting activities.

6. ***Accidental release measures***
   Provides the personal and environmental precautions including the proper personal protective equipment and the appropriate method and materials used during clean ups.

7. ***Handling and storage***
   Provides precautions during handling and the conditions for safe storage.

8. ***Exposure controls and personal protection***
   Shows the control parameters, engineering controls and appropriate personal protective equipment.

9. ***Physical and chemical properties***
   Includes the list of both the physical and chemical properties of the substance such as but not limited to appearance, pH, odor, melting point, initial boiling point, flash point, evaporation rate, flammability, vapor pressure, vapor density, relative density, solubility, auto-ignition temperature and decomposition temperature.

10. Stability and reactivity

Show the product's stability, possible hazardous reactions, conditions to avoid, incompatible materials and hazardous decomposition products.

11. Toxicological information

Gives concise but complete information on various toxicological effects, its route of exposure, symptoms and delayed and immediate effects and numerical toxicity scale

12. Ecological information

Show information of the product's ecotoxicity, persistence and degradability, bio accumulative potential, mobility in soil

13. Disposal considerations

Gives the description of waste residue and information of its proper handling and disposal.

14. Transport information

Provides the UN number, UN proper shipping name, transport precautions, identification as marine pollutant, packaging.

15. Regulatory information

Shows the environmental, safety and health regulations specific to the product.

16. Other information

Before the implementation of the GHS SDS format, manufacturers use the Material Safety Data Sheet (MSDS). Both of the materials have the same element but they differ in content. The GHS SDS format is the one that was discussed in the lesson because it is the one that is more utilized in the industries now a days.

Activities and Assessments:

1. Make an NPFA hazard identification label for a deadly, stable radioactive substance but does not burn.
2. You are to work with a 0.5N hydrochloric acid purchased from LabChem, Inc. The SDS is available for download from the company's website.
    a) Is the product applicable for food use?
    b) Is the product flammable?
    c) What are the personal protective equipment that you need to use when handling the substance?
    d) What is (are) the available GHS pictogram(s) for the product?
    e) What is the first aid measure during skin contact?