

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

B1 Basic concepts for the management of laboratory safety and Health

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- III. Types of laboratory disasters in senior high and vocational high schools
- IV. Notices for laboratory safety and Health in senior high and vocational high schools
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I. INTRODUCTION

Laboratory epitomizes workplace

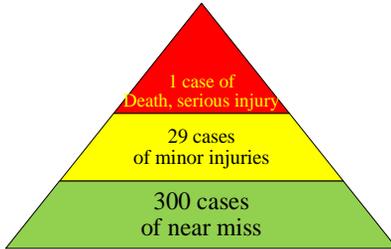
- The following matters and statuses involving safety and health risks may exist in laboratories, similar to workplaces:
 - Machinery equipment
 - Biological materials
 - Radioactive matters
 - Hazardous environment
 - Others

Laboratory epitomizes workplace



Source: final report, 101 counseling group

Heinrich-accident pyramid



II. LABORATORY ACCIDENTS

Potential Laboratory accidents

- 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.

Electricity hazard

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

Unsafe electric facility



Electricity hazard (cont.)

- Common electricity hazards in laboratories
 - Inductive disaster
 - Burn caused by electric arc
 - Electricity-induced fire
- Check arrangement of circuits in laboratories regularly.

Case: Death of student caused by induction during practice

- A technical college student died of electric shock during practice at a power-distribution workshop.
- When student A opened low-voltage switch box with charged circuit, his left chest contacted in mistake bare cord on the back of panel and died of 220V electric shock.



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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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Case: Student was producing work for exhibition, when his finger was severed

- A senior at a university was producing work for graduation exhibition, when he mistakenly severed a finger in operation of a thread sawing machine. He was rushed to a hospital, where a replantation of digits was performed successfully



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Noise hazards

- Source: mechanical operation...
- Health hazard:
 - Impairment of hearing loss: temporary or permanent in nature
 - Physiological and psychological effect: increased blood pressure and increased heart rate, etc.



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Common ionizing radiation hazards in laboratories

- Source: Use of radioactive elements, operation of instruments using radioactive elements, or operation of equipment which may produce ionizing radiation
- Health hazard:
 - Cancer, genetic effect
 - Cataract, skin injury, infertility



Outsiders are forbidden to enter laboratories with radiation mark. Po-210 Sealed radiation source

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Common non-ionizing radiation hazards in laboratories

- Source: ultraviolet ray, infrared, microwave, laser, etc.
- Health hazard: **thermal hazard** (skin, eyes, etc.)



Laser equipment



ultraviolet lamp

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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.

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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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Case: Destruction of laboratory by big fire caused by leakage of inflammable solvent

- Container holding four liters of **n-hexane** in a university laboratory cracked.
- When a graduate student was cleaning the leaked n-hexane with a mop, the vaporized chemical triggered the temperature-controlled switch of a nearby heating furnace, triggering a big fire in an instant.
- Fire brigade spent two and a half hours to extinguish the fire, before it destroyed three laboratories, inflicting NT\$10 million loss.

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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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Case: Graduate student contracted Dengue fever

- Possible reason: The graduate student surnamed Liu contracted Dengue fever, perhaps due to biting by aedes albopictus mosquito which accidentally escaped from mosquito breeding room.
- The Taiwan Centers for Disease Control compared the virus in the student's serum with the virus strain of first-type Dengue fever via RT-PCR and nucleic acid sequencing, both characterizing it as laboratory infection.

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Definition of human-factor 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 !

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Human-factor hazards

- **Inadequate human-machine interface:** Inadequate machine interface design leads to higher error rate or human injuries
 - Computer usage
- **musculoskeletal disorder 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 foolproof device caused by such human factors as emotion, lack of attention, and fatigue



Case: Common hazards for computer operation

- Cumulative trauma disorder (CTD)
 - Shoulder/neck pain: Screen position and height, table height, etc.
 - Lower back pain: choice of chair, sitting posture
 - Hand injury: mouse, keyboard, hand rest, etc.
 - Prevention: **Stay away from your computer once in a while, change body posture, and rest properly.**
- Vision injury
 - Long-term near-distance use of eyes
 - Screen distance, screen quality, position of lighting source, glare
 - Prevention: **Regular rest for eyes**



Unnatural posture

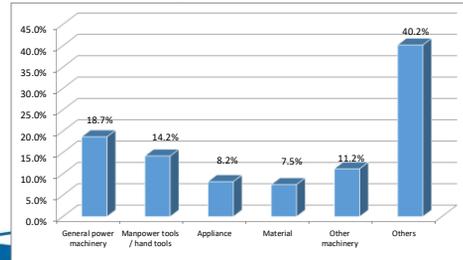


Image source: self-taken

III. TYPES OF LABORATORY DISASTERS IN SENIOR HIGH AND VOCATIONAL HIGH SCHOOLS

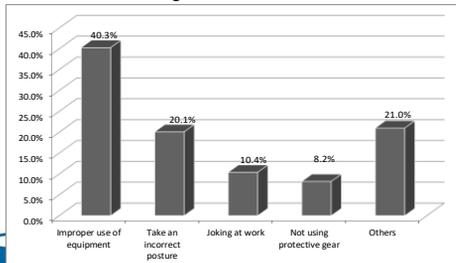
Types of laboratory disasters in senior high and vocational high schools in recent years

- Distinction according to media of accidents



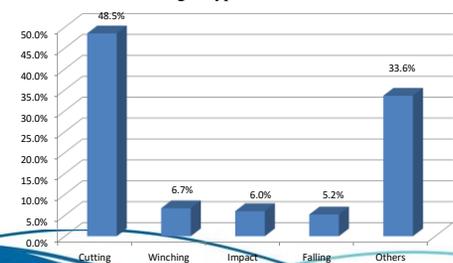
Types of laboratory disasters in senior high and vocational high schools in recent years

- Distinction according to reasons for accidents



Types of laboratory disasters in senior high and vocational high schools in recent years

- Distinction according to types of accidents



IV. NOTICES FOR LABORATORY SAFETY AND HEALTH IN SENIOR HIGH AND VOCATIONAL HIGH SCHOOLS

Workplace--Practical training field: Three stages of safety and Health

- Actually abide by norms, avoid negligence and carelessness
- Understand contents of norms
- Cultivate capabilities for identification, evaluation, and control of hazards.



Follow guidance of teacher in practical training field

- Follow guidance of teacher in practical training field, avoiding practices of fantasy and joke.
 - Metallic sodium and water
- Avoid negligence and omission in executing procedure.
 - A T-type tool was left on lathe due to negligence, flying away and hitting the head of a student upon activation of the machine.



Understand safety and Health norms

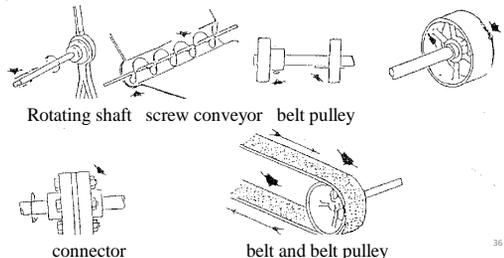
- School learning involves not just taking examination.
 - Form good habits about safety and Health in practical training field--reduce barrier for joining workplace in the future.
 - Understand and learn contents of safety and Health norms in practical training field (including equipment's safety device) → enhance competence in workplace in the future.
 - Cultivate further capabilities for identification, evaluation, and prevention of hazards → enhance capability for safety and Health management comprehensively.

Cultivate consciousness and capability of safety and Health

- Further cultivate capabilities for identification, evaluation, and prevention of hazards→ enhance capability for safety and Health management comprehensively.
- Hazard identification
- Hazard evaluation
- Hazard control
 - Engineering control
 - Administrative management
 - Use of personal protective equipment

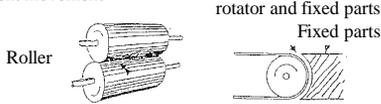
Hazard identification: sources of potential hazards of machinery 1

Rotary, reciprocating, and linear movements

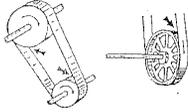


Hazard identification: sources of potential hazards of machinery 2

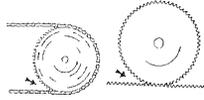
Entanglement movement



Belt and belt pulley

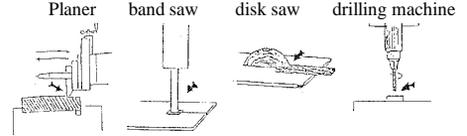


Chain and chain wheel

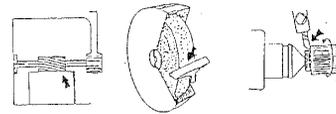


Hazard identification: sources of potential hazards of machinery 3

Cutting movement



milling machine glaze wheel lathe tool cutting



First stage conclusion

- Actually abide by norms, avoid negligence and carelessness
- Understand contents of norms
- Cultivate capabilities for discovery of hazards to facilitate prevention and control.

V. Advanced stage: Management of laboratory safety and Health

Related domestic laws/regulations
Campus safety and Health management system
Laboratory environment and features

What do you have to know before entering a laboratory?

- Understand related domestic laws/regulations
 - Find out laws/regulations are related to laboratory safety and Health.
 - Why is it necessary to receive related education and training before entering a laboratory?
- Understand campus safety and Health management system
 - Find out school unit in charge of campus safety and Health.
 - Campus safety and health work rules
 - Other related administrative procedures.

What do you have to know before entering a laboratory? (cont.)

- Understand laboratory features and environment
 - Laboratory safety and Health guidelines
 - Types of potential hazards
 - Equipment and procedure for hazard prevention

Understand related domestic laws/regulations

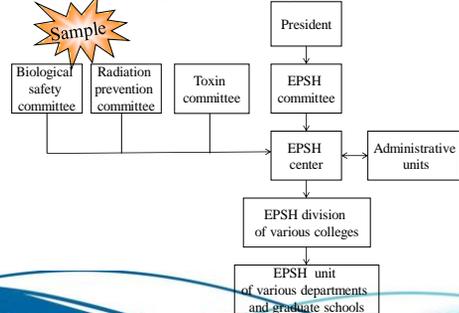
Understanding related laws/regulations is basic requirement for laboratory safety and Health.

Prepare necessary preventive equipment within reasonable and feasible scope.

Occupational safety and health facilities regulations

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Organizational structure for environmental protection and occupational safety and health on campus



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Occupational safety and health management units

- Common names for such units are **environmental protection and occupational safety and health (EPSH) center, EPSH office, or EPSH division**.
 - Main bodies handling laboratory safety and Health affairs on campus.
 - Laboratory workers must know **the name, campus location, contact method and website address, and business contents of those units**.

Enforcement Rules of the Occupational Safety and Health Act & Occupational Safety and Health Management Measures

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Occupational safety and health management units (cont.)

- Some schools have instituted college-level environmental protection and occupational safety and health unit and/or person in charge of the affair for departments and graduate schools.
 - Laboratory workers should follow the system and procedure of various schools concerning handling or inquiring of administrative procedure or affairs related to laboratory safety and Health.

Enforcement Rules of the Occupational Safety and Health Act & Occupational Safety and Health Management Measures

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Understand school-level laboratory safety and Health work rules

- This one of two common such rules on campus, the other being "individual laboratory safety and Health work rules."
- School-level** laboratory safety and Health work rules can often be accessed on the website of campus safety and health management unit.

Occupational Safety and Health Act, enforcement rules of Occupational Safety and Health Act

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Understand school-level laboratory safety and Health work rules (cont.)

- School-level laboratory safety and Health work rules address common laboratory issues of various departments of school.
 - Similar to such rules at enterprises, the **rules** cover occupational safety and health management and responsibility and authority of various levels, occupational safety and health **standards, education, and training, first-aid and rescue, accident notification and report, and accident fine and punishment**.

Occupational Safety and Health Act, enforcement rules of Occupational Safety and Health Act

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Understand school-level laboratory safety and Health work rules (cont.)

- Understand related common campus issues via the work rules, such as **procedure for emergent notification and report following occurrence of accidents.**

Occupational Safety and Health Act, enforcement rules of Occupational Safety and Health Act

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Understand other related administrative procedure

- Such as "flow for application for purchase of toxic chemicals and usage norms," "Norms for usage and reporting of precursor chemicals," "flow for storage and removal of laboratory wastes," "measures for automatic check in laboratories."
- **Understand what norms school have on what matters before entering laboratory, for abidance during experiments and avoid omissions or errors.**

Toxic and Concerned Chemical Substances Control Act, Categories and Regulations Governing Inspection and Declaration of Industrial Precursor Chemicals and Methods and Facilities Standards for the Storage, Clearance and Disposal of Industrial Waste

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Identification, evaluation, and control of Laboratory accidents

- Identify, evaluate, and control Laboratory accidents 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 accidents (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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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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Hazard communication

- Containers for hazardous chemicals in laboratory, if any, should have **labelling** and specifications on:
 - **Hazard icon**
 - **Content include:**
 - Name
 - Constituents
 - **Warning**
 - **Message on hazard warning**
 - **Hazard preventive measures**
 - Name, address, telephone number of **producer, importer, or supplier**



Regulations for the Labeling and Hazard Communication of Hazardous Chemicals, & Regulations for the Labeling and Safety-Data Sheets for Toxic and

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SDS (Safety Data Sheet)

- Laboratory should prepare **safety data sheet** for use of chemicals and place it at conspicuous and easily accessible spot.
- Contents of SDS should be reviewed constantly, **according to actual situation**, to assure correct and updated contents.
 - Updated record should kept for three years.
- Produce and fill in list of chemicals
 - Register purchase of new chemicals, usage (volume), waste, or depletion on the list



Regulations for the Labeling and Hazard Communication of Hazardous Chemicals & Regulations for the Labeling and Materials Safety Data Sheets for Toxic and Corrosive Chemical Substances

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

Ventilation equipment

- Maintain good ventilation in laboratory.
- Volatile chemicals should be handled inside chemical hood.
- Handle microorganism with air-born 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



local exhaust ventilation

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 air tank 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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Automatic check

- Legal basis: Occupational Safety and Health Management Measures
- School's automatic check plan has covered various automatic check sheets and checklists specifying check items for aforementioned environment, machinery, and equipment.
 - Example: Automatic check sheets for laboratory environment, small high-pressure sterilizer, centrifuge, chemical exhaust cabinet.

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Automatic check (cont.)

- Related data and worksheets are often posted on the websites of various-level environmental protection and occupational safety and health units.
- Have laboratory workers check laboratory environment, machinery, and equipment according to items and schedule specified in automatic check plan.

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Toxic chemicals

- Package、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

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

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 grades and follow correct experimental procedures.

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-grade dangerous microorganisms or controlled biological toxins.



Regulations Governing Management of Infectious Biological Materials

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**).



Handheld radiation detector



Radiation exposure badge

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

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**



Handheld radiation detector



Radiation exposure badge

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

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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Prevention of electricity fire



- Avoid sharing of a socket circuit set by multiple electric equipment.
- Don't place inflammable materials near electric heating equipment.
- Plugs and sockets should not contain cracks, be burned black, or have loose connection.
- Dust accumulation** may cause power leakage or short circuit on the part of electric equipment, producing spark to trigger fire or explosion.
- Fire caused by switched-on electric equipment belong **C-type** fire.

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Laboratory wastes

- Laboratory wastes with radioactivity, toxicity, corrosiveness, inflammability, or infectiousness cannot be disposed of randomly, lest they could harm human health or pollute environment, incurring fines by related government units.
- Collection, classification, marking, and storage, as well as date for delivery to campus unit for storage and disposal, should be carried out according to campus regulations.



Standards for Defining Hazardous Industrial Waste & Methods and Facilities Standards for the Storage, Clearance and Disposal of Industrial Waste

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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

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Information source

- Compiled by Hsu Yi-yang, Academia Sinica

References:

- "Laboratory Safety and Health Management" (2013 edition)
 - compiled by examination center for campus laboratory safety and Health
- "Introduction to Workplace Safety and Health" (2011 edition)
 - compiled by examination center for campus laboratory safety and Health

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