3 . Hazards in the Laboratories

Categories:

I. Chemical hazards

II. Biological hazards

III. Physical hazards

IV. Organisational hazard: storage, handling, disposal, occupancy, etc.

GHS

Globally Harmonised System

- proposed by the United Nations.

- Worldwide uniform system of identifying hazards associated with substances and mixtures;

- Global classification criteria for substances and mixtures

United Nations Hazard Class

- Class 1. Explosives
- Class 2. Gases
- Class 3. Flammable liquids
- Class 4. Flammable solids
- Class 5. Oxidisers
- Class 6. Poisons
- Class 7. Radioactive materials
- Class 8. Corrosives
- Class 9. Miscellaneous

Hazard Classifications - 1

Class 1 Explosives

Typical Causes of explosions:

1. Runaway chemical reactions
2. A burst high-pressure vessel
3. A reactive metal making contact with water

Hazard classification:

0: no hazard

1: Slight hazard

2: moderate hazard

Hazard Classifications – 2 and 3

Class 2 Gases

- 2.1 Flammable gases (e.g. H_2, butane)
- 2.2 Non flammable compressed gases (Ar,He)
- 2.3 Poisonous (SO_2, NH_3, Cl_2)

Class 3 Flammable Liquids

- 3.1 Extremely Flammable Liquid and Vapor
- 3.2 Highly Flammable Liquid and Vapor
- 3.3 Flammable Liquid and Vapor
  - (Flash point (1) <23°C; (2)< 35 °C; (3) > 35 °C)

Hazard Classifications – 4 and 5

Class 4 Flammable Solids

- 4.1 Flammable
- 4.2 Combustible
- 4.3 Dangerous when wet

Class 5 Oxidisers

Definition: Causes other materials to burn by supplying oxygen to them.

- 5.1 Oxidiser (general)

Hazard Classifications- 6, 7, 8

Class 6 Poisons

- 6.1 Fatal if swallowed
- 6.2 Toxic if swallowed

Class 7 Radioactive (see later)

Class 8 Corrosives

- 8.1 Causes severe skin burns and eye damage
- 8.2 Causes skin irritation

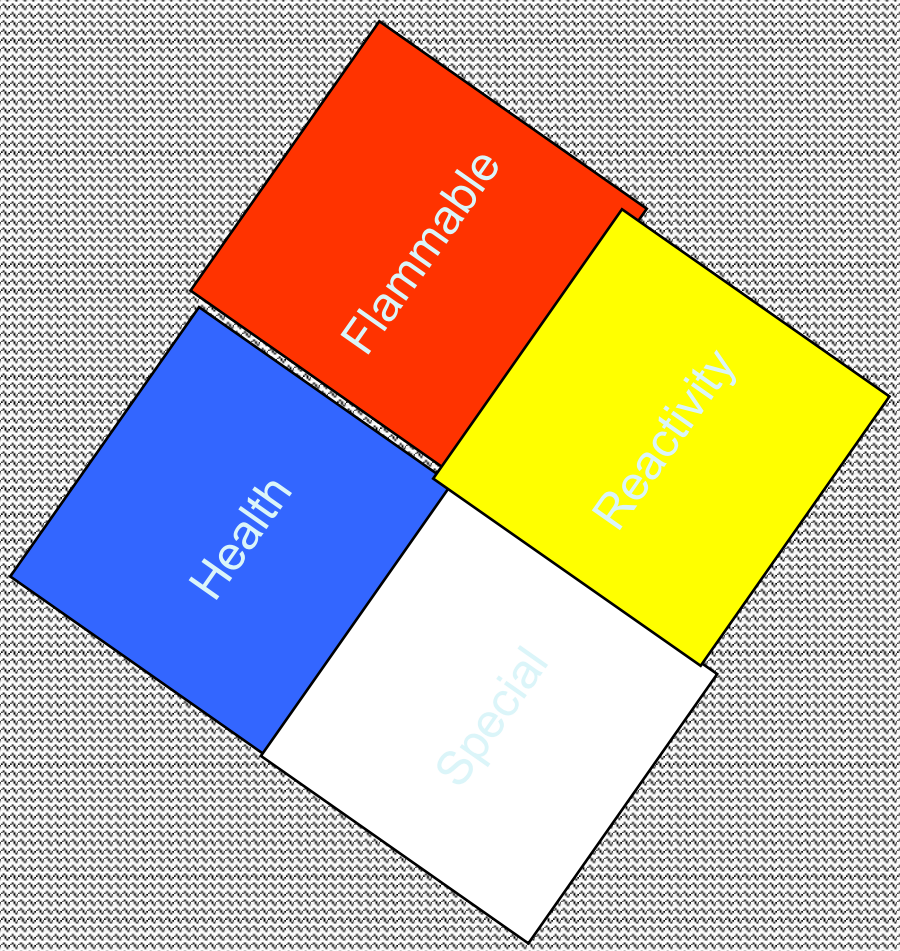
2_1: Chemical Hazards

A chemical hazard arises from contamination with harmful , or potentially harmful cl

Hazard Labels for Transporting and Storage

- Health Hazard
- Fire Hazard
- Reactivity Hazard

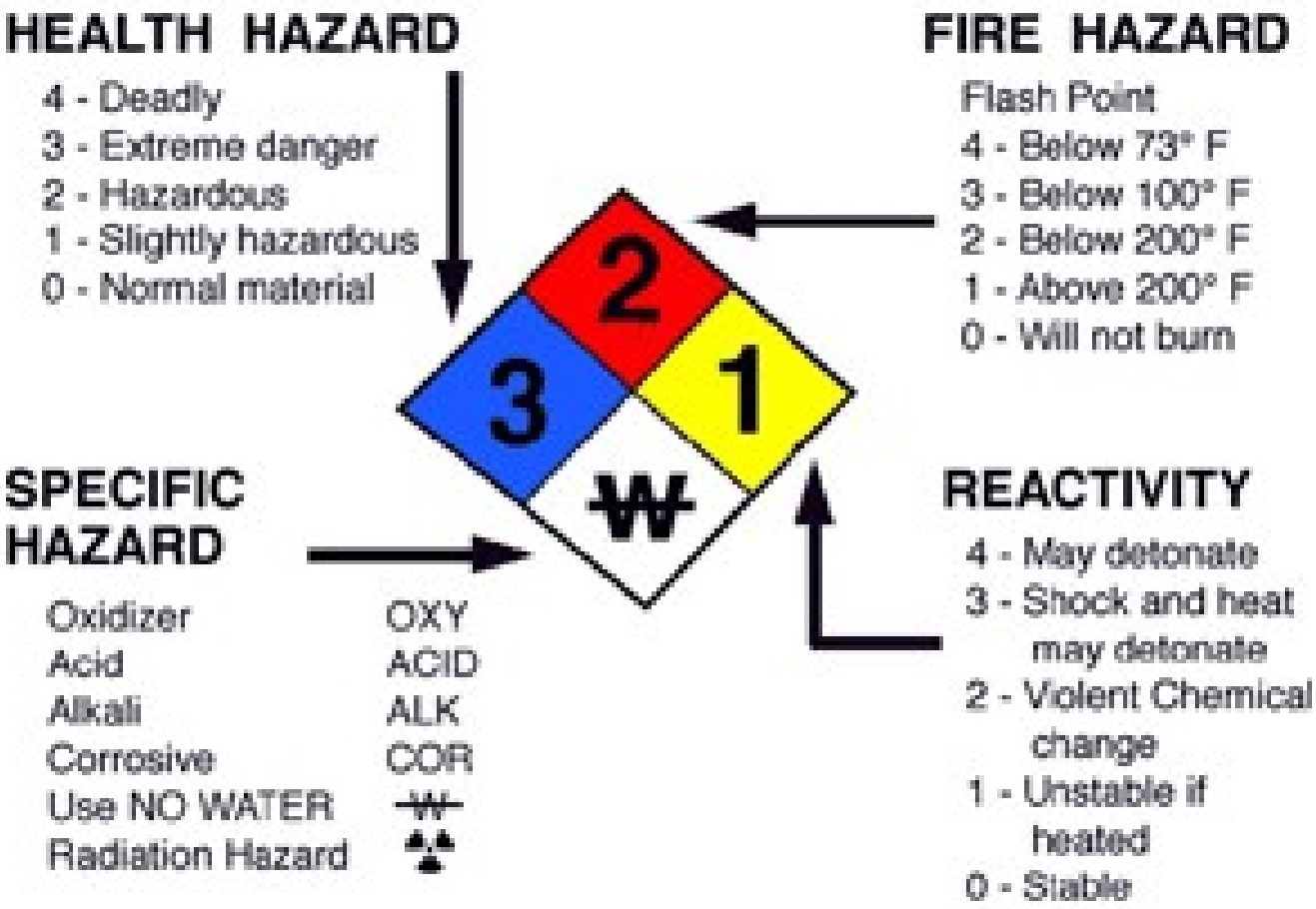
Other specific hazard



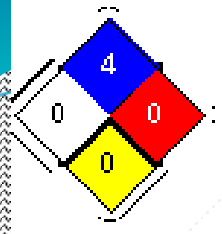
Blue: Health
Red:Fire
Yellow: Reactivity
White: Other particular

http://www.newenv.com/nfpa.htmd

http://www.newenv.com/nfpa.htm

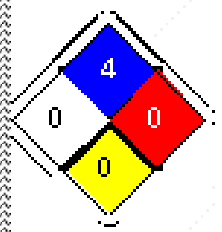


SPECIFIC CHEMICAL HAZARDS



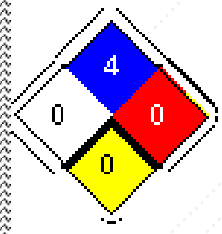
CARCINOGENS - (*cancer suspect agents*)

e.g. acrylonitrile, benzene, cadmium compounds



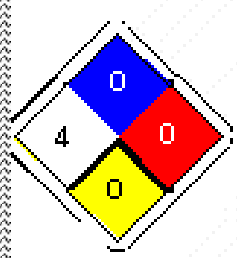
TERATOGENS - (*cause birth defects*)

e.g. carbon disulfide, lead, mercury, radioactive substances



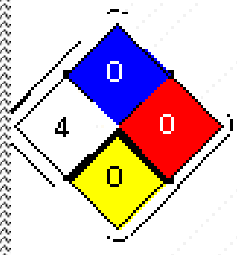
TOXIC COMPOUNDS - (*dangerous if inhaled, swallowed, or skin-absorbed*)

e.g. phenol, oxalic acid, arsenic compounds, barium compounds



WATER REACTIVE CHEMICALS -(*may react to yield toxic or flammable gases*)

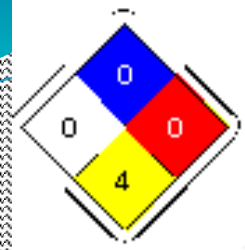
e.g. aluminum chloride, potassium metal, calcium carbide



OXIDIZERS - (*keep away from all reducing agents and comubstible organics*)

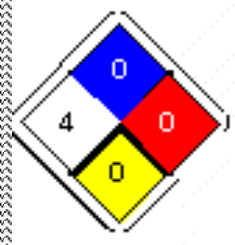
e.g. nitrate salts, perchlorates, bromine, permanganates

SPECIFIC CHEMICAL HAZARDS, cont'd.



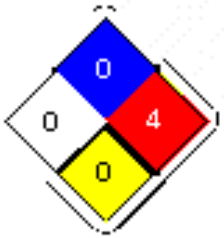
PEROXIDE FORMING CHEMICALS - (*can form explosive peroxides over time*)

e.g. ethyl ether, acrylaldehyde, potassium



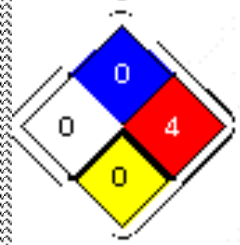
LIGHT SENSITIVE CHEMICALS - (*store in dark places in amber bottles*)

e.g. bromine, silver salts, mercuric salts



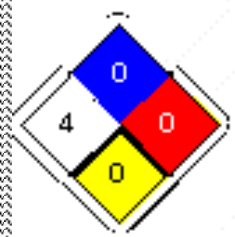
PYROPHORIC SUBSTANCES - (*ignite spontaneously in air*)

e.g. boron, cadmium, calcium, yellow phosphorous



FLAMMABLES - (*keep away from all ignition sources*)

e.g. benzoyl peroxide, ethanol, furan, isopropanol

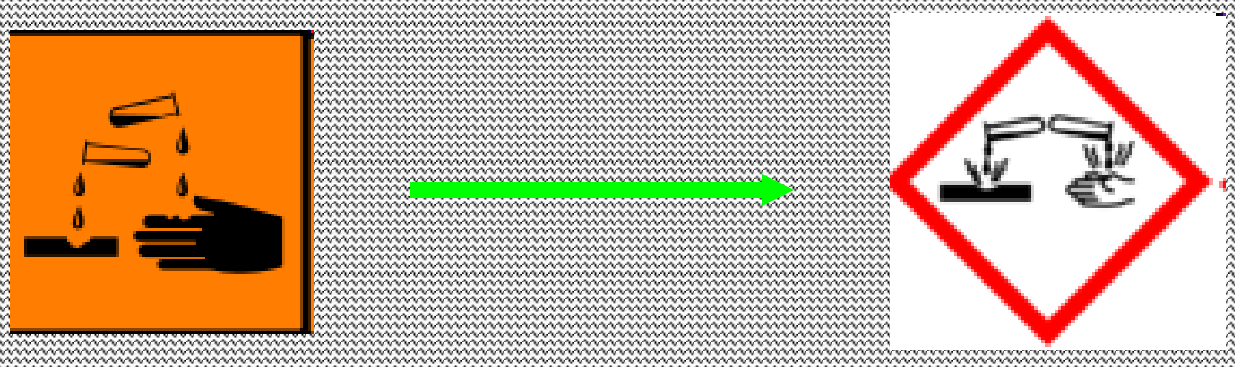


CORROSIVES - (*store away from all reactive metals*)

e.g. all acids and bases

New Regulations coming into force

- CLP represents Regulation (EC) no. 1272/2008 on the Classification, Labelling and Packaging of substances and mixtures.
- The orange hazard symbols are replaced by a diamond with a white background, red border and the symbol



The new pictograms

GHS 01 exploding bomb	GHS 02 flame	GHS 03 flame above circle
		
GHS 04 gas flask	GHS 05 caustic effect	GHS 05 skull and crossbones
		
GHS 07 exclamation mark	GHS 08 health hazardous	GHS 09 environment
		

Typical chemical label

- Name, address, telephone number of the supplier
- Product identifiers (including CAS No. (Chemical Abstract Service)
- Hazard pictograms
- Signal word
- *Hazard* statements and *precautionary* statements
- Supplementary information

These signal words are "Warning" and "Danger" depending on the category of the hazard class

- Hazard diamond

Hazard statements and *precautionary* statements

Hazard Statements:

- *H200-H299* Physical hazard
- *H300-H399* Health hazard
- *H400-H499* Environment hazard

Precautionary Statements

- *P100s* General
- *P200s* Prevention
- *P300s* Response

Typical chemical label

ACETONE

(Dimethyl Ketone, CAS 67-64-1)

DANGER ! EXTREMELY FLAMMABLE 

Acute: **CAUSES IRRITATION OF EYES, SKIN AND MUCOUS MEMBRANES.**

Chronic: **EXPOSURE TO LIQUID MAY CAUSE DERMATITIS.**

Keep away from heat, sparks and flame. Avoid contact with eyes, skin, and clothing. Keep container closed. Use with adequate ventilation. Wash thoroughly after handling.

FIRST AID:

IMMEDIATELY CALL POISON CONTROL CENTER OR HOSPITAL EMERGENCY ROOM.

IF CONTACTED: Immediately flush eyes with plenty of water for at least 15 minutes. Wash skin with soap and plenty of water. GET MEDICAL ATTENTION for eyes. Wash clothing before reuse.

IF INHALED: Remove to fresh air. If not breathing, give artificial resuscitation.

IF SWALLOWED: Give water to dilute. CONSULT POISON CONTROL CENTER OR HOSPITAL EMERGENCY ROOM. Never give anything by mouth to an unconscious or convulsive person.

HCL®

530-1

Handling and Use of Chemicals,

Potentially extremely hazardous !

1. Plan work carefully and do HAZARD ANALYSIS
2. Use Personal Protective Equipment (PPE)
3. If the release of toxic/hazardous substances may occur, work in a fume hood
4. Use explosion shield if there is a possibility of a violent reaction

Handling and Use of Chemicals – Continued

5) Chemicals should be handled carefully at all times - opened containers should be closed after use
6) Do not hurry unnecessarily or compromise on safety. **Take time to label temporary containers**
7) Do not work alone
8) Consider the activity of others
9) Follow all safety and emergency procedures

Flammable chemicals

Typical flammable chemicals are organic solvents. These are volatile (low b.p.) liquids, for example: alcohols, ethers, aldehydes, hydrocarbons

Hazard:

Organic solvents and their vapours can be ignited by

- flame
- contact with hot surface
- sparks from electrical contacts
- static discharge

How to work with them:

Flammable organic solvents must be heated in a round

Flammable chemicals

DEFINITIONS

Flammable:

Will catch fire without heating. A flammable solid can ignite easily and readily and burn vigorously.

Combustible:

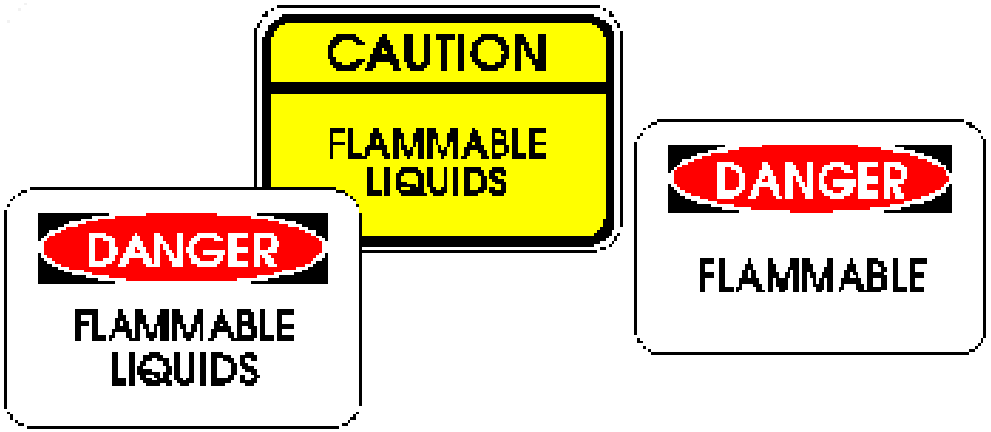
Will catch fire when heated.

Flash Point:

Lowest temperature at which a liquid gives off sufficient

FLAMMABILITY HAZARDS

- Never use an open flame around flammable liquids.
- Store flammable liquids in fire cabinets.
- When working with flammable chemicals, be certain that there are no sources of ignition near enough to cause a fire or explosion in the event of a vapor release or liquid spill.
- Always have vermiculite, absorbent pillows, or some other chemical absorbent available in the event of a spill.



Explosive chemicals

Some chemicals react violently under certain conditions e.g.

1) hydrogen peroxide can decompose violently - stopper must be left loose

2) sodium metal, potassium metal and aluminium chloride can react violently with water

Toxic chemicals

These may enter the body through various routes

1. by skin absorption

Precautions:

- must wear gloves
- if chemicals do come into contact with skin, area should be washed with water
- cuts should be covered when in the laboratory

Toxic chemicals

2. by the respiratory tract (inhalation)

(certain solvents and other volatile compounds give off vapours which can be dangerous if inhaled)

Precautions:

- must be handled in fume hood

3. through the digestive system (ingestion)

Precautions:

- follow rules on food and drink in the lab.
- Avoid oral contact with pencils and pens

Corrosive chemicals

Concentrated acids or bases have a corrosive or caustic effect. Examples of corrosive chemicals include:

conc. sulfuric acid, conc. nitric acid, conc hydrochloric acid, glacial acetic acid, sodium hydroxide, ammonium hydroxide

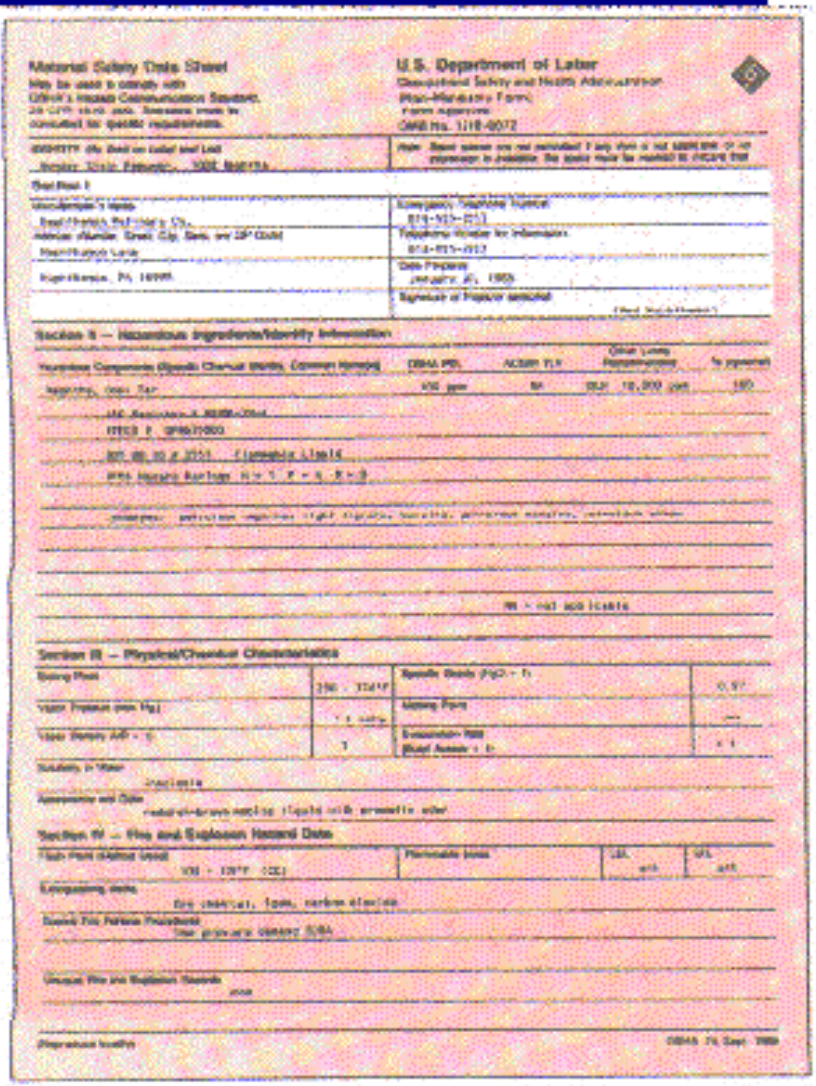
DEFINITION of "CORROSIVE":

Can attack and chemically destroy exposed tissue.

Hazard: can cause severe burns as soon as they touch skin, eyes etc

Precautions: dilute solutions of acid or base should be made up carefully by adding the concentrated acid or base to the water

MATERIAL SAFETY DATA SHEETS (MSDS)



All manufactured chemicals must be accompanied by one copy of a Material Safety Data Sheets packet on shipment.

By law, you have right to know about any hazards associated with storing and manipulating the chemical, and the MSDS must be available to you any time you use the compound.

Our department keeps all received MSDSs on file as hard copies, but most are available on-line by accessing various internet sites.

http://www.chem.utah.edu/MSDS/msds.html

http://www.hazard.com/msds

Material Safety Data Sheets (MSDS)

Information on the MSDS is organized in several sections as follows:

1) **Identity** The chemical name, trade name and manufacturers name, address and emergency phone number can be found here.
2) **Hazardous Ingredients** Hazardous ingredients are identified here.
3) **Physical and Chemical Characteristics** Boiling/Melting point, vapor pressure and density, water solubility, and appearance/odour can be found here.

Material Safety Data Sheets (MSDS)

4) **Fire Data** Flash point, flammable limits, extinguishing media, unusual fire/explosion hazards, and any special fire fighting equipment are listed here.

5) **Health Data** Routes of entry (inhalation, ingestion, etc…), effects from short and long term exposure, emergency and first aid procedures fall in this section.

6) **Reactivity Data** Stability, incompatible materials, hazardous decomposition are among the topics in this area.

Material Safety Data Sheets (MSDS)

7) **<u>Storage and Handling</u>** Precautions needed when handling/storing materials here. And advice about storage.

8) **<u>Spill Precaution Information</u>** Clean-up procedures; any personal protective equipment (PPE), ventilation, and work/hygiene practices are noted here.

- NOTE: another useful Website for MSDS sheets: www.sigmaaldrich.com

2_II: Biological Hazards

A biological hazard (biohazard) is an organism or a by-product from an organism that is harmful or potentially harmful.

Biological Hazards - *4 routes of exposure*

(1) Contact with skin or mucous membranes

- control of contact exposure by wearing PPE

(2) Ingestion

- no mouth pipetting/eating. Good hygiene

(3) Inhalation

- aerosols are primary means by which infectious diseases are spread, procedures include centrifuging, blending

(4) Inoculation

Biological Hazards

- There are four levels depending on seriousness of pathogen
- Known as Biosafety Levels (BSL) or Pathogen Levels(P)
  - BSL1.....BSL4 or P1.....P4
- In coarse terms:
  - BSL1 is pretty innocuous
  - BSL2 equates to a moderate potential hazard, you might need to see a doctor
  - BSL3 are pathogens that are potentially fatal but for which we have treatments
  - BSL4 are pathogens that are potentially fatal and for which we have no treatment

Biological Hazards

- For each level, the precautions are as follows:
  - BSL1
    - PPE of gloves and facemask
    - Can work on an open bench
    - Normal procedures of good hygiene (washing hands etc)
    - Can dispose of material in an autoclave
  - BSL2
    - Need specialist training to work with these
    - Access to work area is limited
    - Work under fume hoods
    - Special care taken with working with sharps

Biological Hazards

- For each level, the precautions are as follows:
  - BSL3
    - Work in fumehoods or glove boxes
    - Air and water supplies filtered before disposal
    - Need expertise in specific pathogen
    - Restrict access with double doors
  - BSL4
    - Limited number of BSL4 facilities worldwide (about 50)
    - Wear positive pressure suit (like a space suit)
    - Segregated air and water supply (scrubbed and recycled)
    - Sealed, multiple doors
    - Multiple showers

Biological Hazards

- Examples of pathogens from each level:
  - BSL1
    - Common cold
    - Chicken pox
  - BSL2
    - Measles
    - Mumps
    - Salmonella
    - Lyme Disease
    - Hepatitus
  - BSL3
    - Typhus
    - Tuberculosis
    - HIV
    - Malaria
    - Sleeping Sickness
    - Black Death
    - Rabies
    - SARS
    - Influenza
    - Anthrax
  - BSL4
    - Smallpox
    - Ebola
    - Marburg Virus
    - Lassa Fever

Microbiology Laboratory Safety Rules

ESSENTIAL RULES:

General Rules:

1. Wear PPE appropriate to the level of hazard
2. Get into the habit of classifying everything as sterile or contaminated and treat it appropriately
3. Treat all cultures as pathogens i.e. disease causing and observe the following precautions.

Specific Procedures – cont'd

6. All culture vessels, Petri dishes containing cultures etc. must be labelled with the organism name, culture medium and your initials

7. In the event of spillage of a culture, cover the area immediately with disinfectant and notify the person in charge of your class

8. Work safely with acids and bases used for adjusting pH

9. Avoid burns from hot media when pouring

10. Organic Solvents

    Most dangerous solvent used is phenol, always use gloves

Safety Procedures – Specific Procedures

1. Always wash your hands before entering and immediately after leaving the laboratory

2. Do not place anything in your mouth while in the laboratory, includes pencils, fingers, food etc.

3. Swab your bench with disinfectant solution at the beginning and end of each practical period

4. Keep all test-tubes containing cultures upright in the test-tube racks provided

5. Cultures must be handled with care and respect. Never remove a culture from the laboratory

2_III: Physical Hazards

A material or a situation or a machine that is potentially harmful from consideration of:

structure, temperature, electrical, radiation , fire .

Physical Hazards

- Electrical

High Voltage Electricity

e.g. high voltages used in electrophoresis

- Heat

e.g. Hot-plates, water baths, furnaces

- Radiation

e.g. Laser beam, ionising radiation (α, β, γ rays)

- Sharps:

Electrical Safety

- Because of the inherent hazards of working with electricity, the following procedures are provided to help identify safe work practices:

1. Electrical service cords should be in good condition
2. all electrical equipment must be grounded, use 3-pronged plugs
3. All power supplies should carry the correctly rated fuse
4. Electrical equipment such as mixers or hot plates should not be used near flammable solvents

Electrical Safety

5. Adequate space should be allowed around electrical apparatus for ventilation purposes.
6. all electrical repairs should be made by qualified personnel
7. Well-soled shoes should be worn when working with electrical apparatus
8. Water can turn anything into an electrical conductor - don't stand in water or have water on your hands when using electrical equipment
9. In case of an electrical fire, don't touch the burning object or douse it with water. Turn off power if possible.

It is the current that kills!

- $I = V / R$

Current drawn by the body

= Voltage / resistance of path through the body

Typical body resistance = resistance of skin + internal body

Internal body resistance: ≈ 400 Ω

Resistance of skin: ≈ 10 k Ω when dry

≈ 1 k Ω when wet

It is the current that kills!

Definitions:

- Shock Intensity: The current, in mA, producing the shock
- Threshold of Sensation: ~ 0.5 mA

  (got when fault in machines using high V, small A)
- No Let Go Current: For men: ~ 16 mA; for women ~ 10 mA (current at which person cannot let go the appliance)
- Constriction of Respiratory Muscles: > 25 mA

  (breathing can be restored by treatment)

Hazards Associated with Heat

1. Gas burners should not be left un-attended. The main gas supply to burners should be turned off when gas not in use.

2. Thermal gloves should be worn when handling hot water, steam or hot plates.

3. Heat resistant gloves and long tongs should be used when hot objects are being removed from a furnace.

Hazards associated with sharp objects

Sharps:

- Tools : saws, blades, screw-drivers etc.
- Flying debris: splinters of glass, metal etc.

Waste consisting of small sharps should be disposed of into a dedicated “sharps” container.

Radiation Safety

- Common radiative decay products:
- (i) ALPHA PARTICLES (α);
- (ii) BETA PARTICLES (β);
- (iii) POSITRONS (β+);
- (iv) NEUTRONS (n);
- (v) GAMMA RAYS (γ).

Radioactive decay of a nucleus can produce any of these particles or can produce gamma rays. Sometimes the decay reaction also produces energy.

Biological Effects of Radiation

- Ionising Effectiveness:

  α > fast n > β > γ, X rays.

- Heat/ Burning:

Non-ionising radiation (visible light, microwave) heats biological tissue.

UV is somewhat more dangerous than visible *(because of higher energy)*.

Ionising radiation ~104 - 107 times more dangerous than typical non-ionising radiation.

Ionising radiation produces reactive chemicals (radicals) in the

Biological effects: Factors involved in Radiation Damage

1) Ability to penetrate into biological system;
   - External α will not penetrate, but skin takes all the dose;
   - Ingested α will harm GIT inner surface, and will cause systemic damage if absorbed.

2) Energy of radiation:
   - For all types, as energy increases, penetration and damage also increases.

3) Type of particle:

Radiation Dose

UNIT	BASIS
rad (radiation absorbed dose)	1 rad = absorbed dose of 10^{-2} J/kg
gray (Gy)	S.I. absorbed unit dose (1 Gy = 1 J/kg = 100 rad)
rem (rontgen equivalent in man) Effective dose in rem = dose in rad x RBE	Effective dose depending on type of radiation/ particle.

RBE (Relative Biological Effectiveness)

There is a value for RBE for each type of radiation.

It allows a comparison to be made between the relative damage done by different types of radiation to biological tissue.

The RBE for a particular radiation is defined as the number of rads of X-rays or γ-rays that would produce the same biological damage as 1 rad of the given radiation.

Radiation Type	RBE
X-rays or γ-rays	1
Beta particles	1.2

Biological effects:

- Natural Background 300 mrem/y
- Mammogram 80 mrem
- Chest x-ray 30 mrem
- Dental x-ray 3 mrem

What is a safe dose?

- No clear definition
- Avoid all unnecessary exposure
-

Storage and Handling of Radiation Sources

- For each different type of source there is an activity limit (e.g. ≥ 10 kBq for Sr-90; ≥ 100 kBq for Co-60) above which the source must be covered by a licence from RPII.

The license lists:

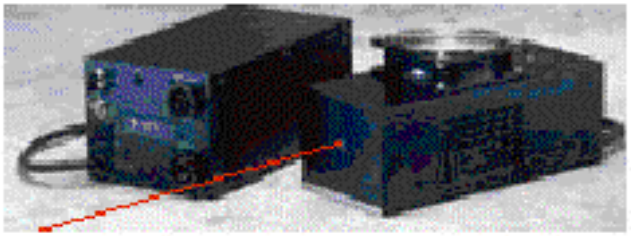
- - the sources and their activity
- - the RPO (Radiological Protection Officer) on site
- - the name of the site/location of the sources
- - Ionising sources not in use for more than 3 months must be converted into 'Custody Only' status (by completion of appropriate form) and submission to RPII

General Radiation Safety Measures

1. No food or drink in radiation area;
2. Radioactive substances should be treated as poison;
3. Have decontaminants available at all times;
4. Use gloves as physical barrier where appropriate;
5. Minimize exposure and maximize working

Laser Safety

LASER SAFETY



- Warning signs must be posted on any laboratory using lasers; no unauthorized guests (including custodians).

- Never look down the barrel of any laser as it can permanently damage your eye. Even low energy (He-Ne) lasers can cause eye damage.

- Avoid specular (polished) reflections of the beam as they will damage the eye.

- Protect your eyes:
  - Ar laser; use amber plexiglass glasses or ruby-tinted plastic.
  - CO2 laser; 2mm fused quartz plates will protect against this invisible beam. Also, hands and clothing must not intercept the beam.
  - He-Ne laser; BG-18 glass will protect the eyes.

Hazard Identification and Risk Assessment

Defintions:

HAZARD: something with the potential to cause harm

RISK ASSESSMENT: evaluation of the likelihood that harm could arise from the hazard and the likely severity and extent of the harm.

Hazard associated with

- <u>The place</u>

  - where equipment is or where experiment is to be done

✓ <u>The Equipment and/or Reagents</u>

- physical danger from apparatus;
- Chemical Hazards
- Biological Hazards

✓ <u>The system of work</u>

- How the experiment is being done

✓ The people

Risk Analysis

Assess risk:

Risk = inherent danger x exposure

Exposure: number of people

frequency of exposure

length of exposure time

Risk Rating: HIGH, MEDUIM or LOW

Risk Rating – another approach

Risk rating has to be estimated.

Can be done as follows:

Give a rating between 1 and 10 to the Likelihood, L

Give a rating between 1 and 10 to the severity, S

Overall Risk Rating given by HRN

HRN (Hazard Rating Number) = L x S

If HRN < 26 ..... Risk Rating LOW

Likelihood and Severity Tables

Rating	Likelihood	Examples
10	Certain	No control measures provided; Hazard difficult to see
8	Very likely	Control measures depend on user and no training is provided
6	Likely	Control measures depend on user but training IS provided
4	May happen	The control measure does not depend on user but it can break down
2	Unlikely	Definite system of supervision and maintenance
1	Very unlikely	

Likelihood and Severity Tables

Rating	Severity	Examples
10	Multiple deaths	Toxic vapours
8	Single death	Fall from a height; electrocution
6	Major disabling injury e.g. Amputation, loss of eye	Fall, laser , acid
4	Injury requiring time off work	Acid, slip/trip, cut
2	Minor injury	Scratch, bruise, cut
1	Delay only	