

**Campus Occupational Safety and Health knowledge and education training promotion program of the Ministry of Education**

Management of Laboratory Safety and Health  
A1 Campus Safety and Health Foundation

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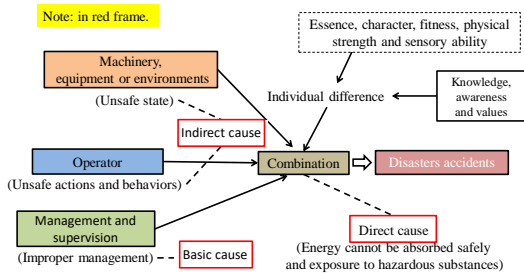
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**I. Introduction**

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**Three major causes of disasters accidents**



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**Accidents or incidents occur frequently in the laboratory**

**How to prevent it?**

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## Environmental characteristics of the laboratory

- Stored and placed kinds of hazardous, harmful or toxic chemical substances
- Operating machinery requires proper protection and safe operating procedures
- High turnover rate of staff or personnel
- Operate various experiments in laboratory
- Engaged in new research and development with unknown high risk
- Numerous machinery and equipment

## The importance of safety and hygiene in laboratory

The top five factors of accidents related to experimental sites **in colleges and universities:**

- Hazardous substances (20.1%)
- Electrical equipment (12.3%)
- Chemical equipment (11.7%)
- Material (6.5%)
- Others (24.0%)

## The importance of safety and hygiene in laboratory (cont.)

The top factors of accidents related to experimental sites **in senior high school:**

- General power machinery(18.7%)
- Manpower tools / hand tools (14.2%)
- Other machinery (11.2%)
- Appliance (8.2%)
- Material (7.5%)
- Others (9.0%)

## II. Common laboratory hazards

### Potential laboratory hazards

- Physical hazards: noise, vibration, radiation, electricity, mechanical hazards
- Chemical hazards: fire, explosion
- Biological hazards: infection, poisoning, allergy
- Human-factor hazards: accumulated musculoskeletal disorder
- Psychological hazard: pressure related to work sheet, burnout, etc.



### Physical hazards

- Definition: Hazards to human body damage caused by **physical energy**, such as noise, radiation, abnormal temperature, vibration, lighting, and abnormal air pressure.

## Noise hazards

- Definition: Sounds make people feel unpleasant or high decibel may cause auditory hazards and other adverse physical or psychological reactions
- Source: mechanical operation...
- Health hazard:
  - hearing loss: temporary or permanent in nature
  - Physiological and psychological effect: increased blood pressure and increased heart rate, etc.



## Non-ionizing radiation hazard

- Definition: The energy of electromagnetic radiation is less than 10 electron volts (eV), not enough energy to ionize atoms or molecules
- Source: ultraviolet ray, infrared, microwave, laser, etc.
- Health hazards: **Thermal hazards** (skin, eyes, etc.)

Laser equipment



UV germicidal lamp



## Source of Non-ionizing radiation in experimental sites

- Ultraviolet: UV germicidal lamp in biosafety cabinets and ceilings of certain biological laboratories, etc.
- Infrared: Infrared drying equipment and oven, etc.
- Microwave: Microwave digestion, open microwave heating equipment, etc.
- Laser: Laser optical equipment, etc.

## Abnormal temperature

- Sources:
  - Contact with utensils being heated
  - Use of **liquid nitrogen** (boiling point at -196°C, brief contact with skin or eyes could cause frostbite or blindness)
  - Use of freezer, etc.
- Health hazard: **Scald** and frostbite
- Preventive methods: In line with status of hazard, wear proper-grade heat-resistant gloves or cold-resistant gloves and protective goggles, as well as other protective gears.

## Electricity hazard

- Definition: Injuries caused by contact of human body or equipment with **electric current** or electric current-induced **high temperature**.

Unsafe electric facility



## Electrical hazards (cont.)

- Electrical hazards in experimental sites:
  - **Inductive disaster**  
The hazard caused by a part of the human body touching a power source to form an electrical circuit
  - **Burn caused by electric arc**  
Short, grounding and flashover of circuit or electrical equipment all might cause the electric arc to burn a human body

## Electrical hazards (cont.)

- Electrical hazards in experimental sites:
  - **Electricity-induced fire**  
The hazard caused by high temperature and heat from overloaded, short-circuited, poor connection circuit or electrical equipment
- **Check arrangement of circuits in laboratories regularly.**

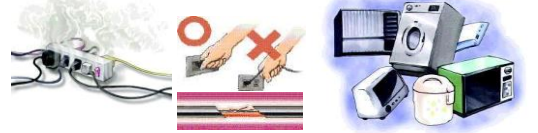
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## Electrical hazards (cont.)

- Electrical hazards in life:

Overload current on the extension cord

Avoid high-power electric appliances sharing the same set of sockets



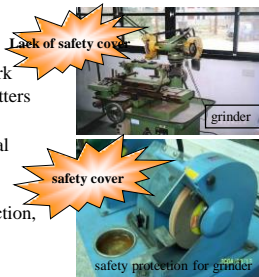
Incorrect usage cause damage on the wire and poor connection

<http://www.klfd.gov.tw>

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## Mechanical hazards

- Definition: hazards caused by mechanical movement of mechanical parts, tools, or work pieces or injection of solid matters or liquid.
- Types of laboratory mechanical hazards: including squeezing, scission, cutting, winching, trapping, impact, stabbing, friction, high-pressure liquid injection, tripping, or falling.



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## Chemical hazards

- Hazardous: Poisoning or corrosion caused by **contact with chemicals** via inhalation, eating, injection or spray on skin, or other channels.
- Dangerous: Disasters, such as fire and explosion, caused by **energy** released from chemical reaction during use of chemicals.



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## Biological hazards

- **Plants, animals, microorganisms**, or their **derivates** with high potential for affecting human health or causing discomfort.
- Sources: Needlestick injury, inhalation of aerosol containing pathogens deriving from mistake in handling biological specimens, or biting or scratching by pathogen-carrying experimental animals.
- Types of biological hazards:
  - **Infection**
  - **Allergy**
  - **Poisoning**



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## Types of biological hazards

- Infection: caused by organisms multiplying and growing in the human body (e.g. influenza, measles, tuberculosis).
- Allergy: caused by repeated exposure of an organism as an allergen to the body 's immune system (e.g. allergic pneumonia, asthma, allergic rhinitis).
- Poisoning: caused by exposure to toxins (bacterial endotoxin, bacterial exotoxin, mycotoxins) produced by organisms (e.g. fever, chills, impaired lung function)

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## Human Factors/Ergonomics Engineering

- Understand environmental features, human capabilities, and restriction
- Improvement of environment and tools to increase work efficiency, safety, and comfort

**Fit the machine to the person !**

## Human-factor hazards

- **Inadequate human-machine interface:** Inadequate machine interface design leads to higher error rate or human injuries
  - Computer usage
- **Muscle/bone injury (cumulative trauma disorder, CTD):** musculoskeletal disorder injury, mostly in upper body, caused by **long-term repetitive and unnatural movements**
  - Low back pain, carpal tunnel syndrome, tennis elbow
- **Human error:** Erroneous movements or damage of foolproof device caused by such human factors as emotion, lack of attention, and fatigue



## Emergency preparedness cabinets

- Appropriate protective equipment should be prepared in advance for the types of laboratory experiments, equipment and experimental materials (chemical substances, etc.):
  - Personal protective equipment
  - Chemical absorbent
  - First aid kit
- Emergency preparedness equipment cabinet **cannot be locked**
- Pay attention to the **shelf life** of various equipment and protective drugs

Occupational safety and health facilities regulations

## Emergency eyewash and shower device

- Need to be familiar with its **location and usage**
- **The main switch cannot be closed**
- No debris around
- **Regular testing** is required to confirm that the function can be used normally
- **Sewage collection facilities** should be provided
- Avoid **power sockets** nearby, otherwise a **protective cover** should be installed



Occupational safety and health facilities regulations & Specific chemical substance hazard prevention regulations

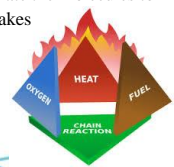
## Four essential elements of fire

- Fuel: Flammable substances such as wood, coal, gasoline, gas or dust reach the lower explosive limit (LEL)
- Oxygen: Air is the main **source of oxygen**. Oxygen in oxidizing substances may also become a **source of oxygen** during high temperature combustion.



## Four essential elements of fire

- Heat: Fuel must have a certain amount of heat to burn. The sources of heat may be open flames, electrical **sparks**, impact, friction, overheated objects, high-temperature surfaces, **spontaneous combustion**.
- Chain reaction: Chain reaction dissociate the molecules to generate unstable free radicals and makes the flame keeping burning



## Laboratory hazard

- Experimenters need to understand the characteristics of their own laboratory, assess the types of disasters and human injuries that may occur, conceive of emergency procedures and prepare related equipment and drugs.
- Common types of laboratory hazard:
  - Chemical leakage
  - Combustion



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## Laboratory hazard (cont.)

- Common types of laboratory hazard to human body:
  - Skin and eye contact with chemicals
  - Inhalation and ingestion of chemicals
  - Burns
  - Frostbite
  - Induction
  - Cutting and stabbing



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## Chemical spill response steps

- **Identify** the types and characteristics of chemicals
- If the leakage has risk of **acute poisoning** or fire explosion:
  - Should evacuate immediately and seek aid
- If the leakage does not cause an immediate danger:
  - If the chemical is **flammable**, immediately turn off all **ignition sources** and remove high-temperature equipment
  - If the leaked gas or liquid is **volatile**, should **open the window immediately** and **notify** the person in charge of the laboratory

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## Chemical spill response steps (cont.)

- If the leakage does not cause an immediate danger:
  - Wear appropriate **personal protective equipment**. Shut off the source of the leak and treat it with **an appropriate absorbent or absorbent cotton**
  - Containers** containing contaminated items (e.g, used absorbent), need to consider **the compatibility of materials and structural strength**

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## Fire response steps

- If the fire is too large, you should **evacuate immediately**, **turn off the main power supply**, implement the emergency notification procedure, and notify the fire brigade to request assistance to extinguish the fire
- **If the fire has not expanded**, **immediately turn off** the on-site **combustible gas container switch and power supply**, and remove the flammable materials and chemicals around as soon as possible

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## Fire response steps(cont.)

- **Confirm the type of fire** and select the appropriate fire extinguisher or fire blanket to extinguish the fire
- If the fire is caused by chemical leakage, try to prevent or reduce the spillage if the personnel can access it
- **Notify** the person in charge of the laboratory and relevant units in the school

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## First aid for exposure to infectious substances

- Situation:
  - Injures by needles or knives contaminated with infectious fluids
  - Infectious fluids contact mucous membranes or incomplete skin, or intact skin but for a long time
  - Bacterial and viral laboratory animal bites and scratches
- Before the experiment, the potential hazards should be evaluated based on the biological materials and experimental procedures, and preventive measures and first aid treatment procedures



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## First aid for exposure to infectious substances

- Treatment:
  - Squeeze the wound blood from the proximal end to the distal end
  - Clean the wound or contact area
  - Notify the laboratory manager and follow-up treatment according to the first aid procedure



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## Identification, evaluation, and control of laboratory hazards

- Identify, evaluate, and control laboratory hazards and set up emergency response procedure, to prevent disasters and minimize damages once disaster occurs.
  - Peruse and abide by laboratory **safety and Health work rules**.
  - Understand features of hazards related **to raw materials** in use, **machinery equipment**, **procedures**, and **environment of laboratory**, evaluate their safety and health risks, and adopt proper hazard control measures.

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## Identification, evaluation, and control of laboratory hazards (cont.)

- Evaluate possible types of disasters according to laboratory features, set up emergency response procedure, prepare necessary response and first-aid equipment, and conduct drill on emergency response procedure.
- Hazard prevention measures vary significantly among different types of laboratories, with common notices and measures listed below as reference

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## Laboratory safety and health work rules

- According to the characteristics and content of each laboratory
- Laboratory personnel must read the content thoroughly and follow it
- Since the type and content of school experiments often change over time, if you find that the content of the code is no longer necessary, please cooperate with laboratory management personnel to revise the content of the rules

Occupational safety and health facilities regulations & Enforcement Rules of the Occupational Safety and Health Act

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## Hazardous chemicals

- Hazardous matters (chemicals)
  - Understand hazard features, level of danger and hazard, transmission channel, and grades and kinds of related preventive equipment.
    - Information source: specifications on container and safety data sheet.
  - Assure conformance and environment and equipment to requirements and adopt correct experimental procedure.

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## Storage of chemicals

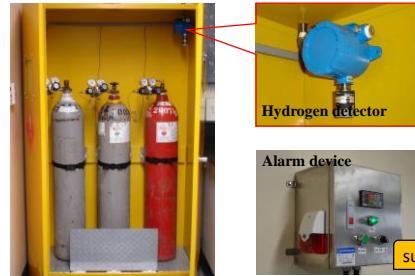
- Hazardous matters should be deposited according to their features (**volatility, inflammability, and compatibility**).
- Exhaust facilities of place for deposit of hazardous matters should be checked and maintained regularly.
- Place with deposit of massive volatile and inflammable liquid should be furnished with **inflammable-gas detectors**, which be checked regularly to assure their normal operation.



Fireproof explosion-proof cabinet

Occupational safety and health facilities regulations & Regulation of Prevention for Organic Solvent Poisoning

## Fire and explosion-proof cabinet for storing hydrogen cylinders



Hydrogen detector

Alarm device

supplement

Occupational safety and health facilities regulations

## Ventilation equipment

- Maintain good ventilation in laboratory.
- Volatile chemicals should be handled inside chemical hood.
- Handle microorganism with air-borne transmission capability inside a biological safety hood.
- Don't mix chemical exhaust tank with biological safe air tank, which has different function and structure.
- Don't place superfluous matters inside chemical exhaust tank to avoid blockage of air flow.



Chemical exhaust tank



Partial exhaust device

Occupational safety and health facilities regulations, Regulation of Prevention for Organic Solvent Poisoning and Specified Chemical Substances Hazard Prevention Standards

## Ventilation equipment (cont.)

- If operation of equipment may emit poisonous gas, connect drain to partial exhaust device.
- Check partial exhaust device and hood regularly (**once annually**, according to autonomous check measures) (such as for sufficiency of control wind speed)
- Stop experiment and seek help for repairing exhaust system, in case there occur following situations for the system:
  - damage of exhaust pipes
  - abnormal rotation speed of motor
  - blockage of filtering device
  - other possible abnormal symptoms (such as noise)

Occupational safety and health facilities regulations, Regulation of Prevention for Organic Solvent Poisoning and Specified Chemical Substances Hazard Prevention Standards

## Machinery equipment

- Understand features of hazards related to operation of various laboratory equipment (high temperature, percussion, noise, optical-energy injury, ionizing radiation), operating method, functions of various components, and significance of interface signals.
  - Information source: **instructions of instruments and equipment**
- Correct operation and maintenance
- In case abnormal situation appears, stop operation instantly.

## Pressure container

- Major points of notice for pressure containers (such as **high-temperature, high-pressure sterilizer**, air tank of air compressor):
  - Whether or not there is damage or deformation in case or interior?
  - Whether or not there is abnormality in the operation of container gate and packing device?



high-pressure sterilizer

Occupational Safety and Health Management Measures



## Pressure container (cont.)

- Whether or not there is abnormality in the function of safety valve, pressure gauge, and other safety devices?
- Whether or not there is damage in pressure gauge, thermometer, and other safety devices?



Occupational Safety and Health Management Measures

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## High-pressure gas container (such as steel gas cylinder)

- Major points of notice for steel gas cylinder
  - Whether or not horizontal support for high-pressure gas cylinder is fixed?
  - Whether or not pressures of various gauges are normal?
  - Where or not there are inflammable materials in the storage space for steel cylinder?

Wrench shouldn't be put on the switch of steel cylinder



Spare cylinder and empty cylinder should be furnished with cap

Occupational safety and health facilities regulations &

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## High-pressure gas container (such as steel gas cylinder) (cont.)

- Whether or not there are clear description of constituents of various steel cylinders?
- Whether or not there is leakage in connector?
- Whether or not temperature in storage space of steel cylinders exceeds 40 °C?

Wrench shouldn't be put on the switch of steel cylinder



Spare cylinder and empty cylinder should be furnished with cap

Occupational safety and health facilities regulations &

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## Toxic chemicals

- Package of containers for toxic chemicals should bear specifications as mandated and safety data sheet (SDS) for the chemicals.
- There should be sign "handling premises of toxic chemicals" at the entry/outlet of handling site.
- Maintain normal operation of anti-emission or -leakage facilities during the handling of toxic chemicals and prepare emergency response equipment.



Materials Safety Data Sheets for Toxic and Concerned Chemical Substances & Categories and Management of Handling for Toxic Chemical Substance

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## Toxic chemicals (cont.)

- Deposit toxic chemicals in airtight solid container and package which should be placed in storage site with good management.
  - Place for deposit of toxins should be locked.
- Check, maintain, and calibrate, with record, emergence response equipment, detector, and alarm equipment regularly.



Materials Safety Data Sheets for Toxic and Concerned Chemical Substances & Categories and Management of Handling for Toxic Chemical Substance

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## Toxic chemicals (cont.)

- Manage toxic chemicals in laboratory properly and assure consistency between stockpile and the amount on record.
- Units in academic institutions in charge of handling toxic chemicals should record handling status for toxic chemicals according to their nature and constituents in a log daily either in print or electronic form, except there is no change in the handling (volume) of such chemicals.
- Record in the log should be kept for three years for check, when necessary.

Regulations for Management of Toxic Chemical at Academic Institutions

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### Infectious biological materials

- Understand features of hazards, risk group, transmission channel, and grade and type of protective equipment.
  - Information source: measures governing infectious biological materials, safety code for biological safety grade 1-3 laboratories, biological safety data sheet
- Ascertain conformance of laboratory to the requirements of **biological safety level** and follow correct experimental procedures.

Ionizing Radiation Protection Act & Safety Standards for Protection against Ionizing Radiation

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### Infectious biological materials

- Laboratories need approval of biosafety committee or biosafety specialists for possession, keeping, or disposal of second- or higher-grade dangerous microorganisms or biological toxins.
- In addition to the aforementioned requirement, installation unit should obtain approval of central-level competent authority for the laboratory to possess, keep, or dispose third- or higher-level dangerous microorganisms or controlled biological toxins.

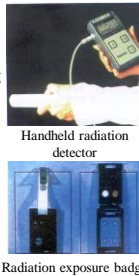
Regulations Governing Management of Infectious Biological Materials



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### Ionizing radiation operation

- Approval by or registration with competent authority is mandatory for operations involving radioactive materials (sealed, non-sealed radioactive source), ionizing-radiation equipment (e.g. X-ray machine) or radiation.
- Radiation operators should **bear radiation exposure badge** to prevent overdose exposure (or **monitoring of operating environment**).



Ionizing Radiation Protection Act & Safety Standards for Protection against Ionizing Radiation

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### Ionizing radiation operation (cont.)

- Detect radioactive materials and ionizing-radiation equipment and facilities at least once a year and submit the results to competent authority as reference.
- **Radiation warning sign**



Protective method for ionizing radiation & Safety standards for protection against ionizing radiation

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### Ionizing radiation operation (cont.)

- Laboratory should formulate proper **guidelines for protection and operation of ionizing radiation** and post it at conspicuous spot in working area.
- Demarcate proper **radiation control area**, subject to control measures, and conduct radiation detection in monitoring area, plus environmental radiation detection for area neighboring workplace.



Protective method for ionizing radiation & Safety standards for protection against ionizing radiation

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### Safety management 5+1S

Refer to effective management of production factors, including personnel, machine, materials, and method, at production site: Push 5+1S movement (sorting out, reorganization, sweeping, cleaning, education, safety)

Common points of notice for laboratory safety management\*  
Placement of matters at designated spots.

- Prepare two or more outlets, if possible, for workplace.

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### Safety management 5+1S (cont.)

- Take into account compatibility factor in waste classification.
- Opening of any chemical container shouldn't be set in the direction of persons.
- Clear marking: Place sign of chemicals and forbidding activation of machinery
- Electricity safety: Extension cord, ground connection

**An ounce of prevention is worth a pound of cure.**

**Good laboratory safety and health management  
greatly reduced the proportion of **injuries** and  
**accidents****

### Information source

- Compiled by Chung Yuan Christian University
- Edited by Yow-Jer Juang, Chang Jung Christian University
- References:
  1. Laboratory Safety and Hygiene Management - basic concepts  
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  2. Laboratory Safety and Hygiene Management - general education  
— Huan-Ping Chao, Department of Environmental Engineering,  
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