

## **Understanding GHS classification, Chemical Labels and Safety Data Sheets**

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### **ABSTRACT:**

Globally Harmonized System (GHS) of Classification and Labelling of Chemicals is now universally accepted to communicate the hazards of a chemical. Occupational Safety and Health Administration (OSHA) adopted the GHS system under the Hazard Communication Standard (HCS) in June 2016. In the course of implementation of the GHS, we need to educate our research community, specially new undergraduate and graduate students and provide them with the most recent knowledge of the chemicals, labels, hazards and the ways to protect themselves and their surroundings from the dangers associated with the chemicals. In this paper, we discuss the basics of OSHA hazard communication, GHS system classification, chemical labeling, new hazard pictograms and sections of safety data sheet (SDS) for our students and researchers in an easy to understand format. It is the hope that this publication will benefit the students to understand chemical hazards, to read safety information and to protect themselves when using these materials.

**Keywords:** Globally Harmonized System, Occupational Safety and Health Administration, Chemical Label, Safety Data Sheet, Hazard Pictogram, Hazard Communication Standard, Laboratory Safety.

## **INTRODUCTION**

Chemical safety has always been a point of concern for research community, lab safety managers, and EH&S professionals [1]. Aim of chemical safety is the application of the best practices for handling chemicals and chemical processes to minimize risk to a person, environment, facility, or community by recognizing and understanding the physical, chemical, and toxicological hazards of chemicals. Recognition of chemical hazard depends on clear and specific information on the label and other sources such as Safety Data Sheet (SDS). We have seen in our experience that students do not pay much attention to SDS because they think that it is very complex to understand. Some students have a feeling that it is not very useful and they know what the chemical and the hazards are. It is crucial for students working in a lab to understand the potential hazards of the chemicals they are working with or are in their vicinity and how to handle them safely. Past incidents as a result of safety lapse at Dartmouth, UCLA, and Texas Tech University forced everyone to rethink how to make safety information easily accessible [1-4]. Often, undergraduate and graduate researchers are not well aware of the hazards associated with the chemicals and lab procedures due to lack of adequate education on easily accessible safety information for hazard assessment and how to interpret the available information.

The Occupational Exposure to Hazardous Chemicals in Laboratory standard (29 CFR 1910.1450), commonly referred as Laboratory Standard, is applicable

to all employers engaged in laboratory use of hazardous chemicals and requires that the employer have a written Chemical Hygiene Plan (CHP) [5]. The CHP must include provisions of worker training, chemical exposure monitoring, medical consultation, criteria for personal protective use (PPE) use, engineering controls, special precautions for particularly hazardous materials and designate a Chemical Hygiene Officer. As a part of Right-to-know and Laboratory Standard / Chemical Hygiene training, the laboratory personnel must receive the training for proper handling and use of material, potential effect of the material upon health and safety, protective measures and the laboratory safety practices. Although OSHA only protects employees, students usually are required to follow these standards in the laboratory to maintain a safe environment for all.

United Nations adopted Globally Harmonized System (GHS) of Classification and Labeling of Chemicals to provide standardize labeling and hazard information for all chemicals worldwide and Occupational Safety and Health Administration has adopted the GHS system under the Hazard Communication Standard (HCS) in June 2016 [6-10]. After the implementation of GHS, all the chemical manufacturers/importers/distributors must follow these guidelines and now the chemicals are coming with new labels and have new safety data sheets. This new GHS system is expected to help improve the chemical safety practice in the research laboratories. GHS labelling provide hazard identifying information on the chemical label and SDS but users especially undergraduate and graduate students are not fully aware how to interpret or understand this information.

Aligned with GHS, key elements of HCS are material inventory, written program, labelling, Safety Data Sheet and training. New undergraduate and graduate students are usually not aware of how to interpret the information

available on chemical container labels and various sections of SDS and practically it is not feasible to educate every undergraduate and graduate student how to safely use every chemical. However, explaining how to look for safety information, learning GHS labeling, OSHA's hazard communication, and SDS information can fill in the gap and this document can serve as a supplementary material to help the students. For new students and researchers, it is not easy to identify GHS information, chemical labeling and SDSs at one platform and understand it from safety prospective. A strong safety education during undergraduate studies will translate to graduate students and researchers who follow strong safety ethics and will lead to a strong safety culture [11]. It can be facilitated by providing easily understandable GHS label information that will enhance their safety awareness and potentially will prevent accidents in lab. To explain various components of chemical safety, we designed a document to share with undergraduate and graduate students.

Few articles have been published on new GHS system to cover one or more of GHS component(s) but no research article was found which could summarize all sections of new GHS system aligned with OSHA HCA and relating it to the SDS in a simple and concise way [12-15]. In this paper, we describe OSHA's hazard communication standard, the GHS labelling and SDS relevance in a simple and easy to understand format for undergraduate and graduate students. This article will provide information on all component(s) of GHS system, various sections of chemical label, hazard pictograms, and a description of 16 sections of safety data sheet for students at one platform.

## **OSHA HAZARD COMMUNICATION STANDARD**

These are the five key elements of the OSHA hazard communication standard [16]:

1. **Inventory:**

The first element of the Hazard Communication Standard is for employers to develop inventory of all hazardous chemicals they have at their worksite. Each facility is responsible for maintaining chemical inventory for their workplaces and procure a safety data sheet (SDS) for each chemical.

2. **Safety Data Sheets (SDS):**

The second element mandates employers to evaluate the hazards of the chemicals they use and communicate this information to their employees. HCS 2012 requires that the chemical manufacturer, distributor, or importer provide SDS for each hazardous chemical to downstream users to communicate information on these hazards. The new format of SDSs is required to be presented in a consistent user-friendly, 16-section format. This provides guidance to help workers who handle hazardous chemicals to become familiar with the format and understand the contents of the specific SDSs.

3. **Labeling:**

The third element requires employers to label all the chemical they use at the workplaces. Chemical manufacturers and importers are required to provide a label that includes a harmonized signal word, pictogram, and hazard statement for each hazard class and category. Precautionary statements must also be provided. If a material is transferred into a more user friendly container the secondary container should be labeled with the product name and the hazard(s).

4. **Training:**

The fourth element mandates that employers shall provide employees with effective information (including new label and SDS format) and training on

hazardous chemicals in their work area at the time of their initial assignment, and whenever a new chemical hazard is introduced into their work area. Information and training may be designed to cover categories of hazards or specific chemicals. Chemical-specific information must always be available through labels and safety data sheets.

5. **Written Programs:**

The fifth and final element of HCS requires employers to prepare and implement a written hazard communication program. This requirement is to help ensure that compliance with the standard is done in a systematic way, and that all elements are coordinated. The written program must indicate how you will address the requirements of labels, SDSs, employee information, training and the chemical inventory for the chemicals at the workplace.

**GLOBAL HARMONISED SYSTEM (GHS) FOR LABELING OF CHEMICALS:**

The purpose of the chemical label is to provide and educate the user of the associated hazard information related to the product. OSHA has adopted this new hazardous chemical labelling requirement as a part of its recent revision of Hazard Communication Standard to align with UN Globally harmonized system of Classification and Labelling of Chemicals [17]. These changes will provide consistency in the classification and labeling of all chemicals and workers will have better understanding of the information available on the safe handling and use of hazardous chemicals, working anywhere in the world.

SDS provides a detailed information of types and level of hazard, various properties and recommended use of specific controls for protection. Chemicals may have different properties with varying degrees of health and physical hazards, such as carcinogenic, flammable, corrosive, explosive, toxic or

harmful to the environment. It is important, therefore, for users to understand the potential hazards through the hazard statements and the pictograms displayed on labels.

GHS has a certain requirement for chemical labeling. All labels must be legible, in English and prominently displayed. The label must contain product identifier, supplier information, signal word or danger warning, hazard pictogram, hazard statement and precautionary statement. GHS and HCS requires the following seven features on labels of hazardous chemicals (Figure 1):

**SAMPLE LABEL**

**Product Identifier**  
CODE \_\_\_\_\_  
Product Name \_\_\_\_\_

**Supplier Identification**  
Company Name \_\_\_\_\_  
Street Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_  
Postal Code \_\_\_\_\_ Country \_\_\_\_\_  
Emergency Phone Number \_\_\_\_\_

**Hazard Pictograms**  
[GHS Pictogram: Health Hazard] [GHS Pictogram: Flammable]

**Signal Word**  
**Danger**

**Hazard Statements**  
Highly flammable liquid and vapor.  
May cause liver and kidney damage.

**Precautionary Statements**  
Keep container tightly closed. Store in a cool, well-ventilated place that is locked.  
Keep away from heat/sparks/open flame. No smoking.  
Only use non-sparking tools.  
Use explosion-proof electrical equipment.  
Take precautionary measures against static discharge.  
Ground and bond container and receiving equipment.  
Do not breathe vapors.  
Wear protective gloves.  
Do not eat, drink or smoke when using this product.  
Wash hands thoroughly after handling.  
Dispose of in accordance with local, regional, national, international regulations as specified.

**Supplemental Information**  
**Directions for Use**  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
**Fill weight:** \_\_\_\_\_ **Lot Number:** \_\_\_\_\_  
**Gross weight:** \_\_\_\_\_ **Fill Date:** \_\_\_\_\_  
**Expiration Date:** \_\_\_\_\_

**In Case of Fire:** use dry chemical (BC) or Carbon Dioxide (CO<sub>2</sub>) fire extinguisher to extinguish.  
**First Aid**  
If exposed call Poison Center.  
If on skin (or hair): Take off immediately any contaminated clothing. Rinse skin with water.

Figure 1. Basic parts of an OSHA Compliant Label

### 1. Product identification:

This is to identify the hazardous chemical and can include (but is not limited to) chemical name, code number, or batch number. The manufacturer, importer or distributor can decide the appropriate product identifier to identify the hazardous chemicals. The same product identifier on the label must correspond to the section 1 of the SDS.

## **2. Supplier information:**

This section provides the information of the name, address and telephone numbers of the manufacturer/importer or other responsible party and must be included on the label.

## **3. Signal word:**

The signal words are used to indicate the level of severity of the hazard to alert the user to a potential hazard on the label. Only two words used as signal words, “Danger” or “Warning”. “Danger” is used for the more severe hazards and “Warning” is used for the less severe hazard. Only one signal word is used on the label irrespective of number of hazards associated with a particular chemical.

## **4. Hazard Statements:**

It describes the nature of the potential hazard(s) (including the degree of hazard) of a chemical, including the degree of hazard (whenever applicable). For example: “Causes damage to kidneys through prolonged or repeated exposure or when absorbed through the skin.” All the applicable hazard statements must appear on the label, whenever a chemical poses several hazards. Hazard statements are specific to the hazard classification categories and users always see the same statement for the same hazards irrespective of the chemical or the provider/manufacturer.

## **5. Precautionary statement:**



Precautionary statements describe the recommended measures that should be taken to prevent or minimize the adverse effect resulting from exposure or mishandling. There are four types of precautionary statements: Prevention – To minimize exposure; Response – In case of an accident or spill, the emergency response or first-aid; Storage – how to store the chemical properly; and Disposal – disposal requirements. OSHA does allow flexibility for applying precautionary statements to the label, such as combining statements, using an order of precedence or eliminating an inappropriate statement. For example, a chemical presenting a specific target organ toxicity would have the following on the label: “Do not breathe dust/fume/gas/mist/vapors/spray. Get medical advice/attention if you feel unwell. Dispose of contents/container in accordance with local/regional/national and international regulations.”

## **6. Supplementary Information:**





This section provides any additional information that deems helpful to handle that chemical such as, any hazards not otherwise classified on the label or identify the percentage of ingredient(s) of unknown acute toxicity when it is present in a low concentrations ( $\geq 1\%$ ). Employers can also include additional information in this section regarding the chemical, for more than what the standard requires. For example, the personal protective equipment (PPE) pictogram to handle that particular chemical, the expiration date etc.






## **7. Pictogram:**

Pictograms are graphic symbols used to communicate specific information about chemical hazards and the manufacturers, importers or distributors are required to include the applicable pictograms on the chemical label

being shipped or transported. These pictograms consist of a red square frame set at a point with a black hazard symbol on a white background and should be clearly visible. OSHA has adopted these worldwide symbols to improve worker health and safety and these are being used worldwide. Although GHS uses nine pictograms, OSHA will only enforce the use of eight. The environmental pictograms is not mandatory but may be used to provide additional information. Table 1 shows the symbol of each pictogram, the written name, and the hazards associated with each of the pictograms.

Table 1. Pictograms and Hazards

Pictogram Symbol	Pictogram Name	Associated Hazards
	Health Hazard	<ul style="list-style-type: none"> <li>• Carcinogen</li> <li>• Mutagenicity</li> <li>• Reproductive Toxicity</li> <li>• Respiratory Sensitizer</li> <li>• Target Organ Toxicity</li> <li>• Aspiration Toxicity</li> </ul>
	Flame	<ul style="list-style-type: none"> <li>• Flammables</li> <li>• Pyrophorics</li> <li>• Self-Heating</li> <li>• Emits Flammable Gas</li> <li>• Self-Reactives</li> <li>• Organic Peroxides</li> </ul>
	Exclamation Mark	<ul style="list-style-type: none"> <li>• Irritant (skin and eye)</li> <li>• Skin Sensitizer</li> <li>• Acute Toxicity (harmful)</li> <li>• Narcotic Effects</li> <li>• Respiratory Tract Irritant</li> <li>• Hazardous to Ozone Layer (Non-Mandatory)</li> </ul>
	Gas Cylinder	<ul style="list-style-type: none"> <li>• Gases Under Pressure</li> </ul>

	Corrosion	<ul style="list-style-type: none"> <li>• Skin Corrosion Burns</li> <li>• Eye damage</li> <li>• Corrosive to Metals</li> </ul>
	Explosion Bomb	<ul style="list-style-type: none"> <li>• Explosives</li> <li>• Self-Reactives</li> <li>• Organic Peroxides</li> </ul>
	Flame Over Circle	<ul style="list-style-type: none"> <li>• Oxidizers</li> </ul>
	Environment (Non-Mandatory)	<ul style="list-style-type: none"> <li>• Aquatic Toxicity</li> </ul>
	Skull and Crossbones	<ul style="list-style-type: none"> <li>• Acute Toxicity (fetal or toxic)</li> </ul>

### **SAFETY DATA SHEET (SDS):**

2012 revision of OSHA Hazard Communication Standard requires that the chemical manufacturer, distributor or importer follow the new Safety Data Sheet (SDS) and provide SDS for all the hazardous chemical to communicate hazard information to user. SDS offer the same information as the old MSDS, except now the SDSs contained consistent user-friendly, 16 section formats. The information contained in the SDS must be in English (other language can be used as secondary) and provide specific minimum information as listed in Appendix D of 29 CFR 1910.1200 [18]. Sections 1 through 8 contain general information about the chemical, identification, hazards, composition, safe

handling practices, and emergency control measures whereas Sections 9 through 11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity, toxicology, exposure control and other information including the date of preparation or last revision. The SDS must also contain sections 12 through 15, to be consistent with GHS, but OSHA will not enforce the content of these sections as they handled by other agencies.

Here is the description of all 16 sections of SDS along with their contents:

### **Section 1: Identification**

Section 1 describe brief information of the chemical identifier, supplier/manufacturer and recommended use. It identifies the chemical with any other common name or synonyms by which the substance is known along with the recommended use or any restriction on use, such as laboratory use only. It provides the name, address, phone number of the manufacturer or supplier, and emergency phone number.

### **Section 2: Hazard(s) Identification**

Section 2 is one of the most important sections for the users because it identifies the hazards of the chemical and the appropriate warning information associated with those hazards. The required information for section 2 consists of: hazard classification of the chemical (e.g. flammable, corrosive etc.), signal word (danger or warning), pictogram(s) (GHS hazard symbols in black and white as described above, e.g. flame, corrosion, skull and crossbones etc.), hazard statement(s), precautionary statements, and any other hazards not otherwise classified. For a mixture that contain an ingredient(s) with unknown

toxicity, a statement describing the percentage of the ingredient(s) should be included.

### **Section 3: Composition/ information on ingredients**

Section 3 provides information of the ingredient(s) contained in the product, including impurities and stabilizing additives along with the information on substances, mixtures, and all chemicals where a trade secret is claimed. For substances, it should provide chemical name, common name and synonyms, Chemical Abstracts Service (CAS) number and other unique identifies. For mixtures, same information is required for substances along with the chemical name and concentrations of all ingredients, which are classified as health hazards. For example, SDS of 1.6M of *tert*-butyllithium solution in hexane or diethyl ether with butylated hydroxytoluene should have the information of all the ingredients and stabilizing additives in this section.

### **Section 4: First-aid**

Section 4 is very important when someone get exposed to hazardous chemical. This section describes the necessary first-aid instructions by various routes of exposure (inhalation, ingestion, absorption, skin and eye contact), the description of the important symptoms/effects, and symptoms that are acute or delayed. The recommendation for immediate medical care and special treatment (when necessary) is also available in this section. For example, first-aid for hydrofluoric acid (HF) exposure require the use of antidote calcium gluconate to treat the affected personnel and this information is available in the section 4 of SDS for HF .

### **Section 5: Fire-fighting measures**

Section 5 can be very important when you are dealing with a fire, involving a chemical that requires special kind of fire suppression method. This section provides recommendations for suitable fire extinguishing equipment and advice on specific chemical fire hazard. For example, pyrophoric chemical such as *tert*-butyl lithium, which react with water, a class D fire extinguisher is required to handle the fire. The recommendation on special protective equipment or precautions for firefighters is also provided here.

### **Section 6: Accidental release measures**

Section 6 lists emergency procedures; protective equipment; and methods of containment and cleanup. It includes recommendations on the appropriate response to spills, leaks, or releases, including containment and cleanup practices and procedures. It also lists personal precautions and protective equipment and procedures that are required to prevent contamination of skin, leaks and clothing.

### **Section 7: Handling and storage**

Section 7 provides precautions for safe handling practices and conditions for chemicals, including recommendations for handling of incompatible chemicals, minimizing the release of the chemical into the environment, and providing advice on general hygiene practices. It also list the recommendations on the conditions for safe storage, including any incompatibilities and advice on specific storage requirement (e.g., ventilation requirements).

### **Section 8: Exposure controls/personal protection**

Section 8 lists OSHA's Permissible Exposure Limits (PELs); American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs); and any other exposure limit listed or recommended by the chemical manufacturer, importer, or employer preparing the SDS where available. This section also provide recommendations for appropriate engineering controls; personal protective measures to prevent illness or injury from exposure of chemicals, such as personal protective equipment (PPE) and any special requirement for protective clothing or respirator.

### **Section 9: Physical and chemical properties**

Section 9 lists the chemical's characteristics. The following information is included in this section: Appearance (physical state, color, etc.), Odor, pH, Melting point, Freezing point, Flash point, Evaporation rate, Flammability, Initial boiling point and boiling range, Vapor pressure, Vapor density, Relative density, Auto-ignition temperature, Decomposition temperature, and Viscosity. The SDS may or may not contain every item on this list due to the information either not be relevant or not be available.

### **Section 10: Stability and reactivity**

Section 10 lists the reactivity hazards of the chemical and chemical stability information. It includes the indicator of whether the chemical is stable under normal conditions, any stabilizers required to maintain chemical stability, conditions that should be avoided, possibility of hazardous reactions, and list of all classes of incompatible materials with which the chemical could react to produce a hazardous situation. For example, acetic acid is incompatible with oxidizing agents, soluble carbonates and phosphates, hydroxides, metals,

peroxides, permanganates, amines, alcohols, nitric acid and this information is available in section 10 of the SDS.

### **Section 11: Toxicological information**

Section 11 includes toxicological and health effects information or indicates that such data are not available. The required information in this section consists of: possible routes of exposures (inhalation, ingestion, skin or eye contact; descriptions of symptoms; delayed, immediate, or chronic effects from short/long-term exposure; numerical measures of toxicity (LD50 – the estimated amount of a substance expected to kill 50% of test animals in a single dose); and whether the chemical is listed as a potential carcinogen in the National Toxicology Program (NTP) Report, International Agency for Research on Cancer (IARC) or by OSHA.

### **Section 12: Ecological information**

Section 12 includes the environmental impact of the chemical(s), which include toxicity test data performed on aquatic and terrestrial organisms. This also provide information about the persistence of chemical as it or in degraded form, the potential for a substance to move from soil to the groundwater (leaching studies) and other adverse effects (e.g. environmental fate, ozone layer depletion potential, photochemical ozone creation potential etc.).

### **Section 13: Disposal considerations**

Section 13 includes guidance on disposal process, recycling or reclamation of the chemical or the container, and safe handling practices. To minimize exposure, this section should also refer the reader to section 8 (Exposure Controls/Personal Protection) of the SDS. This section provide important



information whether or not a chemical is suitable for sewage disposal or have any special precautions for landfills or incineration recommendations/activities.

#### **Section 14: Transport information**

Section 14 provides guidance for shipping and transporting hazardous chemicals by road, air, rail or sea. This information may include UN number (four-figure identification number of the substance), UN shipping name, transport hazard class(es), degree, packing group number (if applicable), environmental hazards (if any), guidance on transport in bulk or any special precautions required for transportation of the chemical.

#### **Section 15: Regulatory information**

Section 15 identifies safety, health and environmental regulations specific for a chemical that have not been discussed in the SDS. Any national and/or regional regulatory information of the chemical or mixture (e.g. from OSHA, DOT, EPA etc.) is included in this section.

#### **Section 16: Other information**

Section 16 includes the date of preparation or last revision or any other information that is not included in any of the previous sections. Other useful information (e.g. HMIS rating, NFPA rating, Full-text of H-statements etc.) also may be included here.

The employers must ensure that the SDSs are readily accessible to employees for all hazardous chemicals at their workplace. Employers may keep the SDSs

in a binder or on computer as long as employees have immediate access to the information. SDS should be consulted, when a lab is planning for a new experiment involving any hazardous chemical or gas. Understanding the SDS information can be very helpful in risk assessment, personnel/environmental protection and emergency management when designing new standard operating procedures of a hazardous chemical.

### **CONCLUSION:**

Safety is utmost priority in research labs. We have discussed the importance of access to safety information and the need for the undergraduate and graduate students to understand the safety information. This paper is a simplified and brief document for the students to understand the elements of GHS labelling system, Hazard communication standard which otherwise is not included in detail in trainings. Every single measure taken to be more aware can save a life. We hope this article will be helpful to new students to understand GHS, it's relevancy to HCS, chemical labels, hazard pictograms and SDS in simple and easy format.

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