Kyushu University

Guidelines for Safety in Education:
-- Laboratory Activities --

(Ver. 2)

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【Working Group to Study Course-related Safety Management】

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Introduction

As education at universities and other educational institutions has grown more sophisticated and diverse in recent years, those institutions have come to provide various experience-based learning environments. Although experience-based educational activities provide valuable educational outcomes that cannot be gained through textbook learning alone, they also entail risks that can lead to serious accidents as a result of things like participant inexperience and inadequate preparation. Consequently, whenever experiments, practical work, drills, fieldwork or other experience-based educational activities are undertaken, it is essential that careful attention be paid to safety/health management and accident prevention/response. For that reason, Kyushu University began work on drafting university-wide educational safety guidelines with the creation of a Working Group ("**WG**") to Study Course-related Safety Management under the Education Planning Committee in November 2016.

Given the difficulty of creating general safety guidelines to cover the wide range of experience-based educational activities and the lack of practical application that all-encompassing safety guidelines would entail, it was decided to divide experience-based educational activities into the following three categories and create safety/health management and accident prevention/response guidelines for each.

- Outdoor Activities

  These include educational activities conducted in a natural environment, whether on or off campus, and educational activities related to primary sector industries (agriculture, forestry, livestock industry, fishery, etc.) that are conducted outdoors or at production sites (plastic greenhouses, livestock barns, boats, etc.).
- Off-Campus Activities

  These include educational activities conducted off campus, such as interviews in the humanities and social sciences and travel to educational sites, fieldwork, and stays (including overseas research).
- Laboratory Activities

  These include course and research-related educational activities that are conducted within laboratories.

The Educational Safety Guideline for Outdoor Activities was released in AY2016 (Ver.1). The one for "Laboratory Activities" was released in AY2018 (Ver.1) and that for "Off-Campus Activities" was released in AY2019 (Ver.1). This volume is the English version of the Educational Safety Guideline for Laboratory Activities.

Appropriate safety/health management and accident prevention/response requires meticulous preparation before activities, careful attention during activities, appropriate response in case of an accident, and post-activity reflection and improvement plan review. Consequently, these safety guidelines will be revised as needed. Additionally, various media and opportunities will be used to raise awareness of the safety guidelines, while more practical, education-related safety management will be promoted in the future through courses, training sessions, faculty development (FD), handbooks and so on.

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Working Group to Study Course-related Safety Management

Kyoichi Otsuki, WG Leader

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Chapter 1 Basic Information for conducting laboratory activities

Laboratory activities in educational institutions such as universities are high-level research activities. They form the basis for education, and also accompany various risks. In particular, laboratory activities in graduate schools are leading-edge research activities. Dangerous chemicals and equipment are frequently used, and there is the possibility of unexpected experimental results occurring. There is an inherent risk of serious accidents. In order to ensure sufficient safety in these settings, sufficient knowledge about experimental content as well as chemicals, equipment etc., detailed preparations and experiment plans, refined operation of experiments as well as meticulous focus, abundant experience, using the imagination to predict danger, and so forth are required. In experiments conducted in groups, it is necessary to form a common understanding through sufficient discussion, and have each member confirm each other's codes of behavior. Furthermore, it is necessary to understand in advance what kind of danger exists, and to be aware of possible measures for minimizing such damage (particularly harm to humans) when an accident occurs.

At Kyushu University, under our Education Policy Planning Committee, we established a Working Group for Safety Management in Class Practice (hereinafter, the "**WG**") in November 2016, and began creating university-wide safety guidelines for education. However, education activities are quite diverse. It is difficult to compile safety guidelines that cover everything at once, and a comprehensive set of safety guidelines would lack practicality. Therefore, the **WG** decided to, out of all education activities, focus on experience-based educational activities. They classified experience-based educational activities into the following three types of activities, setting up guidelines for safety and health management, accident prevention, and response measures individually for each.

- Outdoor Activities

  These include educational activities conducted in a natural environment, whether on or off campus, and educational activities related to primary sector industries (agriculture, forestry, livestock industry, fishing, etc.) that are conducted outdoors or at production sites (plastic greenhouses, livestock barns, boats, etc.).
- Off-Campus Activities

  These cover regular educational activities conducted outside the university. These include educational activities in interpersonal and social relations, as well as transit to, surveys of, and stays at educational sites (including traveling to conduct surveys overseas). Specifically, they are such as interviews, (participation) observation, measurements, clinical training, clinical practice, internships, etc.
- Laboratory activities

  These include course and research-related educational activities that are conducted using laboratories.

This present document provides guidelines on health and safety management, accident prevention, and accident responses for "laboratory activities" in education.

In order to properly implement health and safety management, accident prevention, and accident response, the following are essential:

- Meticulous preparation before activities
- Careful attention during activities

- Appropriate response to an accident
- Post-activity reflection and improvement plan review

No matter how carefully preparations are conducted, and how much caution is taken during the activity, there is always the possibility of accidents or disasters due to force majeure. While making efforts to prevent accidents as much as possible, it is also necessary to establish a system in advance for responding to accidents, to establish a responsibility and communication system, and to carry out training and simulations in preparation for emergencies.

The purpose of this present guideline is to compile the following as common safety guidelines for Kyushu University as a whole:

- Preparation and planning in advance, instruction for implementation, reporting of near misses, etc., in accordance with Chapter 2 “Preparation and implementation of laboratory activities”
- Risk assessment in accordance with Chapter 3 “Before commencing laboratory activities”
- The respective precautions in Chapters 4-11
- Responding to accidents that occur during an activity, in accordance with Chapter 12 “What to do when an accident occurs”
- Emergency resuscitation methods for victims in accordance with Chapter 13 “Emergency resuscitation”
- Chapter 14 “Examples of risk assessment”
- Chapter 15 “Examples of accidents”

This present guideline’s purpose is to be useful for safety and hygiene management, as well as accident prevention and countermeasures, when conducting laboratory activities in each department. Chapters 4-11 and Chapter 12, Sections 3-7, are written for students. Please refer to them and instruct students of the contents.

Chapter 2　Preparation and implementation of laboratory activities

2.1 Preliminary research and mindset

In laboratory activities, conceivable dangers will differ according to experiment content and location. Therefore, it is important that each participant understands the following:

- laboratory environment,
- experiment content,
- expected risks during the experiment,
- knowledge, preparation, and attitudes necessary to avoid potential hazards,
- what to do in case of an actual accident.

It is of the utmost importance that each person properly understands the above.

In laboratory activities conducted as part of education in the university, there are expected to be some participants who are novices or have insufficient experience. If such participants have worries or concerns prior to the experiment, they must not commence with the experiment. It is necessary for them to first gain sufficient experience by repeating preliminary experiments, etc., together with, or under the supervision of another person who has sufficient experience.

Student experiments are a place for training to gain experience. The person in charge of a student experiment must devise a thorough experimental plan so that dangerous situations do not occur. They must also be sufficiently focused while the experiment is being carried out, in order to ensure that incorrect procedures or usage do not occur. On the other hand, students must understand the content of the experiment in advance, and strictly adhere to instructed procedures and usage while carrying out the experiment.

Laboratory activities in postgraduate research and graduation research require more advanced knowledge, preparation, and mental preparation. It is necessary for each department to mandate the required safety education, and oversee that sufficient instruction is being provided in each laboratory. Each course supervisor (research advisor) must provide safety education and provide thorough guidance in accordance with agreements within the department. They must, in addition to being obliged to comply with various laws, also conduct pre-determined enrollment procedures and require students to attend classes in accordance with relevant agreements. The students, on the other hand, before commencing laboratory activities, must undergo training in general safety management by referencing these guidelines, as well as the safety guidelines provided by the department (undergraduate school, graduate school, or center) to which they belong. They must also individually receive specific safety education at the laboratory to which they belong, and conduct risk assessment as necessary. In addition to this, they have an obligation to fully prepare for each individual experiment, as well as undergo pre-determined enrollment procedures and participate in classes in accordance with relevant agreements.

Note) Risk assessment: Assessing in advance how much of an impact a crisis will have.　Data is used to evaluate the source of hazards, routes of transmission, reaction of the victims, etc. It is a method to identify, and then eliminate or reduce, any potential hazards or harm during work.

2.2 Safety management system and laboratory activity plan

2.2.1 Safety management system

Safety management of laboratory activities in the education of Kyushu University shall be placed under the general supervision of the Kyushu University Executive Vice President of Education.

Figure 2.1 shows the departments serving as administrative units for subjects that involve laboratory activities. The Director of the Department will be referred to as the **"managing supervisor"**. The management supervisor is responsible for overseeing the safety management of all laboratory activities for a particular subject area.

Also, in the present guidelines, the Director of the Department refers to a director as defined in Article 25 of the School Regulations of Kyushu University, and also to a Center's Director as defined in Article 26 of the same.

① The administrative unit for subjects that comprise the school curriculum or education program shall be the school (undergraduate school, graduate school, or center) that houses the relevant section of the school curriculum.

② The administrative unit for KIKAN education shall be the Faculty of Arts and Science.

③ Notwithstanding item ②, for KIKAN education courses conducted by the individual schools organizing them (undergraduate course: general education course and certain courses for sophomores and above; graduate schools: special skill development courses), the administrative unit will be the relevant school.

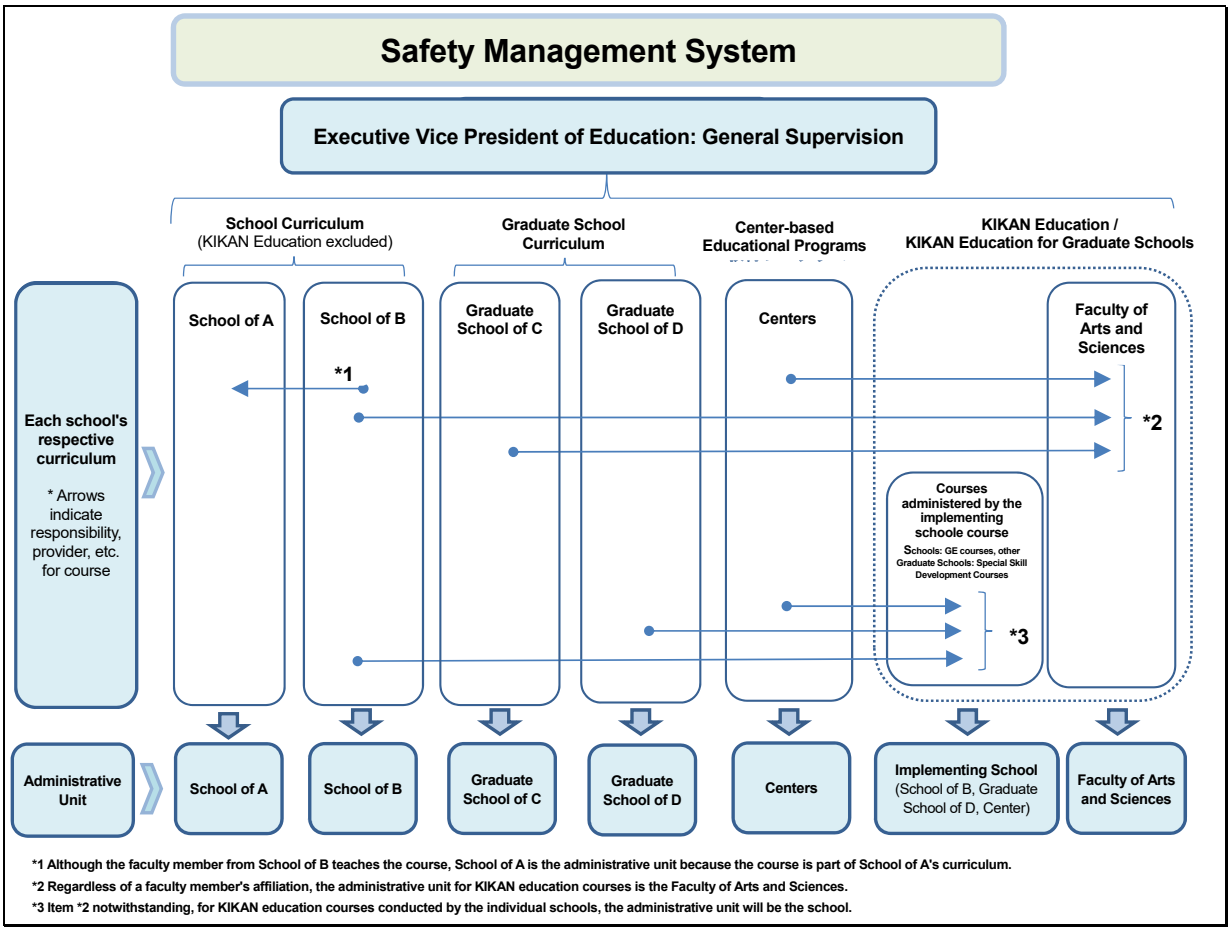

Fig. **2.1 Safety Management System for Laboratory Activities**

2.2.2 Preparation for laboratory activities

The lead faculty member responsible for a course that involves laboratory activities is the **course administrator**. The course administrator must pay attention to accident prevention and safety measures, instructing the students so as to allow them to prepare sufficiently.

(1) Student experiments

1. The course administrator shall prepare a guide for the experiment and distribute it to the students so that they can understand the experiment's content. The course administrator must also explain how to use relevant chemicals and equipment.
2. Furthermore, they should make sure that no dangerous situations will arise during the experiment.
3. When conducting high-risk experiments, inform the students of, and have them fully understand, the content of the risk as well as related countermeasures. Take appropriate risk reduction measures.

(2) Postgraduate research and graduation research

1. The course administrator, instructor, or another department member will distribute these guidelines and any other safety guidelines, etc., unique to their department. They will also, in the form of lectures and so forth, provide general education for safe laboratory activities.
2. The course supervisor or instructor will endeavor to educate each student on the knowledge and understandings required for safe laboratory activities. They will also conduct risk assessments as necessary, so that each student fully understands the content of risks and mitigation measures (Chapters 3 and 14). Further, they will record and retain the results of these risk assessments.
3. The course administrator or instructor will comply with various laws relevant to the experiment, and mandate enrollment procedures and class participation according to the relevant agreements.

2.2.3 Implementation of laboratory activities

Upon conducting laboratory activities, the course administrator will take all necessary measures to ensure safety, having fully familiarized themselves with legal provisions, accident countermeasures, and relevant agreements relating to enrollment and class attendance. In addition, they will instruct students using the precautions on laboratory activities described in Chapters 4 to 11.

1. The course administrator will provide participants with prior instruction and guidance regarding the laboratory activity, ensuring they are fully aware of matters relating to safety and accident prevention/response during laboratory activities.
2. The course administrator, when providing participants with prior instruction and guidance, will also collect participants' questions and concerns, and seek to improve safety measures by incorporating student perspectives.
3. Provision of accident and near-miss information
   If an accident occurs during a laboratory activity, the experiment must be immediately halted, appropriate measures must be taken, and the event must be reported to the managing supervisor. Even if an accident does not occur, if there is information that contributes to safety measures for laboratory activities, information on the near miss (Form 4) must be provided to the department, etc.

2.2.4 Insurance

As a general rule, students should enroll in Personal Accident Insurance for Students Pursuing Education and Research (PAS; Gakkensai in Japanese) in case of injury as participants and Liability Insurance coupled with PAS (LSR; Futaibaisai in Japanese) in case of causing damage to property or injury to another party, or insurance equivalent to these. Depending on the nature of the course, enrollment in insurance will be treated as a condition for taking it.

PAS and LSR cover compensation for on- or off-campus accidents that occur during practical training conducted as classes. Moreover, enrollment in insurance may be a condition for participation in programs such as internships, while accidents during extracurricular events or travel to or from university are also eligible for compensation; therefore, the university recommends that students enroll as soon as they matriculate. However, as compensation coverage under PAS is limited, it is also necessary to consider other insurance appropriate to the nature of the off-campus activity and its location.

Verification of PAS and LSR, etc. enrollment by students participating in a laboratory activity will be conducted by the school

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* Reference

- Personal Accident Insurance for Students Pursuing Education and Research (PAS) / Liability Insurance coupled with PAS (LSR)

  Japan Educational Exchanges and Services website:

  http://www.jees.or.jp/gakkensai/index.htm

- Examples of off-campus activity insurance and mountain-climbing insurance: Montbell off-campus activity insurance and mountain-climbing insurance (Japanese)

  http://hoken.montbell.jp

Near-miss Information (Form 4)

Date: MM/DD/YY

Near-miss Information (Education-related Laboratory Activities)

Course Name				
Number of Participants	Faculty/staff:	TA:	Students:	Other:
Reporter				
Date & Time				
Location				
Description, Countermeasures, Outcomes				
Recommendations				
Remarks				

• This is not an accident report. Please provide any information that you think will contribute to better safety measures.
• The reporter's name will not be disclosed.
• Content for release from "Description, Countermeasures, Outcomes" and "Recommendations" will be edited by the WG.

{Example} **Near-miss Information (Form 4)**

Date: MM/DD/YY

Near-miss Information (Education-related Laboratory Activities)

Course Name	Master's thesis research			
Number of Participants	Faculty/staff: 0	TA: 0	Students: 1	Other: 0
Reporter	KYUDAI Taro			
Date & Time	October / 21 / 2018 13:30-14:00			
Location	Building B2, Room 123			
Description, Countermeasures, Outcomes	Overview: A student tipped over a thiophosgene bottle (25 g) during the experiment. Panicking, the student used paper to absorb the thiophsgene and took the paper out of the draft chamber. An odious smell pervaded the building. The student escaped from a window on the terrace-side of the room. Although experiencing coughing symptoms, afterward the student did not experience any health abnormalities. Response: A faculty member quickly arrived at the site, collected the paper that had absorbed the thiophosgene, and used ammonia water to detoxify it. Result: Because the thiophosgene was removed from the draft chamber, an odious smell spread to the entire building (However, this smell did not escape the building). Because of the response of the faculty member, damages to health did not occur.			
Recommendations	1. Thorough education to ensure students understand that dangerous operations should be kept within the draft chamber from start to finish. 2. Install gas masks, and increase awareness of their installment location. 3. Conduct experiments in groups of two or more. Place limits on experiment operations when faculty members are not present. 4. Confirm and consider the cooperation structure for when an emergency occurs in the laboratory.			
Remarks				

• This is not an accident report Please provide any information that you think will contribute to better safety measures.
• The reporter's name will not be disclosed.
• Content for release from "Description, Countermeasures, Outcomes" and "Recommendations" will be edited by the WG.

Chapter 3 Before commencing laboratory activities – Recognizing risks in the laboratory and preparing countermeasures (risk assessment)

Faculty members and students, in various situations of research and education, will use various chemicals and electrical devices, as well as high pressure or cryogenic temperatures, and are faced with the risk of accidents or health problems. For protection against and prevention of health damage, it is of utmost importance to have knowledge on what causes the risk of damage, the extent of possible damage, and also to research what kind of countermeasures exist. Risk assessment is the evaluation of the above in advance. According to the Industrial Safety and Health Act, businesses are obliged to conduct risk assessments for work taking place in the workplace, and to ensure that workers understand and are aware of assessment results; they are also responsible for recording and saving assessment results (practical obligations). Furthermore, businesses are required to create and implement measures to reduce risk (best-effort obligations). This means that the Kyushu University President, the respective trustees, the leaders of each department etc., persons in charge of managing health & safety and chemical substances, and people in charge of each laboratory have an obligation to implement risk assessments and reduce risk. The types of risks that exist are different for each laboratory, and are even different for each individual faculty member and student, so it is necessary to conduct risk assessment for each member in the laboratory. Even for cases where each member carries out a risk assessment, the person in charge of each laboratory is responsible for ensuring that this is done. The people in charge of each laboratory must make sure each member understands the results of the risk assessment, and should have them carry out risk reduction measures in order to prevent accidents from happening.

Chapters 4 to 11 of these safety guidelines include responses toward accidents, as well as risks and countermeasures by category – e.g., hazardous substances, machinery, electricity, light, radiation, information, genetic modification, and animal experiments. As materials for reference, examples of actual accidents are also presented. By reading these, we would like the reader to recognize that accidents can occur at any time, even from the smallest instance of carelessness.

Chapter 14 presents examples of specific risk assessments for particular types of students. In accordance with the content mentioned above, each laboratory must create a risk assessment table for each member and post it in the laboratory so that it is visible at all times during a laboratory activity.

The persons in charge and faculty members in each laboratory are in a position to lead risk assessments for each member in the laboratory (faculty members and students), and must check the risk assessment of each member at the beginning of the new academic year, or any time research methods are changed.

Chapter 4 Safe handling of chemicals

4.1 General precautions

Nothing is more dangerous than carelessly conducted experiments. No matter how small the scale of an experiment, one should never be careless. An accident inflicts damage not only on the body and properties of the person but also on his/her mental health. Moreover, it inflicts the same damage on the people nearby. Considering that an accident will harm oneself and others, an experiment should be conducted with utmost care. Those conducting an experiment should take precautions regarding the following points.

(1) Always maintain order on the experiment table and inside the laboratory in order to prevent accidents during research experiments and optimize the efficient use of the building.

(2) Secure the safety of the things kept inside the laboratory, whether it is a reagent, chemical, or equipment, in order to prepare for an unexpected situation such as an earthquake. Flammable substances such as organic solvents or legally defined hazardous materials in quantities larger than the regulated quantity must be stored in designated hazardous material storage in an orderly manner, categorized, and locked under the supervision of the person responsible.

(3) When using poisonous substances, harmful substances (sometimes referred as “deleterious substances”), and explosives, they must be handed directly from the person responsible for the storage and the relevant points of caution must be checked before the usage. There are substances that are strictly regulated by law even if they are not poisonous or harmful. Be careful when using them, and keep a record of their usage, including their names, people who used them, the date of their usage, and the purpose. At Kyushu University, usage of every chemical substance is registered and managed by its chemical management system (IASO). Therefore, follow the instructions of the person responsible for managing the chemical substances. Check the university’s website for how to use IASO
(http://chem.ofc.kyushu-u.ac.jp/iasor7/fw/FW0000/)

(4) Make sure to conduct a risk assessment in advance when using a hazardous or toxic substance. Thoroughly study its danger of ignition, explosion or flammability (ignition point, flash point, or mixture explosion range), or its harmfulness (permissible dose or lethal dose) in advance using, for example, a safety data sheet (SDS), examine the following measures and treatments for possible accidents, and prepare necessary internal and external medicines and equipment in advance.
   (a) Fire extinguishing methods against the flammable substances.
   (b) Removal and cleaning methods against poisonous and harmful substances.
   (c) Removal and cleaning methods against volatile malodorous substances and irritants.

(5) When storing a flammable substance with a low boiling point in a refrigerator, make sure to use an explosion-proof type.

(6) When conducting an experiment, attention must be paid to the following points besides the points above.
   (a) Always wear protective glasses when conducting an experiment. Moreover, use protective gear such as gloves, a protective mask, gas mask, metal fence, or screens appropriately depending on the nature of the

experiment.

(b) To prepare for the worst, always be aware of the locations of the fire extinguishers. Do not conduct an experiment that might start a fire, especially in the common laboratory. It is necessary to permanently keep appropriate types of fire extinguishers for different possible types of fire, as different types of fire extinguisher/fire extinguishing methods may be required depending on the cause of fire and the types of the chemicals stored in the laboratory.

(c) When a chemical gets into your eyes or on your skin, immediately wash with plenty of running water for at least 15 min. The same goes for light burns. Then, go to a hospital.

(d) Do not wash chemicals such as an organic solvent down the drain as they might start fire in the sewage downstream.

(7) Strictly adhere to the following points when conducting an experiment that will generate volatile malodorous substances or irritants.

(a) Conduct the experiment in a draft that satisfies relevant standards, and use devices that are isolated from the outside air.

(b) Treat the bad smell and irritants generated from the experiment device with appropriate removal/cleaning devices before releasing them outside from the experiment device.

(8) Make sure to conduct an experiment that is possibly dangerous when there are several people in the laboratory, and notify everyone in the room about the possible danger.

In 2003, the United Nations published the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Following this, danger and safety information was displayed in easy to understand manners on labels using pictures. Though this system does not necessarily match with Japanese regulations, parts of the regulations are being revised. For instance, Categories 1 and 2 of “Skull Mark” correspond to poisons, and Category 3 corresponds with hazardous materials. Moreover, Category 1 of “Corrosiveness Mark” also corresponds with hazardous materials. On the other hand, “Flame Mark” (Categories 1 and 2) corresponds to the special flammable materials and class I petroleum in Category 4 Hazardous Materials defined in the Fire Service Act. Table 4.1 shows these picture displays and their meanings. Refer to the websites of the Ministry of Health, Labour and Welfare and the Ministry of Economy, Trade and Industry for more detail.

Currently, distributors of chemical substances are obliged to provide SDS for the chemicals they sell. Therefore, thoroughly inform yourself of SDS and obtain information related to the above in advance. SDS is often included in the CD catalogs of reagent companies, and can be viewed on the website of Japanese Reagent Association (http://www.j-shiyaku.or.jp/), Safety Site of Labor and Welfare Workplace, Ministry of Health (https://anzeninfo.mhlw.go.jp/anzen_pg/GHS_MSD_FND.aspx), or chemical substance search using IASO.

Table 4.1 Picture display of GHS, their names, and meanings

Hazard Symbols (to be used in pictograms for substances of the particular class)		
		
FLAME OVER CIRCLE—USED FOR THESE CLASSES : ▪ Oxidizers	**FLAME—USED FOR THESE CLASSES:** ▪ Flammables ▪ Self Reactives ▪ Pyrophorics ▪ Self-Heating ▪ Emits Flammable Gas ▪ Organic Peroxides	**EXPLODING BOMB—USED FOR THESE CLASSES:** ▪ Explosives ▪ Self Reactives ▪ Organic Peroxides
		
SKULL & CROSSBONES—USED FOR THESE CLASSES: ▪ Acute toxicity (severe)	**CORROSION—USED FOR THESE CLASSES:** ▪ Corrosives	**GAS CYLINDER—USED FOR THESE CLASSES:** ▪ Gases Under Pressure
		
HEALTH HAZARD—USED FOR THESE CLASSES: ▪ Carcinogen ▪ Respiratory Sensitizer ▪ Reproductive Toxicity ▪ Target Organ Toxicity ▪ Mutagenicity ▪ Aspiration Toxicity	**ENVIRONMENTAL HAZARD—USED FOR THESE CLASSES:** ▪ Environmental Toxicity	**EXCLAMATION MARK—USED FOR THESE CLASSES:** ▪ Irritant ▪ Dermal Sensitizer ▪ Acute toxicity (harmful) ▪ Narcotic Effects ▪ Respiratory Tract Irritation

4.2 Fire prevention - Hazardous materials defined in the Fire Defense Law

The Fire Defense Law defines liquid and solid substances among flammable materials that have particular potential for starting a fire, and are therefore, dangerous as hazardous materials. The law regulates their storage, handling, and transportation methods when they are above a certain quantity, in order to prevent fire. They include substances that spontaneously combust in the atmosphere or start to burn when reacting with water (Category 3 hazardous material), thermally unstable substances that decompose and heat up at relatively low temperatures or easily ignite/explode with an impact (Category 5 hazardous material), and substances that catch fire (ignite) when there is fire nearby (Category 4 hazardous material), as well as substances that do not burn themselves but have properties to strongly oxidize/burn other materials (Category 1 and 6 hazardous material). Each of these has a

different appropriate method for handling, and when burning to extinguish a fire, one must fully understand the characteristics of each when handling the same.

Among these hazardous materials, the flammable materials of Category 4 include petroleum and various solvents. As they are often used in large quantities, there is a designated hazardous material storage in each faculty. Thus, one must make efforts only to bring in the minimum necessary amount of these materials to the laboratory. Moreover, as the handling of hazardous materials in storage must be conducted under the instruction of a hazardous materials engineer, it is desirable for those who are using such storage to obtain a hazardous materials engineer's qualification

4.2.1 Spontaneous-combustible substances

There are many substances that can potentially start a fire. Those materials that easily oxidize, heat up, and ignite only by being exposed to air are called spontaneous-combustible substances. Well-known examples include organometallic compounds such as alkyl aluminum, alkyl zinc compounds, and alkyl lithium compounds (these also react with water, and thus, refer also to the following section on water prohibitive substance for their handling), reduced nickel, reduced palladium, and yellow phosphorus (white phosphorus). Take precautions regarding the following points when handling them.

(1) As they can start a fire when exposed to air, they must be handled inside an inert gas such as nitrogen or argon.

(2) As they can also become a fire source for solvents, do not leave solvents near them.

(3) Do not use plastic products as their container/syringe.

(4) When taking an organometallic compounds or solution with a syringe, a fire sometime starts at the tip of its needle (e.g., *t*-butyl lithium solution, undiluted solution of trialkylaluminum, and dialkylzinc solution). Do not panic when this occurs. As long as you do not spill the solution, the fire will not spread beyond the initial small fire.

(5) When conducting a hydrogenation reaction using a reduced metal catalyst, do not add a new catalyst to the reaction system in the hydrogen atmosphere when the reaction has stopped. This will certainly cause a fire.

(6) When filtering the reduced metal catalyst after hydrogenation reaction, avoid using filter paper. Put it through a Celite column to prevent drying.

(7) Never discard the reduced metal catalyst after hydrogenation reaction in a bin. Recover it and store it in a container filled with ethanol or water.

(8) As yellow phosphorus starts to burn/generates smoke when exposed to air, it must be kept in water with a pH of 7 to 9. Handle it with care as it causes severe chemical burns when one touches it.

(9) Use dry-chemical fire extinguishers or fire-fighting sand to extinguish the fire. When it is a very small amount, use of a large quantity of water is effective.

4.2.2 Water-prohibitive substances

Water-reactive substances are substances that ignite or generate heat when they come into contact with water

(or moist air, in some cases). Typical examples are alkali metals such as sodium and potassium, metal carbides such as calcium carbide, metal hydrides such as lithium hydride, sodium hydride and lithium aluminum hydride, organometallic compounds such as organolithium, and sodium amide. The following precautions are necessary when handling water-reactive substances:

(1) Absolutely avoid their contact with water.

(2) As they can also become a fire source for solvents, do not leave solvents near them.

(3) Sodium and potassium should be stored in kerosene or liquid paraffin. Sodium chips should also be stored in kerosene or liquid paraffin. Upon decomposition, sodium should be added to alcohol such as 2-propanol little by little in order to prevent generated hydrogen from igniting. For potassium, the same operation should be carried out with *t*-butyl alcohol in a nitrogen stream.

(4) Do not place a lower halogenated solvent (chloroform, dichloromethane, etc.) nearby when handling sodium and potassium. If a piece of metal enters the solvent by mistake, it will cause an explosion.

(5) When decomposing a metal hydride, add it to ethyl acetate in small portions.

(6) Use of dry-chemical fire extinguishers or fire-fighting sand is appropriate to extinguish their fire. Do not use water or carbon dioxide fire extinguishers.

(7) Be cautious as even when they do not start a fire on their own, substances with high hygroscopicity can absorb water and become very hot.

4.2.3 Low-temperature combustible substances

These are substances that can catch fire at relatively low temperatures when in air. They include metallic powders such as aluminum and magnesium, red phosphorus, and phosphorus sulfide. Generally, they are strongly reducible substances, and would start fire when heated up, received an impact, or through friction, either on their own or as oxidized substances. Take precautions regarding the following points when handling them.

(1) Keep them away from heat sources and fire, and store them in cold and dark places as they start fire when heated.

(2) Avoid their contact with oxidants.

(3) Be careful as metallic powders are easy to burn and difficult to extinguish once they start a fire.

(4) For extinguishing their fire, injecting water would be appropriate when the scale of the fire is small. However, water is generally inappropriate for these substances, except for red phosphorus; thus, use powder extinguisher, CO_2 extinguisher or fire-fighting sand to extinguish their fire.

(5) Be aware of the possibility of heat being accumulated and leading to fire through atmospheric oxidation when storing a large quantity.

4.2.4 Strongly oxidizing substances

Strongly oxidizing substances include chlorate, perchlorate, permanganate, nitrate, inorganic peroxide, organic peroxide, and chromic anhydride. Generally, they decompose easily through heating, impact, or friction; release oxygen; and cause strong fire together with flammable materials. When they are mixed with organic or reducing

substances, they may combust or explode. Moreover, some of them decompose and explode when mixed with a strong acid. Take precautions regarding the following points when handling them.

(1) As they explode when heated or with impact, store them in a cold and dark place away from heat, and avoid impact.

(2) Prevent them from coming into contact with organic or reducing substances.

(3) Inorganic peroxides can produce an exothermic reaction. They generate oxygen when coming into contact with water, generate hydrogen peroxide when they come into contact with dilute acid, heat up, and sometimes start fire.

(4) Some peroxides strongly decompose when coming into contact with a metal or metal salt; thus, be careful of iron rust getting mixed with them.

(5) Alkali metal oxides react with water; thus, be cautious to prevent humidity.

(6) Generally, water can be used to extinguish the fire caused by them. However, water is not appropriate for alkali metal oxide, and fire-fighting sand is suitable for this purpose.

4.2.5 Oxidizing liquids

The Fire Services Act designates perchloric acid, nitric acid, fuming nitric acid, hydrogen peroxide, bromine trifluoride, etc., as oxidizing liquids. In addition, a chromic acid mixture is an example of an oxidizing liquid. Moreover, while its oxidizing properties are not strong, concentrated sulfuric acid can cause fire or accidents as it heats up strongly when diluted.

These substances can heat up or combust when mixed with organic or reducing substances. They may also explode when mixed with an oxidant. Take precautions regarding the following points when handling them. Hydrogen peroxide will be discussed in the next section.

(1) Avoid contact with organic substances, reducing materials, or strong oxidants.

(2) When spilled, cover with sodium bicarbonate powder and dilute with large amount of water.

(3) Make sure that they do not get onto your skin or clothes. When they do, wash with a large amount of running water.

(4) Use dry-chemical fire extinguishers or fire-fighting sand to extinguish their fire.

(5) To dilute concentrated sulfuric acid, add small quantities of the acid to water. Do not add water to concentrated sulfuric acid

4.2.6 Explosive and self-reactive substances

Substances that would combust/explode from heat, fire, impact, or friction include nitric ester (C-O-NO_2), nitro compound (C-NO_2), nitroso compound (C-NO), diazo compound ((-N=N), diazonium salt ([-N≡N]$^+X^-$), azide (RN_3, MN_3), peroxide compound (R-O-O-R, RCO-O-OR), halogen acid derivative ($HClO_3$, $HClO_4$), and heavy metal acetylide. Generally, substances with more bonding, such as N-O, N=O, N-N, N=N, O-O, O-halogen, N-S, and N-halogen are more dangerous. In addition, there are reagents that would not explode on their own but might produce peroxide while being stored, which may cause an explosion. Pay particular attention to dioxane,

tetrahydrofuran, or diethyl ether that have been used or have been in storage for a long time. Do not concentrate them carelessly.

Take precautions regarding the following points when handling them.

(1) A blow, friction, or heating can be a direct cause of explosion; thus, do not put these substances under such treatments.

(2) They might explode when brought in contact with acid, alkali, metal, or reducing substances; thus, do not mix them carelessly. In particular, be cautious so that a heavy metal salt or iron rust does not get mixed in.

(3) Avoid using metallic spatulas, glass equipment with ground joints, or glass filters. Anneal the edges of the glass equipment before their usage.

(4) Wear personal protection such as protective coats (white coats), protective glasses, protective masks, or gloves.

(5) Handle them in a draft facility that satisfies the necessary standards and from behind a screen made of safety glass or transparent plastic.

(6) Only conduct small-scale experiments until you understand the reaction and the level of safety of the substances you are handling.

(7) They require other cautions required for flammable substances.

4.2.7 Flammable substances

These substances do not start burning just by being exposed to air. However, when there is a fire source, they burn easily in air. The lower their flash point is, the more dangerous they become. Exercise caution, as even substances with a high flash point become dangerous when heated above their flash point. The Fire Services Act (“Shobo-ho” in Japanese) categorizes them according to their flash points into categories such as Special flammable materials, Class I petroleum and so on. Table 4.2 lists typical substances for each category. Following the table, the measures that must be taken when handling these substances are discussed.

Table 4.2 Typical flammable substances

The Fire Services Act Categories		**Typical Substances**
Class 4 Hazardous Materials	Special Flammable Substance	Diethyl ether, carbon disulfide, acetaldehyde, pentane, isopentane, propylene oxide, divinyl ether
	Class 1 Petroleum (highly flammable)	Petroleum ether, gasoline, petroleum benzene, ligroin, hexane, heptane, octane, pentane, benzene, toluene, dioxane, acetone, 2-butanone, methyl formate to butyl formate, methyl acetate to isobutyl acetate, acetonitrile, pyridine, chlorobenzene
	Alcohols	Methanol, ethanol, *n*-propanol, isopropanol
	Class 2 Petroleum (medium flammable)	Kerosene, gas oil, creosote oil, spindle oil, turpentine oil, xylene, styrene, allyl alcohol, cyclohexanol, benzaldehyde, formic acid, acetic acid
	Class 3 Petroleum (low flammable)	Heavy oil, tetralin, ethylene glycol, diethylene glycol, ethanolamine, nitrobenzene, aniline, toluidine

A. Special flammable substances

This is the most dangerous group among flammable substances. The Fire Services Act defines them to be substances that liquidize at 20°C or 20°C–40°C, whose ignition temperature is 100°C or below, whose flash point is -20°C or lower, and whose boiling point is 40°C or lower. Be conscious that fire is the most common accident in chemistry laboratories, and take precautions regarding the following measures when handling these substances.

(1) Pay particular attention to the gases and vapors.

(2) Be aware of their flash points, ignition points, explosion limits (the highest and lowest concentrations of the explosion range), etc.

(3) Do not leave solvents that are not required for the experiment on the experiment table.

(4) Extinguish nearby exposed fires as they have low ignition temperatures and flash points, and are therefore, highly flammable.

(5) Ventilate well and prevent them from stagnating as they have low boiling points, low minimum explosion ranges, and wide explosion limits.

(6) Be cautious as, once they catch fire, they spread explosively and are difficult to extinguish.

(7) The upper space of a solvent container is often in the explosion range. Pay particular attention to the fire around you when taking a small quantity of the solvent, and seal when not using.

(8) Do not store a large quantity of these substances in a laboratory for a long time.

(9) Be aware of the locations of fire extinguishers. In particular, when there is a possibility of fire, ensure that one is nearby.

(10) Use dry-chemical fire extinguishers, carbon dioxide fire extinguishers, or fire-fighting sand to extinguish their fire. Though water is not appropriate to extinguish fires from these substances, it is suitable for extinguishing fires on other flammable materials nearby.

B. Highly flammable substances

These are substances that are highly flammable at room temperature. Their flash points are 20°C or less, and they correspond to Class I petroleum and alcohols defined in the Fire Service Act. Many are important solvents for chemistry experiments. Take precautions regarding the following points when handling them.

(1) Be aware of their flash points, ignition points, or explosion limits.

(2) Do not leave solvents that are not required for the experiment on the experiment table.

(3) As they are highly flammable (though not as much as special flammable substances), keep them away from fire, electric sparks, the flame of a hand burner, or red-hot objects. Take caution regarding the fire nearby and do not heat with direct fire.

(4) Ventilate well and prevent stagnation as they accumulate near the floor.

(5) Use of dry-chemical fire extinguishers, carbon dioxide fire extinguishers, or fire-fighting sand is appropriate to extinguish their fire.

C. Medium-flammability substances

Substances that are highly flammable when the temperature is increased correspond to Class II petroleum, as defined in the Fire Service Act. Their flash points are around 20°C–70°C. It is necessary to be cautious regarding the stagnation of vapor when heating these substances in an open container. Use of dry-chemical fire extinguishers is appropriate to extinguish their fire.

D. Low-flammability substances

Substances that ignite due to the decomposition of gas when heated at a high temperature are defined as substances whose flash points are 70°C or higher, according to the Fire Service Act. Though they do not burn easily due to their high flash points, their fire is difficult to extinguish once it has started. Thus, make sure not to exceed their flash points when heating, and prevent the produced vapor from catching fire. Use dry-chemical fire extinguishers to extinguish their fire.

See Table 4.3 for the characteristics of common solvents that are flammable/combustible substances.

Table 4.3 Properties of common solvents

	Boiling point (°C)	Flash point (°C)	Explosion limit (%)		Ignition point (°C)	Vapor density (air = 1)	Allowable limit (mg/m^3)	Toxicity
			upper	lower				
pentane	36	-49	1.4	8	309	2.48	1800	a
hexane	69	-23	1.2	6.9	260	2.97	180	a, ro
heptane	98	-4	1.2	6.7	233	3.45	1600	a, ro
benzene	80	-11	1.4	8	538	2.77	80	car, sc, a, ro
toluene	111	4	1.3	7	552	3.14	370	p, h, mm
xylene	138	25	1.1	7	496	3.66	435	p, a, ro
dichloromethane	40	—	12	19	662	2.93	1740	sc, a, mm
chloroform	61	—	—	—	—	4.12	50	p, a, mm
carbon tertrachloride	77	—	—	—	—	—	65	p, sc, a, ro
ethylene dichloride	82	21	6.2	15.9	449	3.35	200	sc, mm, sk
methanol	65	18	6	36.5	470	1.11	260	p, sc, a
ethanol	78	16	3.3	19.6	399	1.59	1900	a
2-propanol	82	21	2.5	5.2	456	2.07	980	a
diethyl ether	34	-45	1.8	48	180	2.55	1200	a
tetrahydrofuran	66	-14	2.3	11.8	321	2.5	590	a, mm
1,4-dioxane	101	12	2	22	180	3.03	180	p, mm, h
acetone	57	-18	2.6	12.8	538	2	2400	h
ethyl acetate	77	4	2.7	11.5	482	3.04	1400	p, mm, ro
acetic acid	118	43	4	16	426	2.07	25	cor, mm, ro, sk
acetic anhydride	140	54	3	10	380	3.52	20	cor, mm, ro, sk
acetonitrile	80	6	4	16	524	—	70	p, mm, ro, sk
carbon disulfide	46	-30	1	44	90	2.64	30	p
DMSO	189	95	2.6	42	215	—	—	sk
DMF	153	58	2.2	15.2	445	—	30	mm, ro, sk
HMPA	233	105	—	—	—	6.18	—	mm, sk

a：anesthetic, car：carcinogenic to human (IARC Class 1), cor：corrosive, h：headache,
mm：mucous membrane stimulation, p：poison, ro：respiratory organ inflammation,
sc：special harmful substance defined in the Soil Pollution Countermeasures Law, sk：skin inflammation

Note; DMSO is dimethyl sulfoxide, DMF is *N,N*-dimethylformamide, and HMPA is hexamethylphosphoric triamide.

4.3 Toxic substances

One should assume that almost every reagent is hazardous to health in some way. Not only are there many substances without defined permissible concentrations, but it is also common that the toxicity information of new compounds generated through reactions is not available. Thus, one must be extremely cautious not to touch or inhale reagents and products carelessly. Toxicity can be divided into the type that causes poisoning symptoms within a short period (acute toxicity) and the type in which symptoms appear after repeated exposures to small amounts of the substance over a long period (chronic toxicity). Moreover, when they directly affect the eyes or skin, some of the substances cause corrosion or irritation of the exposed part immediately accompanied by severe pain, similar to an acid or alkali, and others cause rashes after some time. Among the known chemical substances, those with particularly strong toxicity include poisonous gas (permissible concentration is 200 ppm or less), poison (oral lethal dose (LD_{50}) is 50 mg for every 1 kg of body weight or less), and deleterious substances (oral lethal dose between 50 mg and 300 mg). However, be aware that not every toxic substance is designated as a poisonous or deleterious substance. Besides these acute toxic substances, one must be very careful when handling chronic toxic substances or carcinogens. Take precautions regarding the following points when handling them.

(1) Check permissible concentration and other information well and understand them in advance.

(2) While it is often easy to identify harmful inorganic substances based on common knowledge in chemistry, organic substances are difficult to analogically infer. As it is common that an unexpected organic substance turns out to be highly toxic, conduct proper research before using them.

(3) Wear protective gear such as protection glasses, protective masks, and gas masks. Do not touch what is around you while wearing contaminated protection gear. When discarding, follow the correct procedure.

(4) Handling should be done in a draft facility that meets specified standards. Even within the draft chamber, poisonous or harmful substances should not be released as they are.

(5) Make sure not to cause even a minimum leakage of substances with low permissible concentration.

(6) Receive approval from the person responsible for the laboratory before using these substances. Notify everyone in the same room before using these substances.

(7) Be extremely cautious when using a large quantity.

(8) Even if one is wearing a protective gear when using a toxic substance, first-aid is required when it is inhaled or the eyes or skin are exposed to it. Commonly, when the eyes or skin are exposed, it is necessary to immediately wash them with plenty of running water for at least 15 min. Seek medical treatment after, depending on the situation. When inhaled, move the person away from the experiment site immediately and warm his/her body with a blanket. When he/she has difficulty breathing, administer artificial breathing or oxygen inhalation and immediately seek medical treatment.

(9) Toxic substances (poisons, deleterious substances, and harmful substances) are stored in a chemical closet with a lock that is labeled as “poison” or “deleterious”. Ask the laboratory staff when you need to use them. Record the date, name of the person using it, and the amount in the IASO system.

(10) The Ordinance on the Prevention of Organic Solvent Poisoning (Organic Solvent Ordinance) stipulates

that a laboratory that uses organic solvents, etc., must display the points of caution when using them, such as their effects on the human body, points of caution when handling them, and appropriate first-aid in case of poisoning in an area that is easy to see in the laboratory.

(11) When using a specified chemical substance specified in the Ordinance on the Prevention of Organic Solvent Poisoning, the nomenclature, effects on the human body, handling precautions, use, and protective equipment used for each specified chemical substance should be posted in a visible place in the laboratory.

The influence of hazardous substances on the human body are shown in Table 4.4.

Regarding individual hazardous substances, please refer to books such as the following: *Jikken wo anzen ni okonau tameni* [Requirements for safely conducting experiments] (8th edition) (Kagaku-Dojin), *Yuuki kagaku jikken no tebiki* [Organic chemistry experiment companion] (Kagaku-Dojin), *Toriatsukai chuui shiyaku labo gaido* [Laboratory guide for handling reagents that require caution] (Kodansha), *Sentan gijutsu sangyo ni okeru kiken/yuugai kagaku purofiiru 100* [Profiles for 100 dangerous/toxic chemicals in the advanced technology industry] (Maruzen), and the Merck Index. Please also refer to sources such as safety data sheets released by reagent companies, databases by the National Institute of Health Sciences (International Chemical Safety Cards - Japanese version -, etc.), or the Japan Chemical Industry Association's chemical information database.

In addition, relevant laws include the Fire Services Act and the High Pressure Gas Safety Act regarding fire and accident, the Poisonous and Deleterious Substances Control Law, the Chemical Substance Control Law, the Industrial Safety and Health Law, and the Basic Environmental Law and its related regulations regarding harm on health.

Table 4.4 Category of common harmful substances

a. Dermopathy	Skin cornification: arsenic, cobalt, dilute alkali liquid Skin coloration: picric acid, nitric acid, iodine, silver salt Pigment abnormality: tar, pitch, arsenic Acute skin inflammation and eczema: acid, alkali, chlorodinitrobenzene, formalin, tar, pace Ulcer: chrome, nickel, acid, alkali Lesion of hair or sebaceous gland: mineral oil, tar, chloronaphthalene Lesion of the hair: thallium, manganese Lesion of nail and its neighborhood: selenium, thallium, fluorine
b. Mucous membrane disorder	Attack on upper respiratory tract: aldehyde, alkaline dust and mist, ammonia, chromic acid, ethylene oxide, hydrogen chloride, hydrogen fluoride, sulfurous acid gas, sulfuric anhydride. Attack on upper respiratory tract, lung tissue: bromine, chlorine, oxidation chlorine, cyanogen bromide, chlorination cyan, methyl sulfuric acid, fluorine, iodine. Attack on respiratory tract end part and alveolus: arsenic trichloride, nitrogen peroxide, carbon oxychloride.
c. Suffocation	Simple suffocation: carbon dioxide, ethane, helium, hydrogen, methane, nitrogen, nitrous oxide. Chemical suffocation: carbon monoxide, cyan, hydrogen cyanide, nitrile, aromatic nitro-compound (nitrobenzene, dinitrobenzene), aromatic amines (aniline, methyl aniline), hydrogen sulfide
d. Anesthetic effect	Most organic solvents and fat-soluble solids have a difference of degree, but there are anesthesia characteristics.
e. Nervous system disorder	Carbon dioxide, halogenated hydrocarbon, methanol, thiophene, tetraethyl lead, manganese, mercury
f. Liver/renal damage	Carbon tetrachloride, tetrachloroethane, hexachloronaphthalene, trinitrotoluene, dioxane; (particular to kidney) uranium, cadmium
g. Blood disorder	Benzene, lead, radiation, phosphine, arsine
h. High-level tissue disorder	Acid mist, yellow phosphorus, fluorine.
i. Lung disorder	Alveolus pungency material (dropsical swelling of lungs, pneumonia), insolubility dust (pneumoconiosis), silicic acid (silicosis), asbestos (asbestosis), talc (talc lung), pyrophyllite pneumoconiosis, aluminum lung, culm lung, graphite lung, beryllium lung, and pitch (welding lungs).
j. Carcinogen	Arsine, benzene, cadmium, chloromethyl methyl ether, ethylene oxide, formaldehyde, acrylamide, dimethyl sulfate.

Chapter 5 Disposal of effluents and wastes

5.1 Introduction

From the perspective of global environmental protection, the laws related to environmental protection are increasingly being strengthened, and Japan is not an exception. Currently in Japan, standards and obligation for appropriate processing of releasing harmful substances to the atmosphere and the hydrosphere are stipulated in laws such as the Air Pollution Control Law, the Water Pollution Control Law, the Mercury Pollution Control Law, and the Waste Disposal Law and their related regulations.

As diverse substances are used in research activities at our university, the researcher conducting an experiment must be fully aware of what type of effluents and wastes his/her experiment produces, and must take appropriate measures for their contents and characters. Especially, when these are to be released outside the university, one must follow various regulations for protecting the health of the citizens and the environment of the planet. The person conducting the experiment has the obligation and responsibility to follow the regulations and make sure not to release harmful substances to the outside. Naturally, attention must be paid not only to the effluent/waste generated by the experiment but also to the disposal of the waste from everyday goods such as bottles and cans of food and medicines. As a student of science and engineering, one must take lead in everyday actions such as “not to throw away oil in the drains” or “recycle resources”.

Since methods for storage and consigned treatment of wastewater and waste can be different for each department, etc., it is necessary to be familiar with the specific methods of disposal within the department, etc., and perform procedures and treatment correctly according with the rules agreed upon. We ask that you do not pollute the environment inside or outside the university by inappropriate treatment or leakage of harmful substances.

5.2 Overview of waste classification and disposal/processing methods

According to the Waste Disposal and Public Cleansing Act, waste is defined as something in either liquid or solid form that cannot be sold to another person for a fee and is no longer needed because it cannot be reused by the user. Waste can be classified into household waste, which is discharged from ordinary households, and business waste, which is generated by business activities in factories, offices, stores, restaurants, hospitals, and schools such as universities. Although the municipalities such as cities, towns, and villages are responsible for the disposal of household waste, business operators are responsible for the disposal of business waste. All waste generated by the university is classified as business waste, and the university must take responsibility for proper waste disposal.

Business waste can be classified into industrial waste and general business waste, as shown in Figure 5.1. Here, industrial waste refers to the 20 types of waste specified by the Waste Disposal and Public Cleansing Act, listed in Table 5.1. Industrial waste is further classified into industrial waste requiring special treatment and other industrial waste, as shown in Table 5.2. By law, industrial waste containing hazardous substances must be properly treated.

The experimenter needs to be fully aware of what kind of waste they are handling, and take appropriate measures accordingly. On the other hand, general business waste is waste that is generated by business activities and is not classified as industrial waste. Some examples are non-recyclable paper, kitchen waste, incombustible refuse, and plant cuttings.

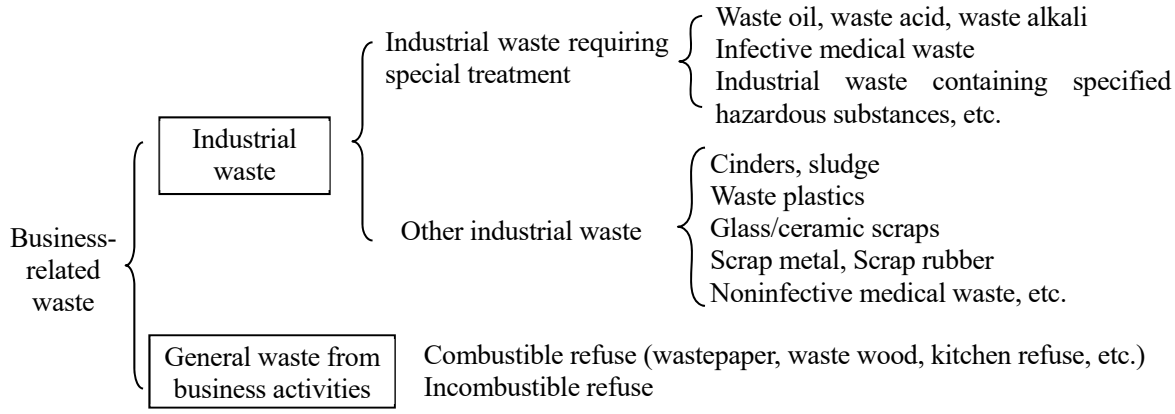


Figure 5.1 Classification of waste from business activities

Table 5.1 Types of industrial waste

Associated with all business activities:	Associated with specific business activities:	(20) Items that do not correspond to any of the categories listed on the left, but are formed as a result of processing the industrial waste listed on the left. (e.g. solidified forms of concrete)
(1) Cinders, (2) Sludge, (3) Waste oil, (4) Waste acid, (5) Waste alkali, (6) Waste plastics, (7) Scrap rubber, (8) Scrap metal, (9) Glass scraps, concrete scraps and ceramic scraps, (10) Slag, (11) Debris, (12) Dust	(13) Waste paper, (14) Waste wood, (15) Fiber waste, (16) Plant and animal residue, (17) Animal-related unnecessary solids, (18) Animal excrement, (19) Animal carcasses	

Table 5.2 Types of industrial waste requiring special treatment

Waste oil
Waste acid
Waste alkali
Infective medical waste
Industrial waste containing specified hazardous substances PCB waste (PCB waste, etc., PCB-contaminated waste, processed PCB products) Mercury waste, etc., and its processed products Asbestos, etc. Industrial waste containing hazardous metals
Import waste (dust, cinders, sludge, and processed materials from these)

5.3 Waste disposal at Kyushu University

The waste that Kyushu University disposes of includes wastewater, experimental waste generated from experiments, recyclable waste (used paper, plastic bottles, glass bottles, etc.), and business-related general waste (combustible waste, incombustible waste). Recyclable waste and business-related general waste are combined in the category of household waste. Experimental waste and household waste are further classified within each category, and are outsourced for treatment. Also, Kyushu University has established the "Kyushu University Regulations on Managing Water Supply, Water Drainage, and Waste", which includes stipulations necessary for properly managing drinking water and reclaimed water supply, wastewater, and waste.

5.4 Role of the Center for Environment and Safety, Kyushu University

Because the composition of liquid waste created by university laboratories varies widely, it is best if it can be treated by the experimenter – who is knowledgeable about the properties, toxicity, and risks of each liquid – until it is ready for final disposal. However, this often involves difficult tasks. Therefore, at Kyushu University, in 1972, with the aim of raising awareness of the environment and preserving the environment by properly treating the liquid waste generated by educational and research activities, a "Special Wastewater Treatment Facility" (the previous facility) with a capacity for inorganic special liquid waste treatment was installed in the Department of Agriculture located at Hakozaki Campus. In 1982, the facility was renewed as the "Special Waste Liquids Treatment Facility" in the Department of Engineering, also on Hakozaki Campus. In April 2010, as work related to environment and safety was becoming its main focus, the facility was renamed the "the Center for Environment and Safety" and moved to the Ito Campus Water Supply Center, which is its current location. Until 2013, the Center for Environment and Safety conducted neutralization and coagulating sedimentation treatment on heavy metal liquid waste collected from the university. However, from 2014 onwards, the treatment of heavy metal liquid waste at the Center for Environment and Safety was abolished. The collection, transport, and treatment of liquid waste are outsourced to an extramural contractor.

Currently, the main waste treatment related activities of the Center are the batch collection of waste and liquid waste, including heavy metal liquid waste, as well as manifest management over all waste. In addition, the Center also provides services such as water quality management of discharged water, chemical substance management, seminars and classes on environment and safety, and tours of the Water Supply Center.

5.5 Wastewater quality control and water recycling

5.5.1 Standards regarding waste

Tap water, rivers, groundwater, sewers, etc., all have established water quality standards. When wastewater is

released into the sewer, the sewerage standards from the Sewerage Service Act apply. When it is released directly into rivers, the wastewater standards from the Water Pollution Prevention Law apply. Table 5.3 lists the standard values for sewage release. The standard value for 1,1-dichloroethylene was relaxed from 0.2 mg/L to 1 mg/L in November 2011, and 1,4-dioxane was added as a target of regulation in May 2012 (standard value: 0.5 mg/L). For reference, Table 5.3 also lists environmental standard values.

Under the Water Pollution Prevention Act, etc., discharge water released to the sewer from each campus in Kyushu University is subjected to on-site inspection by the sewer manager of the local government where each campus is located. In addition, there is an obligation to voluntarily inspect discharged water and report the analysis results, and this is carried out by the Center for Environment and Safety.

If a standard value is exceeded during a voluntary inspection, the sewer manager should be contacted immediately. The cause should be investigated, appropriate measures should be taken (e.g., sending a notification to members of the department), and a report summarizing the above should be prepared and submitted to the sewer manager. In some cases, a restriction or prohibition may be placed on the releasing of wastewater into sewers. Therefore, please be very careful when handling the hazardous substances listed in Table 5.3.

Based on the results of voluntary inspections conducted so far by the university, "pH" and "*n*-hexane derived from animal and vegetable oils" are the water quality categories where the sewage release standard value tends to be easily exceeded. As one may understand from the fact that an acid of pH 1 must be diluted by 1:10000 or more in order to be brought to pH 5, if a highly concentrated acid or alkali is poured into the sink, the wastewater pH could fall outside the standard range (pH 5 to 9) Regarding animal and vegetable oil, this comes from the kitchen drainage. High concentrations are mainly caused by outflow from the oil trap.

Hazardous substances that demand caution even without exceeding the standard value are mercury and organic solvent dichloromethane. Mercury is a substance where detection itself should be avoided. As can be seen from the fact that a value of 0.1 mg/L (equivalent to double the standard value from the Water Pollution Prevention Law) has been reported for tap water that came into contact with mercury, mercury has the property of dissolving easily in water. Thus, care should be taken to prevent mercury from broken thermometers, etc., from entering the sink. For hazardous heavy metals such as mercury, enormous costs may be required for cleaning the water pipes, etc. Dichloromethane has a high solubility in water, and the ratio of solubility to its standard value is 65,000 times. This means that 1L of water that comes into contact with dichloromethane cannot go under the standard value unless it is diluted with 65 m^3 of water. It goes without saying that dilution or aeration processes should not be conducted, as they pollute the environment.

Table 5.3 Sewage standards and environmental standards (public water areas) December 2014

Substance name/category		Sewage standards (Sewerage Service Act)	Environmental standards (Environmental Basic Act)
Cadmium and its compounds		0.03 mg/L or less	0.003 mg/L or less
Cyanide compounds		1 mg/L or less	Should not be detected
Lead and its compounds		0.1 mg/L or less	0.01 mg/L or less
Hexavalent chromium compounds		0.5 mg/L or less	0.05 mg/L or less
Arsenic and its compounds		0.1 mg/L or less	0.01 mg/L or less
Mercury and its compounds		0.005 mg/L or less	0.0005 mg/L or less
Alkyl mercury compounds		Should not be detected	Should not be detected
PCB		0.003 mg/L or less	Should not be detected
Trichloroethylene		0.1 mg/L or less	0.03 mg/L or less
Tetrachloroethylene		0.1 mg/L or less	0.01 mg/L or less
Dichloromethane		0.2 mg/L or less	0.02 mg/L or less
Carbon tetrachloride		0.02 mg/L or less	0.002 mg/L or less
1,2-dichloroethane		0.04 mg/L or less	0.004 mg/L or less
1,1-dichloroethylene		1 mg/L or less	0.1 mg/L or less
Cis-1,2-dichloroethylene		0.4 mg/L or less	0.04 mg/L or less
1,1,1-trichloroethane		3 mg/L or less	1 mg/L or less
1,1,2-trichloroethane		0.06 mg/L or less	0.006 mg/L or less
1,3-dichloropropene		0.02 mg/L or less	0.002 mg/L or less
Thiuram		0.06 mg/L or less	0.006 mg/L or less
Simazine		0.03 mg/L or less	0.003 mg/L or less
Thiobencarb		0.2 mg/L or less	0.02 mg/L or less
Benzene		0.1 mg/L or less	0.01 mg/L or less
1,4-dioxane		0.5 mg/L or less	0.05 mg/L or less
Organic phosphorous compounds		1 mg/L or less	—
Selenium and its compounds		0.1 mg/L or less	0.01 mg/L or less
Boron and its compounds		Ito and Beppu Campus: 230 mg/L Other campuses: 10 mg/L or less	1 mg/L or less
Fluorine and its compounds		Ito and Beppu Campus: 15 mg/L Other campuses: 8 mg/L or less	0.8 mg/L or less
Nitrite and nitrate compounds		—	Total amount of nitrite- and nitrate nitrogen: 10 mg/L or less
Phenols		5 mg/L or less	—
Copper and its compounds		3 mg/L or less	—
Zinc and its compounds		2 mg/L or less	—
Iron and its compounds		10 mg/L or less	—
Manganese and its compounds		10 mg/L or less	—
Chromium and its compounds		2 mg/L or less	—
Hydrogen ion concentration (pH)		within the range of 5~9	—
Biochemical oxygen demand (BOD)		600 mg/L or less in 5 days	—
Suspended solids (SS)		600 mg/L or less	—
n-hexane extract content	Mineral oil content	5 mg/L or less	—
	Animal and vegetable oil content	60 (Beppu campus: 30) mg/L or less	—
Number of coliforms		—	—
Temperature		45 ℃ or less	—
Iodine consumption		220 mg/L or less	—

5.5.2 Water recycling at Kyushu University

Kyushu University complies with Japanese laws and regulations regarding water supply and sewage, as well as ordinances of local governments in each of its campuses. Internal rules have been established (Kyushu University Regulations on Managing Water Supply, Water Drainage, and Waste) for properly managing water supply and drainage on campus. Please read below regarding the use and drainage of water in Kyushu University's main campuses.

(1) At the Ito Campus, drinking water and the water used in cafeterias is from Fukuoka City. All wastewater, other than from toilets, is treated at the Water Supply Center and recycled. The treatment method is a two-stage membrane treatment, comprised of a biological treatment followed by a hollow fiber membrane and an ultrafiltration membrane. Water that has passed through the membranes and has become clean is used as water for experiments. Concentrated water that contains dissolved substances removed by membrane treatment is supplied to each campus building to be used as toilet water. Hazardous substances released from the laboratories would damage the microorganisms used in biological treatment. Also, harmful substances that are not decomposed by biological treatment are concentrated via membrane treatment and are contained in toilet water, which means they are released directly into the sewage system. Given the above, hazardous substances should never be flushed from the sink.

(2) At the Chikushi Campus, wastewater from the laboratories is reclaimed using the coagulation sedimentation method. The reclaimed water is mixed with well water and used in experiments. Therefore, although wastewater from the laboratory is not directly released into the sewer, if an amount of hazardous substances that exceeds the reclamation capacity is released from a laboratory, this could damage the reclamation facility or cause water to leak from the drain pipes and contaminate groundwater. It goes without saying that as reclamation of drainage water is different from liquid waste treatment, hazardous substances should never be flushed from the sink.

(3) The Hospital Campus also uses tap water from Fukuoka City, and at the same time, for drinking water, well water from the wells that have been desalted and filtered is mixed with city water. At each school building except the hospitals, the miscellaneous-purpose water obtained by filtering well water is used for flushing toilets. The new hospital has a facility that treats the wards' wastewater from baths, handwashing, etc., as well as rainwater and well water, and reuses it for flushing toilets. This reuse facility is equipped with a device for sterilizing and filtering wastewater.

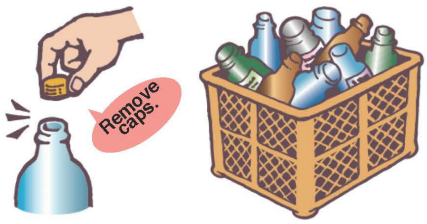
(4) At the Ohashi Campus, the drinking water is filtered well water. All wastewater is released directly into the sewer, so hazardous substances should never be flushed from the sink.

5.6 Laboratory waste disposal

Experimental waste (excluding medical waste) is treated as industrial waste regardless of whether or not it is harmful. The classification of experimental waste is shown in Table 5.4, and its poster is shown in Figure 5.2.

Experiment-Related Waste

Bottles



Put only cleaned chemical bottles into the same basket as residential waste (bottles). Put uncleaned bottles into the "Hazardous-Material-Containing Substances." Put small bottles into "Unburnable Waste."

Hazardous-Material-Containing Substances

Put materials containing hazardous substances into drums with lids. Put non-hazardous desiccants and adsorbents into containers and indicate their names.

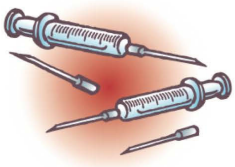
Unburnable Waste

Glass instruments, plaster, etc. Put them into the drum used for residential waste.
Put only **aluminum foil** in a plastic bag and separate it as **Metal Junk**.

Experimental-Related Burnable Waste

Use recyclable materials after cleaning to reduce CO_2 emissions.

Infectious Medical Waste



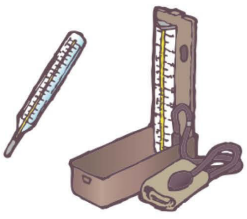
Quasi-medical waste such as syringe, etc., used other than medical practice has been processed by outsourcing as infectious medical waste since 2018. Put infectious medical waste in dedicated hazard boxes. For details of processing, please contact the manager of your department.

Pharmaceutical Waste and Others

Unnecessary drugs, hazardous solids and sludge, etc., excluding mercury-containing waste and spray cans. Please consult the supplier for the treatment of reagents in spray cans.

Mercury-Containing Waste

Inorganic mercury waste liquid, organic mercury waste liquid, unnecessary mercury and its compounds, sludge containing mercury,



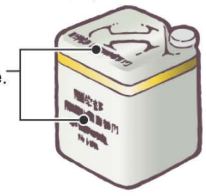
Submission of the list of the waste is in May and collection of the waste in October

Inorganic Waste Liquids

Color of Tape

- Blue — B … Cyanogen and arsenic waste liquid, pH>10
- Brown — C … Fluorine waste liquid
- Yellow — D-a … Heavy metal waste liquid
- Yellow — D-b … Heavy metal waste liquid containing organic matter
- Black — E … Photographic fixer waste

Indicate your affiliation on the top and the side.



Do not use deteriorated polyethylene containers.

Organic Waste Liquids

H-a … Halogenated organic solvent

H-b … Other organic waste liquid (Including oil and aqueous materials)

pH of aqueous materials should be >5.

For details on how to request treatment of inorganic and organic waste liquids, refer to the "Manual for Management of Chemical Substances and Treatment of Waste Liquid and Waste Material Treatment" of the Center of Environment and Safety. (TEL: 802-2591)

Kyushu University Environmental Protection Committee

Figure 5.2 Poster of Categorizing experiment-related waste

Table 5.4 Category and processing of experiment waste

Type	Category	Sign	Collection method/date
Inorganic effluent	Cyanogen and arsenic effluent	B	Carried in designated 20 L plastic container Collected on the first Thursday of every month
	Fluorine effluent	C	
	Heavy metal effluent	D - a	
	Heavy metal effluent containing water-soluble organic substance	D - b	
	Photo fixer effluent	E	
Organic effluent	Halogenated organic solvent	H - a	Carried in drum can Collected on the last Wednesday of each month
	Other organic effluent	H - b	
Waste containing mercury	Inorganic mercury effluent, Organic mercury effluent, Chemical waste containing mercury, Sludge containing mercury, Solid waste with mercury attached, Equipment using mercury (e.g., thermometer)		Collected once in a year around October
Others	Chemical waste (Dangerous/harmful solid/liquid wastes)		Collected once in a year around November
	Infectious medical waste (including pseudo-medical wastes)		Individually requested
Sorted waste from experiment	Burnable waste from experiment (e.g., old plastic)		Collected on 10th, 20th, and 30th of each month Carry to the waste storage Collected by external collector when necessary
	Harmful attachment (both burnable/non-burnable)		
	Glass bottle (cleaned chemical bottles)		
	Non-burnable waste		

5.6.1 Inorganic liquid waste

Inorganic liquid waste that the Center for Environment and Safety outsources disposal for are shown by the classification symbols B~E in Table 5.5. Liquid waste outsourced for processing should be stored and carried out in a 20 L polyethylene container designated by Kyushu University. As shown in Table 5.5, it is necessary to separate the liquid waste using the tape of the color determined for each liquid waste, and also to clearly indicate the content of each container. Liquid waste containing mercury falls into the category of “waste containing mercury”, and is treated separately from inorganic liquid waste.

The procedure for collecting and treating inorganic liquid waste is as follows

(1) Before requesting treatment, check whether proper pretreatment has been done and whether the amount of liquid is appropriate.

(2) Submit the request slip for inorganic liquid waste disposal.

(3) Bring the color-coded liquid waste containers to the designated location by the collection date.

(4) Emptied containers for liquid waste other than cyan and arsenic will be returned on the day of collection.

(5) Liquid waste that does not meet the conditions specified in the treatment request, or that violate precautions, will not be collected and will be returned.

Table 5.5 Classification of special liquid waste and tape colors March 2018

Classification symbol	Tape color	Classification	Treatment subjects	Requested conditions
B	(Blue)	Cyan and arsenic liquid waste	Complex cyanides, water-soluble organic substances, and heavy metals other than mercury may be included. Alkaline liquid waste	pH > 10 Hg < 1 mg/L
C	(Brown)	Fluorine liquid waste	Liquid waste of inorganic fluorine compounds. Water-soluble organic substances and heavy metals other than mercury may be included.	pH > 6.0 Hg < 1 mg/L
D-a	(Yellow)	Heavy metal liquid waste	Liquid waste containing heavy metals. Acid liquid waste	Organic matter < 4 g/L Hg < 1 mg/L Cyan/arsenic < 1 mg/L Fluorine < 15 mg/L
D-b	(Yellow + black)	Heavy metal liquid waste containing organic matter	Heavy metal liquid waste containing chelating agents, or at least 4 g/L of water-soluble organic matter	Organic matter > 4 g/L Hg < 1 mg/L
E	(Black)	Photographic fixing solution	Only photographic fixing solution that contains silver	Developing fluids must not be mixed in

・What cannot be processed: infective waste, radioactive substances, PCB, dioxins, beryllium, osmium, thallium, selenium, rare earths.

・Any solids and precipitates in the liquid waste must be separated and removed. Treatment of solids, sediments, etc., which have been removed from the liquid, should be disposed of as “Sludge, etc. (Class B)” in “Haiyakuhin nado no gakugai itaku shori (Extramural contracted treatment of chemical waste, etc.)”.

・Liquids divided into water and oil layers due to the mixing of an organic solvent, etc. should be separated into water and oil, and with each receiving an appropriate treatment.

Details can be found in the “Waste Liquid and Waste Material Treatment Manual” issued by the Center for Environment and Safety. Those who are conducting experiments that may produce hazardous waste should read this document carefully. Further, when requesting treatment, please adhere to prescribed procedures and pretreat the liquid waste as required.

5.6.2 Organic liquid waste

Collection and outsourcing for treatment of organic liquid waste follows almost the same procedure as for the case of disposing of inorganic liquid waste. Regarding organic liquid waste from each laboratory, transfer them into the drums placed at the collection space for organic liquid waste established at each school. (Please prepare and wear safety protection equipment – gloves, eye protection, masks.) The drums are collected every month by

a contractor outside the university.

Classification is as follows:

- "Halogenated organic solvents (H-a)"
  (However, for CFCs a request must be sent to a registered contractor.)
- "Other organic liquid waste (H-b)" – non-halogenated organic solvents, water that has been in contact with an organic solvent, aqueous solutions of organic substances, photograph developing fluids (water-type liquid waste should have a pH higher than 5, in order to avoid corrosion of the drum.)

Regarding details on how to submit an organic liquid waste discharge application, and how to carry out the liquid waste, contact the person in charge at each department.

5.6.3 Acidic/alkaline liquid waste

Acidic/alkaline liquid waste that does not contain mercury is classified as either inorganic liquid waste or organic liquid waste. Although it is possible to neutralize acidic/alkaline liquid waste that does not contain heavy metals or organic substances, check that pH is in the 5-9 range, and release it, the neutralization of strong acids or alkalis is dangerous, as it generates heat and gas. Therefore, please treat the acidic liquid waste as "heavy metal liquid waste" and the alkaline liquid waste as "cyan liquid waste". Acidic/alkaline liquid waste containing water-soluble organic matter should be adjusted to pH >5 and categorized as "other organic liquid waste". Or, if the neutralization work is difficult, acidic liquid waste should be categorized as "heavy metal liquid waste containing aqueous organic matter". Alkaline liquid waste should be categorized as "cyan liquid waste" (pH > 10). Hydrochloric acid and concentrated sulfuric acid should be treated as chemical waste.

5.6.4 Chemical waste

Old chemicals that are no longer usable or that are unlabeled can lead to unexpected accidents. Be sure to organize and categorize them, and process them using one of the methods listed below. For details on procedures and sorting methods, please adhere to the "Waste Liquid and Waste Material Treatment Manual".

(1) Organic solvents and water-solvable organic chemical waste in chemical bottles must be taken out of the bottles as liquid waste, and processed as "organic liquid waste".

(2) Water-solvable heavy-metal inorganic salts, if existing in small quantity, should be dissolved in water and categorized as "heavy metal liquid waste".

(3) Chemical waste other than the above must be disposed of during yearly extramurally outsourced processing (request list submission by July, batch collection in November). They should be carefully stored until collection time. In particular, regarding old toxic or harmful substances, ensure that accidents such as misplacement or loss do not occur. Chemicals in ampules must be processed by an extramural contractor, without exception.

(4) Chemicals with unknown content cannot be processed as part of the batch collection of chemical waste. For these, treatment must be consigned to an individual contractor.

5.6.5 Waste containing mercury

Until 2017, inorganic mercury liquid waste was processed as “inorganic liquid waste”, and organic mercury liquid waste, thermometers, sludge containing mercury, etc. were processed as “chemical waste, etc.” However, since 2018, waste containing mercury has been collected once a year for contracted processing outside of the school (request list submission by June, batch collection in October). For specific procedures and sorting methods, please adhere to the “Waste Liquid and Waste Material Treatment Manual”.

The following points must be considered when bringing this waste to collection, or storing it until the collection date.

（1） Prevent dispersion, leakage, and seepage into the ground when storing them.

（2） Inorganic and organic mercury liquid waste must be stored in plastic containers that are robust, and that remain stable during transport. The Center for Environment and Safety does not supply the containers.

（3） Proof of the concentration measurement of mercury content is required for processing liquid waste that contains mercury. This should be commissioned to an analysis contractor in advance, Liquid waste without proof of the concentration measurement cannot be processed.

（4） Waste is categorized as “mercury liquid waste” even if it contains heavy metals other than mercury.

（5） Alkaline waste liquid that contains cyan/arsenic compounds are also included in the category of “waste containing mercury”. Neutralization of these compounds is extremely dangerous, as it generates hydrogen cyanide (cyanide fumes).

（6） The amount of water-solvable organic substances contained is not relevant.

（7） Mercury thermometers and electrodes can be grouped together be type. Place them in a plastic bag (double layered, so that the contents can be seen from the outside. Damaged thermometers and electrodes should be placed in individual plastic bags (double layered) to prevent mercury leakage. Metallic mercury in bottles should also be placed in a plastic bag (double layers).

5.6.6 Infective medical waste

Although syringes used for non-medical purposes and other such wastes were previously treated as pseudo-medical waste, beginning in 2017 they have been individually sent out for contracted processing as infective medical waste. Pseudo-medical waste, as in the case of infective medical waste, should place in the hazard box used for infective medical waste, and then carried out. Please be aware that there is no batch collection for this category. For details on processing procedures, contact the person in charge in your department.

5.6.7 Solid waste containing toxic substances (sludge, etc.)

Solid waste generated in each department, such as sediment accumulated in the trap under the laboratory sinks, should be processed under “Sludge, etc. (Class B) in “Haiyakuhin nado no gakugai itaku shori (Extramural contracted treatment of chemical waste, etc.)”. Muddy substances, sediment, catalysts, etc., containing harmful substances such as cadmium, cyan, lead and chromium should be stored securely until the time of collection.

5.6.8 Sorted refuse from experiments

・Burnable waste from experiments

Burnable waste such as plastic or rubber gloves, which have no harmful substances attached, must be placed in a transparent bag (commercially available) and placed in the sorted refuse area in the department (Fig. 5.2).

・Waste with harmful substances attached (combustible and non-combustible)

Glass reagent bottles, pieces of glass, plastic, used silica gel, etc., that have not been sufficiently washed should be placed in a drum with a lid labelled “waste with harmful substances attached”, which can be found in the sorted refuse area in each department.

・Glass reagent bottles with no harmful substances attached.

Only glass reagent bottles that have been thoroughly washed and are free of harmful substances may be placed in the “bottles” basket in the residential waste section. Small bottles are categorized as “non-burnable waste”.

・Non-burnable waste

Non-burnable waste such as glassware, gypsum, aluminum foil, etc. that are free of harmful substances should be placed in the “non-burnable waste” drums in the sorted refuse area in each department. Aluminum foil should be sufficiently compressed.

・PCBs, asbestos, etc.

When finding something that seems to be waste that includes PCBs, asbestos, etc., do not open the packaging. Immediately report to the person in charge in your department or the Center for Environment and Safety, and follow instructions from them. Wear protective equipment such as dust masks or rubber gloves when handling them.

5.7 Residential waste disposal

The category of residential waste includes recyclable waste such as used paper, bottles, beverage cans, plastic bottles, Styrofoam, metal scraps, etc., fluorescent tubes containing harmful substances, dry-cell batteries, and burnable as well as non-burnable waste that is general waste from business activities. At Kyushu University, sorting of refuse is conducted with the aim of increasing the amount of waste that can be recycled, and decreasing burnable and non-burnable waste as much as possible. Figure 5.3 outlines the method for sorting residential waste.

Residential Waste

Used Paper
(For details, see the waste paper sorting table.)

Prohibited Substances
Tape, tissues, waterproof paper, thermal paper, carbon paper, photos, and coated paper.

Remove all plastics, tape, and metal fittings as much as possible.

Newspapers


Cardboards


Remove packing tape.

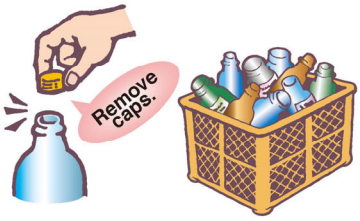
Magazines and Books


Magazines, books, pamphlets, copy papers, etc.

Miscellaneous Papers


Paper scraps that cannot be bundled by strings, such as notes, postcards, cut papers, etc.

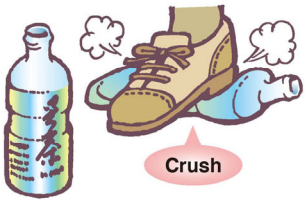
Newspapers, cardboard and magazines should be tied.

Bottles


Put them into a case at the pickup point.
Put transparent, brown, green and black bottles together.

Beverage Cans


Aluminum and steel cans can be mixed together.
Remove any objects from cans first.

PET Bottles


Discard the contents, wash, and crush.
Put in a dedicated box.
Caps should be removed and discarded with combustible waste.

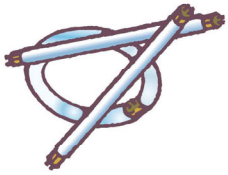
Styrofoam
Recycle Styrofoam larger than 30cm.
Remove tape and labels.
Check for the recycling mark below and put items without it into the burnable waste.

Metal Junk

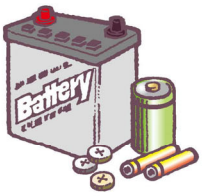

For waste made mostly of metal (including electrical wires).
Put aluminum foil in to a transparent bag.

Unburnable Waste


For glass and ceramic waste only.
(Do not put appliances or furniture in this box. Treat them as oversized trash.)

Fluorescent Lights


Fluorescent light tubes, light bulbs, equipment affixed with lamps, LED lamps, etc., are collected every year in October.
Store them in the department until then.

Batteries


Batteries including dry batteries are collected in July.

Spray Cans


After using them up, pierce and throw away spray cans as metal junk for recycling.

The Committee for Environmental Conservation, Kyushu University As of May 2020

Figure 5.3 Poster of categorizing residential waste

5.7.1 General waste from business activities

Burnable waste that is general waste from business activities should be placed in a designated plastic bag and brought to the sorted refuse area in each department. The plastic bags should not be overfilled, and should be tied firmly. Electrical appliances and furniture are put out according to the rules set by each department. Put only glass scraps and ceramic scraps in the “non-burnable garbage” drums. Non-burnable waste or metal waste should not be mixed into the burnable waste. Please show consideration to the safety of waste collection and post-treatment workers by placing sharp glass pieces or needle-shaped metal scraps, which could be dangerous to the collection workers, into a can.

5.7.2 Used paper

Waste paper will be collected by a collection company and recycled. Sort into the following four types (Figure 5.4).

・Newspaper

・Cardboard

・Magazines and miscellaneous paper (notebooks, copy paper, pamphlets, stationery, etc.)

・Pieces of paper (Small scraps of paper that cannot be tied with string, memo paper, postcards, envelopes, shredded paper, etc.)

Items that should not be mixed in:

Tissue paper, thermal paper, waterproof paper, oil paper, carbon paper, coated paper, photographs, synthetic paper, cellophane, packing tape, cloth, string, metal (Stapler needles can be mixed), etc.

Notes:

・Newspapers, cardboard, magazines and miscellaneous paper should be tied with string.

・Pieces of paper should be placed in a transparent plastic bag (commercially available type), with foreign matter removed.

・Do not mix other pieces of paper with shredded paper.

・Tissue paper, thermal paper, waterproof paper, oil paper, carbon paper, vinyl processed paper, wrapping foil, waxed paper, beverage paper packs, photographs, synthetic paper, etc. are not subject to waste paper collection, so they are considered as combustible waste for daily life. Thermal paper, carbon paper, vinyl processed paper, wrapping foil, wax processed paper, oil paper, beverage paper pack, etc., are not subject to collection.

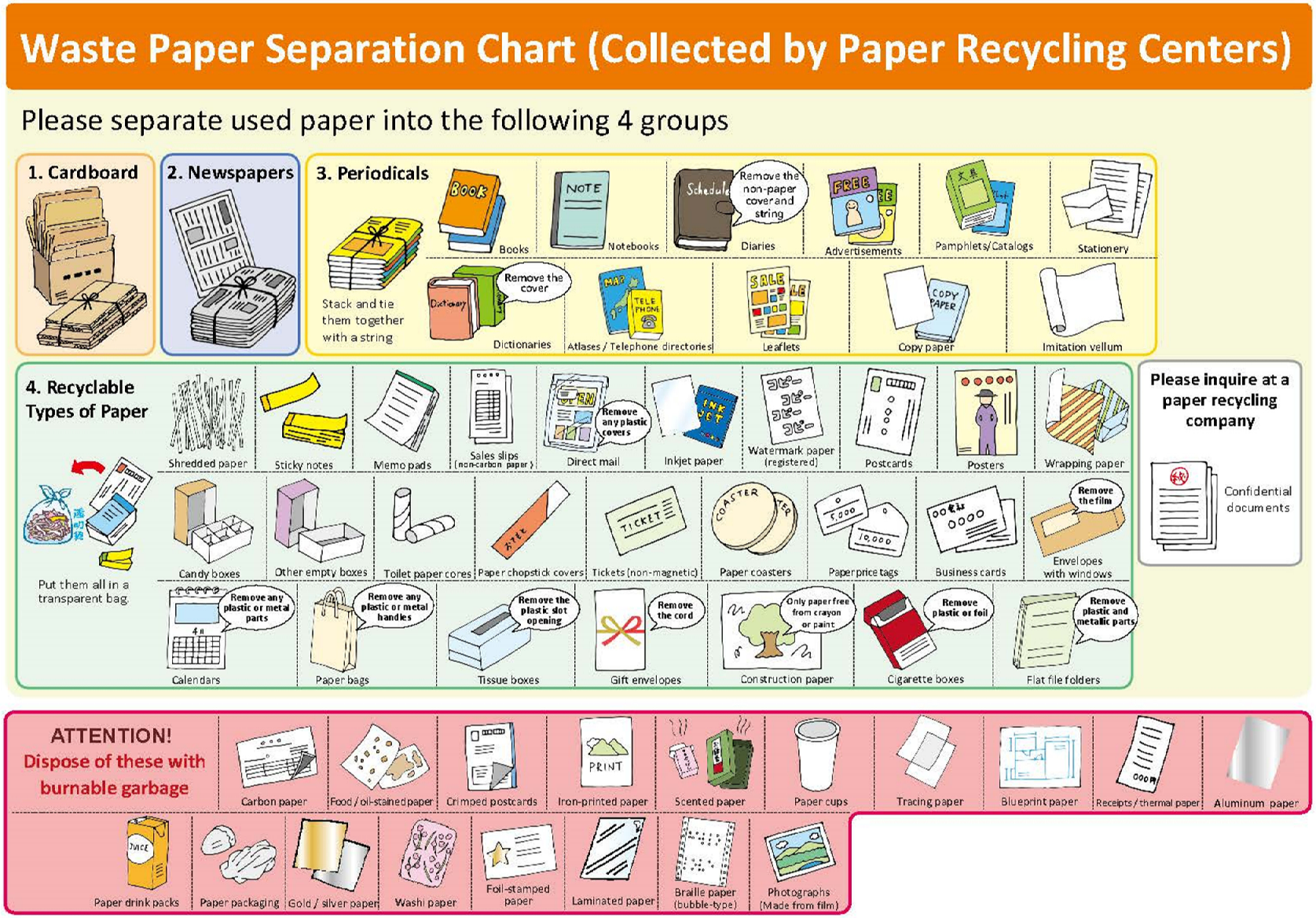


Figure 5.4 Poster of categorizing waste paper

5.7.3 Bottles, beverage cans, plastic bottles

Be sure to clean glass bottles by first removing the lid. They should be emptied and placed in the recycling basket in the sorted waste area of each department. Empty beverage cans should be washed with water, emptied, placed in a transparent plastic bag, and placed in the sorted waste area of each department. Aluminum and steel cans can be mixed. Foreign matter (e.g., cigarette buts) should not be included.

Remove caps and labels from PET bottles, and wash them with water. After emptying and crushing them, put them in a transparent plastic bag and take them to the sorted waste area of each department. In the Ito area, for most of the garbage areas, the Eco Center at Kyushu University collects and recycles beverage cans and PET bottles.

5.7.4 Styrene foam

Only box- or board-shaped styrene foam can be recycled. “PS” or “Recycle” marks are on polystyrene foaming materials. A polypropylene foaming material that looks like styrene foam but is elastic (viscous) and is not crisp like styrene foam when broken, or chip-shaped, sponge-shaped, a few-centimeter-long filling material or sheet-shaped styrene foam, must be treated as “burnable waste”.

5.7.5 Florescent tubes, etc.

Any undamaged fluorescent tubes, arising when installing new fluorescent tubes, waste mercury lamps, and LED lamps should be taken to the designated locations. Mercury lamps used as light sources for analyzers are also treated together with waste fluorescent tubes. Collection and consigned processing are done once a year (disposal request application in August, collection in October). Regarding disposal procedures, as in the case of batteries, follow the instructions of the person in charge in your department.

5.7.6 Batteries

There are various types of dry-cell batteries such as nickel-cadmium batteries, lithium dry-cell batteries, and button batteries, however, in 2003 classification based on inclusion of mercury was abolished, and these batteries now fall into the unified category of “dry-cell batteries”. There are also lead-acid batteries. Note that batteries of laptops, etc., are categorized as lithium-ion batteries. Collection and consigned processing are done once a year (disposal request application in June, collection in July). Regarding specific disposal procedures, such as disposal applications, and transport to the collection location, follow the instructions of the person in charge in your department.

5.7.7 Spray can

In principle, spray cans that are not empty are not collected. They can either be used, degassed, punched a hole

in, and treated as “metal waste”. Disposing spray cans that are not empty as common business waste may lead to an accident.

Small pressured containers (cylinders) of chemicals are not collected in bulk, even if they are chemical wastes. Their processing should be requested to either their manufacturer or the distributor.

5.7.8 Metal scraps

Small metal scraps, which are mostly made of metal, are recycled. They should be placed in the drum labelled “metal scraps”, installed in the sorted waste area of each department. Because sharp objects like blades and needles can be dangerous to the collectors, be sure to place them in metal cans. 18 L cans (oil cans) should be crushed if possible. Metals with large plastics attached are classified “Bulky waste” or “metal scraps”. For aluminum foil, put it in a transparent bag and turn it into metal scraps.

5.7.9 Bulky waste

Regarding large metal pieces with value, such as shelves and desks, electrical appliances, the office of each department makes a request to a collection company to have them carried out. For details such as collection date and time, location of pick up, etc., please contact the staff in charge.

5.7.10 Online recycling system at Kyushu University

Items that are usable but no longer needed can be registered as unused items or rental items on the “Online recycling system at Kyushu University”. (http://recycle.jimu.kyushu-u.ac.jp/asp/enteruser.asp) Through this system, they can be gifted or lent within the university to assist with effective utilization of items and cost reduction. So far the Kyushu University online recycling system has been used for experimental equipment, personal computers, copiers (including peripherals and related consumables), office supplies (desks, bookshelves, lockers, etc.), office supplies (writing instruments, paper, etc.), and more.

Chapter 6 Safe handling of high-pressure and hazardous gasses, and points of caution for high-pressure and vacuum experiments

6.1 Handling high-pressure gas cylinder ("bonbe" in Japanese)

6.1.1 Labels

Check the following labels (example) on the shoulder of each cylinder.

(1) Signs of the manufacturer of the cylinder, name of the filled gas U112・O_2

(2) Cylinder symbol and serial number of the manufacturer MLF44946

(3) Capacity (actual inner volume): L V47.2

(4) Tare weight: kg W51.4

(5) Date of pressure test Month-Year (last two digits) 3−19

(6) Test pressure: kg/cm^2 TP250

(7) Maximum filling pressure: kg/cm^2 FP150

(8) Color labels of the cylinder

Oxygen → Black Hydrogen → Red Carbon dioxide→ Green

Ammonia → White Chlorine → Yellow Acetylene → Brown

Others → Gray

(9) To show the character of the gas, flammable gases are labeled as “燃” and toxic gases are labeled as “毒”.

6.1.2 Precautions for their transportation

(1) Close the valve, remove the regulator, and attach the valve protection cap before moving a cylinder.

(2) Use the appropriate pushcart designed for cylinders.

(3) When moving through places where the pushcart cannot be used, move the cylinder by tilting it slightly and using the edge of the bottom to rotate it. Be careful not to let it fall.

(4) When moving a cylinder through stairs using human power, make sure to move it with two or more people. At this time, should not put a rope around the cap.

6.1.3 Notes on installation and storage

(1) Install the cylinders on a properly fixed cylinder stand.

(2) When not using a stand, secure the cylinder at two spots of its body on an experiment table or a pillar using chains or belts. Make sure that the chain or belt is not wrapped around the neck of the cylinder.

(3) Make sure that a liquefied gas or acetylene cylinder is vertical when using it.

(4) Avoid direct sunlight or humidity, place them in a well-ventilated spot, and make sure that the temperature does not exceed 40°C. Do not place fire or ignitable, flammable, or corrosive substances close to where the cylinders are installed/stored.

(5) Avoid installing/storing them near electric or ground wires.

(6) Do not store them in a spot that may hinder evacuation, such as an emergency staircase.

(7) When not using, always close the valve, remove the pressure regulator, and attach the cap. Unused or used cylinder (after an experiment) must be stored in the cylinder storage following the high-pressure gas storage usage regulation included at the end of this booklet.

(8) Flammable or toxic gases must be clearly labeled and separated, and full and empty cylinders must also be separated in the storage. Pay special attention to distinguishing between flammable gas cylinders and oxygen gas (combustion-supporting gas) cylinders

6.1.4 Notes on use

(1) Pressure regulator (hereinafter regulator)

(a) Use the regulator specific to each gas and do not exchange them.

(b) As each regulator type has different ways to operate them, fully understand its operation in advance.

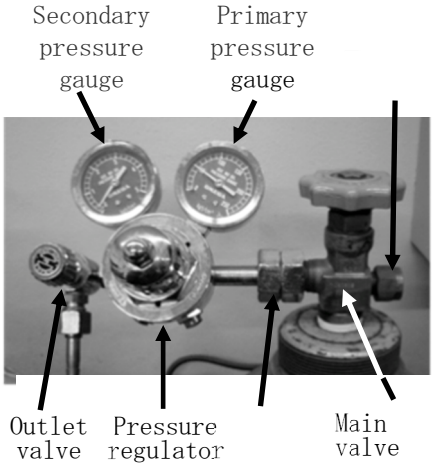
(c) Properly clean the connecting section between the valve and the regulator, and check if its screw fits well. Use a new packing that fits the contact area well.

(d) Use only the designated spanner when attaching the cap nut of the regulator. Moreover, make sure you do not fix the nut too tight and break the packing or screw thread.

(e) Use a pressure gauge that can measure between 1.5 to 3 times higher than the working pressure.

(f) Do not lubricate the regulator without reason. It could cause a fire.

(g) When removing the regulator, close the valve securely and completely release the gas in the regulator first.



(2) Main valve operation

(a) Be aware that the main valve has left and right screws.

(b) Never operate the over-pressure relief valve.

(c) Always stand on the side of the pressure gauge of the regulator when opening or closing the main valve, and do it quietly. Sudden opening can cause an accident or damage on the regulator. Use the designated handle or spanner when opening/closing the main valve.

(d) Rotating once or one and half times is enough for opening the main valve.

(e) When gas is leaking from the main valve, move the cylinder to a safe spot outside.

(f) Never remove the main valve or damage the cylinder, and absolutely avoid the gas transferred from one cylinder to another.

(g) When the gas is used up, make sure to close the main valve while there is a small amount of gas left, remove the regulator, and attach a valve holding cap.

(3) Other points of caution

(a) When temporally stopping the usage of gas, make sure to close both the regulator and main valve and

detach the connection between the experiment equipment and the regulator.

(b) When warming the regulator, the valve, or pipes, use a hot towel or hot water less than 40°C.

(c) Return used cylinders immediately irrespective of whether or not there is gas left in them.

6.2 Handling hazardous gas

(1) Flammable/combustion supporting gas

(a) Prohibit usage of fire within 5 m of the facilities that use flammable gases (hydrogen, hydrocarbon, etc.), oxygen, and do not place the flammable/ignitable materials. However, this does not include them used in these facilities.

(b) When using oxygen, use it with laying out the pipes with specified materials and removing flammable substances (e.g., petroleum, fat, oil) from the equipment.

(c) The oxygen cylinder should be opened and closed slowly and carefully (to avoid adiabatic compression fires).

(d) It is safer to, as much as possible, avoid using combustion-supporting gasses and flammable gasses in the same room. When using a combustion-supporting gas and flammable gas in the same room, separate and shield them from each other.

(e) For combustion-supporting gases, use a dedicated regulator that is labelled “oil-free”.

(f) For ethylene oxide, use after replacing the inside of the equipment with N_2, CO_2, etc. Also, install a backflow prevention device between the cylinder and the equipment.

(g) When using acetylene gas, set the exit pressure at 0.1 MPa (1 kg/cm^2) or less in order to avoid decomposed explosion.

(2) Toxic gas

(a) For an experiment using a toxic gas (H_2S, CO, Cl_2, HCN, or SiH_4), conduct it inside a local ventilation device such as a draft in order to avoid inhaling it. Cyanogen gas (hydrogen cyanide: HCN) may cause cyanide poisoning (headache, dizziness, problem breathing, etc.) when inhaled. Moreover, silane gas (SiH_4) is auto-combustible and may cause explosion. Thus, the usage of pressured gas is strictly regulated by law.

(b) When disposing toxic gas, make it harmless by using, for instance, an alkaline absorbent beforehand. Return the toxic gas cylinders after usage to the dealer immediately irrespective of whether or not there is gas left in them.

(c) Should be aware of the fact that even a small leakage of toxic gases can be fatal when handling them.

(d) Always wear protective gears suitable for each gas, such as a gas mask, gas-proof clothing, gas-proof glasses, or gas-proof gloves, when handling toxic gases.

(e) Use a container that is as small as possible when using toxic gas. Do not store toxic gas for long periods of time without using it.

(f) Toxic gas cylinders in the laboratory should be stored basically in a cylinder cabinet.

6.3 Notes on high and low temperature experiments

Chemical experiments are sometimes conducted in a combination of situations such as high temperature, low temperature, high pressure, and low pressure. Be cautious as this could cause physical harm, such frostbite, and accidents, such as fire or explosion, when handled inappropriately.

6.3.1 High-temperature experiments

(1) Experiments using high-temperature devices should be conducted in a fireproof building, or a room with fire-prevention facilities. Take special care to ventilate the room properly.

(2) Prepare fire-extinguishing facilities that are most suitable to the nature of the experiment (e.g., dry-chemical fire extinguishers, foam fire extinguishers, and carbon dioxide fire extinguishers).

(3) Do not add water to the high-temperature liquid that is being used as the heat medium. Also, not drop hot objects into water. The water will evaporate rapidly, causing a phreatic explosion, and be scattered to the surrounding area.

(4) For older electric furnaces, there is the possibility that asbestos was used, so caution should be exercised during their disposal.

6.3.2 Low-temperature experiment

For obtaining a low temperature, cryogens are often used. When using dry ice or cryogenic liquefied gas, pay attention to the following points in order to prevent accidents.

[A] Hypoxia prevention

When a cryogenic liquefied gas, which is used as cryogen, vaporizes, its volume increases from 600 to 700 times. Thus, it may cause hypoxia when used in a room without good ventilation. The Industrial Safety and Health Act defines hypoxia as a state where the oxygen concentration is 18% or less, and states regulations for its prevention. Hypoxia first reduces the brain function. When air with extreme oxygen deficiency is inhaled, it causes immediate unconsciousness and breathing to stop. When oxygen is not provided to the brain cells for more then three minutes, several brain functions will be lost, and even if the patient is rescued, it will cause aftereffects such as paralyzed limbs, memory loss, dementia, or change of personality.

Oxygen concentration (%)	Symptom
14	Slow thinking
12	Dizziness, nausea, etc.
10	Unconsciousness
8	Unconsciousness will lead to death without treatment
6	Faint immediately after one breath, breathing stops after a few breaths, untreatable after 2−3 min.

Moreover, ventilation should be secured when using dry ice in order to prevent carbon dioxide poisoning (minimum poisoning concentration: 2%). It is desirable to install an oximeter or a carbon dioxide alarm in order to prevent the poisoning

[B] Points of caution for handling

(1) Dry ice cryogen

(a) Dry ice cryogen may cause frostbite when it touches skin directly. Therefore, it should be handled using thick protection gloves or newspapers, and should be used in a well-ventilated place in order to avoid carbon dioxide poisoning.

(b) The volume of dry ice cryogen increases 750 times when it evaporates, and may cause explosion when stored in a sealed container such as a glass jar. Thus, avoid storing it in a sealed container.

(2) Cryogenic liquid (liquid nitrogen, liquid helium, etc.)

(a) Prevent cryogenic liquids from touching skin directly, and it is safer to handle them in a well-ventilated place and at a spot as close to floor as possible.

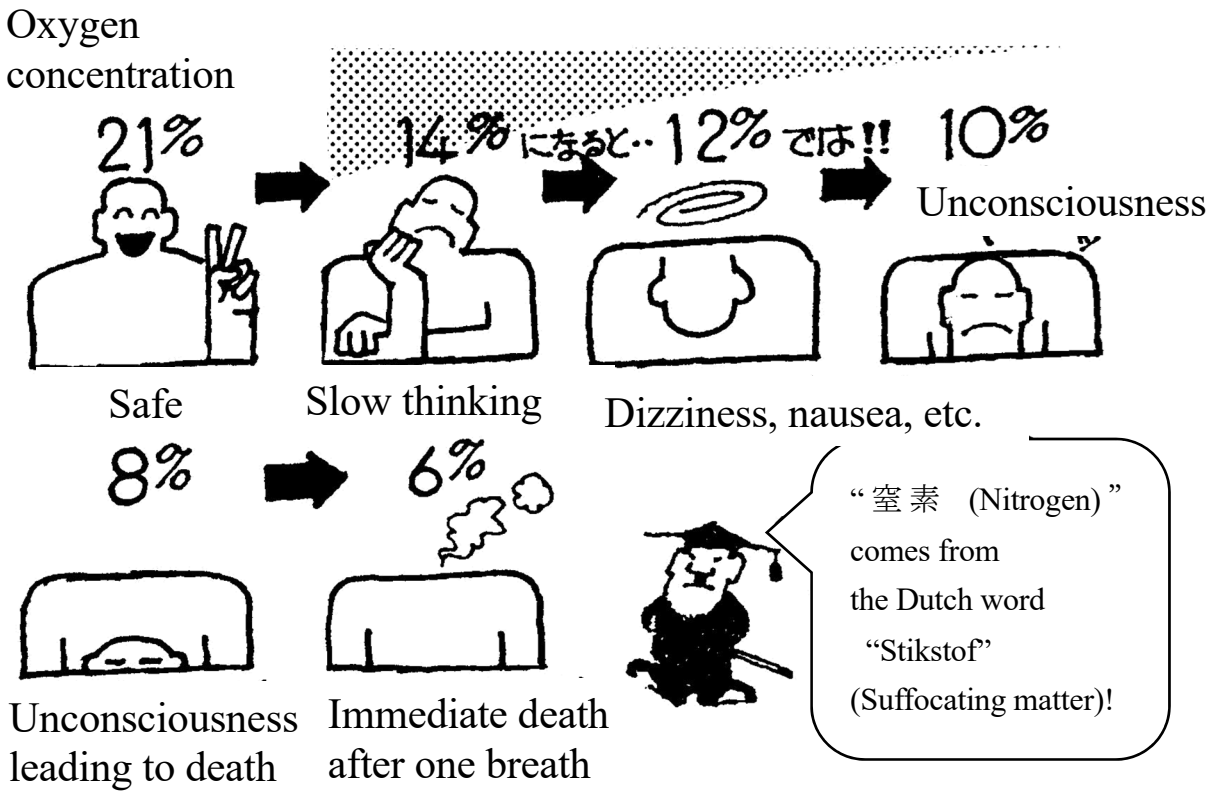
(b) Never use the oils and greases on equipment that will contact with cryogenic liquids.

(c) When using cryogenic liquids, wear leather gloves. Do not use cotton gloves as they may cause frostbite.

(d) Upon evaporation, the volume of liquid nitrogen increases by around 650 times, and that of helium increases by around700 times. Thus, caution must be taken to avoid hypoxia accidents. For this reason, the laboratory should have an oximeter. Also, open containers should not be sealed, so as to avoid the risk of container rupture.

(e) Follow the points below when taking out liquid nitrogen into a container from the liquid nitrogen tank (cold evaporator) in the building.

- In principle, always work as a team of two and do not stray from the container when taking out the liquid nitrogen.
- Treat the valve and pumping pipe carefully. Close the valve thoroughly after taking the liquid nitrogen out.
- Use a special pushcart when moving liquid nitrogen container, and be careful not to let it fall.
- Do not use a vehicle where the inside is sealed, such as passenger cars, for transport as it may cause a hypoxia.
- Do not transport it in a vehicle that may cause the container to fall, such as bicycles.
- When moving it in an elevator, a person should not ride the elevator with liquid nitrogen.



6.4 Notes on high-pressure and vacuum experiments

6.4.1 High-pressure experiments

(1) Construct a solid stand or frame device even for a short experiment, and conduct the experiment while the device is securely fixed.

(2) Make sure the pressure regulator is a suitable one, and is working properly, before mounting it on the cylinder. Keep in mind that if oils are stuck to the valves or pressure regulators, this may cause a fire.

(3) Gas reaction devices, when the pressure is lowered, have an inherent risk of sucking in air and causing an internal explosion. Thus, it is good idea to arrange for piping of an inert gas such as nitrogen, so that the reactor can be purged with inert gas. When carrying out gas phase oxidation reactions with air such as hydrocarbons (or oxygen), be especially careful regarding the explosion limit.

(4) When the pressure regulator or pressure gauge is old, its front glass sometime breaks from the shock produced by opening the mail valve of the cylinder. Thus, do not bring face close to where the regulator and do not stand in front of the pressure gauge when opening the valve.

(5) Release the gas after the reaction, to outside. To avoid prevent gas poisoning, fire, or explosion, use methods such as gas absorbent or local exhaust ventilation.

6.4.2 Piping

(1) Connect devices properly in order to avoid gas leak. Pay attention to the connections between pipes, device and pipe, and flange and the welded parts, and use an inert gas for each connection to check gas leaks.

(2) Check for gas leaks from the connection between the cylinder and pressure regulator, the connection between the pressure regulator and the device, the pressure regulator, etc. One method for inspecting the presence/absence of gas leakage is to apply soapy water to the connecting section, under pressure, and check for bubbles. There are other methods as well, such as closing the valve and checking for changes in the pressure gauge reading.

(3) Use metal pipes for piping from cylinders. When using rubber hoses, ensure a secure connection by using hose bands and other devices.

6.4.3 Vacuum experiments

(1) Pump

(a) Use an appropriate vacuum pump for the required degree of vacuum.

(b) Do not operate an oil rotary vacuum pump continuously at a high evacuation pressure of 10 kPa or more. Moreover, let the air in immediately after stopping the pump. When the pump is stopped while it is left in vacuum, the oil flows backward to the device. Use of an automatic isolation valve (a backflow preventer which isolates the pump and let the air in the pump in case of electric power cut) is highly recommended.

(c) When a water-cooled oil diffusion pump is hot, make sure that the cooling water is circulating properly.

(d) Change oil regularly. If rust/particles are observed in the oil, the pump should be overhauled and cleaned. If the rotation is prevented by the rust/particles and the pump is stopped (rocked), overcurrent runs through the motor and it is heated.

(e) Do not run a pump without the overcurrent prevention circuit unattended. When using a pump with a prevention circuit, be aware of the pump oil flowing backward when it is stopped. (Check if the pump has an overcurrent prevention circuit.)

(f) Tidy up the surrounding area and do not bring oil or flammable materials close.

(g) When using an oil mist trap, check the element appropriately. When the element becomes saturated, it may cause diffusion of oil mist in the room and start fire, or (when in-line) may lead exhaustion resistance, which would put load on the pump and cause heating.

(h) Avoid the pump from sucking in dust and fine particles. Moreover, absorption of acid or excessive moisture causes rust, so change the oil when they are sucked in. It may require cleaning.

(i) Check for air leak when the decrease in pressure is slow (though this depends on the size of the system). If operation is continued with high pressure, the rotary pump may diffuse the oil mist.

(j) The direct-drive oil rotary vacuum pump has less oil and higher rotation of the motor compared to the belt-driven rotary pump, and therefore, its motor and pump heat up more. Thus, pay particular attention to the abovementioned usage conditions.

(k) When using a belt-driven oil rotary vacuum pump, check for loosening or crack on the belt and change the belt in advance if necessary. It is extremely dangerous if the belt breaks while the pump is in operation.

(2) Handling of gases

(a) Do not use the oil rotary vacuum pump for large amount of acidic gas, water vapor, or organic vapor.

(b) Be cautious with the fumes of toxic gas, flammable gas, and malodorous gas. If necessary, take measures such as absorbing the gas fumes or using local exhaust ventilation.

(c) Avoid using mercury with a vacuum device as much as possible. If it is necessary to use mercury, take sufficient measures against contamination with mercury vapor or its diffusion due to breakage of the equipment.

(3) Handling of vacuum system

(a) Pay particular attention to the damage on the piping when using a glass vacuum device.

Chapter 7 Safe handling of machines

7.1 General precautions

(1) Receive sufficient instruction and be fully aware of its operation when using a machine.

(2) Always check the surrounding area yourself before starting a machine.

(3) When noticing abnormality of a machine (judged from sound, smoke, smell, heat, vibration, etc.) or any other type of problem, stop the machine immediately and notify the person responsible.

(4) When cleaning, repairing, inspecting, or oiling a machine, stop its operation and turn off its switch first.

(5) Cover the rotational parts such as gears, belt, shaft, or grindstone.

(6) Do not stop an inertial work of the machine by using your hand/foot, a tool, or a stick.

(7) When there is a power cut, make sure to switch off all machines.

(8) Do not reach across to the other side over a rotating machine or workpiece.

(9) When finishing work, inspect properly and ensure that each part of the machine is properly returned to the initial position.

(10) Remove every obstruct within the activity area necessary for the work in order to avoid tripping.

7.2 Tools

Treat every tool carefully including common tools such as hammer or wrench. General points of caution in using them include 1) handle with care, 2) choose appropriate size for the work (make sure that they are not too big or too small), 3) discard damaged tools that are chipped or loosened if they cannot be repaired, 4) always keep the storage of tools in order and return them to the same spots after usage, and 5) wear protective glasses when using them. Following are the points of caution for individual tools.

(1) Hammer: Use it with bare hands without wearing any gloves. Use a hammer without chips, burr, or scar on its head; without cracks or loosening on its handle; and with its wedge properly in place. Check that there is no oil on its head or handle, and use a hammer that is appropriate for your strength.

(2) Wrench: Do not use a wrench with its broken jaw, scars, cracks, burr, or excessive wear. Use the one that fits the size of a nut. Make sure that there is no oil on its grip or handle.

(3) Chisel/Punch: Use the one whose head is without burr, warping, cracks, or scars and whose blade is not worn. Adjust the angle of the blade of a flat chisel to 50–70° when using it to cut a mild steel and to 60−75° when cutting copper.

(4) File: Hammer in the file to its handle properly before using. A file with scar can easily break so be cautious when using it. Always wear dust-proof glass to prevent chips from entering your eyes.

7.3 Machine tools

7.3.1 Precautions

(1) Do not wear gloves when using machine tools. (Especially when using drill press, lathe, or milling machine).

(2) Wear work clothes with closed sleeves and hems, and do not work with something such as a towel hanging from your waist.

(3) When using a machine that causes chips, dust, and cutting oil to fly, wear protective glasses and mask while working. If a chip enters your eye, do not touch under any circumstance, as it is often piercing the eye. See an eye doctor immediately to receive an appropriate care.

(4) When oiling the sliding part or fitting part of a machine, do not oil them excessively as it might cause the oil to fly, or get to the operation part and the handles and make them slippery.

(5) Do not bring your face close to the rotating part when cutting.

(6) Attachment or detachment of a workpiece or tool, checking of measurement, etc., must be conducted when the machine has completely stopped.

(7) When adding oil using, for instance, an oil brush, be careful not to be caught in the rotating part.

(8) Wait until the machine has completely stopped to remove chips using a brush or pliers.

(9) Always wear shoes with heel and without holes. Never wear slippers, sandals, or crocs.

(10) Never remove safety device when working.

(11) If the machining edge and the burr are left as they are, one can injure one's finger, or they can reduce the accuracy of the subsequent process. Remove burr each time it is produced.

7.3.2 Lathes

(1) Check every switch, including the main power switch, of the lathe before turning it on. Inspect each part such as the chuck or the bed, as well as if any chip is left. Oil it if necessary.

(2) Turn on the main power switch and check if the starting and operation sounds are normal.

(3) Secure the workpiece to the chuck, and center it while turning the chuck by hand in order to align the center of the workpiece and the main axis of the lathe as much as possible.

(4) If the workpiece is a long bar that goes over the center of the cross slide, always use a tailstock. However, if the material is significantly longer than the measurement of the finished piece, cut it to the possible shortest length with a cutter before using it as the workpiece.

(5) Secure the cutting tool appropriate for the desired cutting work to the cutter holder, and center it so as the tip of the cutting tool is at the same height as the central axis of the main axis by operating the cross-slide steering wheel and the carriage steering wheel. At this point, check the edge of the cutting tool and avoid using a chipped or worn tool as it could lead not only to less efficient work but also to an accident.

(6) Operate the cross-slide steering wheel and the carriage steering wheel to move the cutting tool away from the workpiece until it does not touch the tool even if it moves while rotating.

(7) Properly check if the fixing knob of the cutter holder or the tailstock is completely turned to the fixing side and if the chuck fastening device and cutting tool fastening device are removed before starting the rotation.

(8) Check if the main axis rotation speed, main axis rotation direction, and if using the automatic feed, feeding speed are set at appropriate number for the material, shape, and processing requirements of the workpiece before turning on the main axis rotation switch.

(9) While cutting, make sure that the cross slide, cutter holder, or the cutting tool except for its tip do not touch the rotating parts. (If possible, set the safety device and do not remove it without permission.)

(10) When cutting, do not stand right next to the rotating bodies such as the chuck or the workpiece (the direction where the workpiece will fly when there is an accident).

(11) Do not touch the chuck, the workpiece, or the cutting tool under any circumstance during cutting. It is also strictly forbidden to bring a rag (waste cloth) close to these.

(12) Supply cutting oil to the tip of the cutting tool with a nozzle if necessary. At this time, it is necessary to use a cover to prevent the oil from flying to the surrounding area. Be careful as visually checking the cutting situation becomes more difficult.

(13) When using an automatic feed, pay extra attention to ensure that there is no abnormality when starting the cutting. Do not leave the lathe during the automatic feed, and carefully observe the cutting progress.

(14) When you notice an abnormally, use the emergency brake immediately.

(15) When stopping the main axis, move sufficiently away from the cutting tool first and then let out its clutch.

(16) When checking the measurement, changing the workpiece grip, or changing the cutting tool in the middle of the cutting work, properly remove the chips and burrs on the cut surface after the main axis has completely stopped.

(17) After the cutting work, turn off every switch, remove and properly clean the cutting tool, and return it to its original storage. Be careful when detaching the workpiece as it could be very hot or its cutting surface could have sharp burrs.

(18) Gather the chips on each part of the lathe to the chip collector below the lathe base, and collect them fter dropped sufficient amount of used cutting oil. Put them together with the chips that flew around the lathe, sort them as trash corresponding to the type of the chips, and dispose of them.

7.3.3 Drill presses

(0) Draw guiding lines to the spot where holes are to be drilled on the workpiece, and mark the center of each hole with a punch.

(1) Check all switches of the drill press, including the main power switch, are off. Inspect each part including the main axis, the drill chuck, and the table; as well as if there are any chips left. If necessary, oil the press.

(2) Adjust the main axis, idler, and the belt position of each pulley of the motor in order to set an appropriate main axis rotation speed for the drill blade to be used and the workpiece.

(3) Set an appropriate height of the table. The height should take into consideration the measurement of the workpiece, its fixation method (usage of vise, support plate for through holes, etc.), type and length of the drill blade (the depth of the holes to be made), and whether it is possible to change the drill blade while the workpiece is fixed.

(4) Release the table lock, move the table to an appropriate height by turning the lifting handle, and fix it by turning on the table lock again.

(5) Check the tip of the drill blade and avoid using a chipped or worn drill as it could lead to not only less

efficient work but also an accident. Either change it to a suitable drill or sharpen in before the usage.

(6) There are two types of drills: straight drill and taper-shank drill. The former is attached to the main axis through the drill chuck, while the latter is attached through the drill sleeve. When attaching the former, make sure that there is no chip inside the drill chuck, select the drill that is suitable for the material of the workpiece, and secure the drill blade without decentering using the chuck handle. After tightening, check if the chuck handle is removed. The latter is securely attached through the drill sleeve after removing the chips inside the main axis. Ensure that it does not exceed the maximum permissible diameter of the drill press.

(7) After securing the vise or the support plate required for each fixture method to the table, fix the workpiece to the table using vise, pressure plate clamp, or fixing bolts. Ensure the horizontal and vertical straightness of the workpiece at this point. If necessary, adjust the height of the table.

(8) Carefully position the workpiece so that the center of the drill blade is where the center of the hole on the workpiece is going to be, and then secure it.

(9) Turn on the rotation switch and turn the control handle to start drilling, carefully. If the drill blade slightly wobbles when it touches the workpiece, it means it is not properly centered. Adjust it and start drilling again.

(10) If the drill is properly centered, proceed with drilling. Make sure to pay attention to the drilling sound or vibration while operating the control handle, in order to avoid applying excessive force on the drill.

(11) Do not touch the drill chuck, the workpiece, and the drill during the drilling under any circumstance.

(12) Add sufficient oil using a brush or an oilcan. Be careful that the brush does not get caught in the drill blade. When the drilling continuously produces long chips along the groove of the drill blade, stop pushing forward the drill, let the chips be cut, and use a brush to remove them. Do not remove them by hand.

(13) When the operation handle or the drilling is deficient, it can cause the drill to get stuck in the workpiece, causing the idling of the main axis and ceasing of the rotation, the workpiece starting to rotate with the drill, or if using a drill with a small diameter, the drill to break. When these problems occur, immediately turn off the rotation switch and take measures after the rotation of the main axis has completely stopped.

(14) When drilling through the workpiece, be careful at the moment of the drill going through as the cutting resistance suddenly decreases at that point and the operation handle could turn rapidly, causing an injury. When this occurs, the feeding speed also becomes excessive, the drill eats into the workpiece, and causes damages around the hole if the workpiece is made of a plastic material, leading to unsatisfactory finish.

(15) When drilling is completed, return the operation handle to the original position, turn off the rotation switch, and remove the workpiece after the rotation of the main axis has completely stopped.

(16) Be careful while removing the workpiece as it could be very hot during and immediately after drilling, and there could be sharp burrs around the hole.

(17) Remove the drill, vise, fixing bolts, and clumps; clean them properly; and return them to their storage.

(18) Gather the chips on the drill chuck, table, and each part of the drill press after dropping sufficient cutting oil. Put them together with the chips that flew around the drill press, sort them as trash corresponding to the type of chips, and dispose them of.

7.3.4 Milling machines

(1) Before starting the milling machine, check if all its switches, including the main power switch, are turned off. Inspect each part including the main axis chuck and table; and if there are any chips left. If necessary, oil them.

(2) Turn on the main power switch, and check if the starting and operation sounds are normal.

(3) Set an appropriate height of the table. The height should take into consideration the measurement of the workpiece, its fixation method (usage of vise, support plate for through holes, etc.), and the type and length of the end mill (the depth of the holes).

(4) Release all table locks and use the vertical operation lever of the table to move it to an appropriate height.

(5) Fix the workpiece to the center of the table using vise, pressure plate clamp, or fixing bolts. Ensure the horizontal and vertical straightness of the workpiece and its correct attachment angle at this point.

(6) If necessary, move the table using its horizontal and back-to-front operation levers. Following this, secure the end mill that is suitable for the required cutting to the main axis chuck. Check the tip of the end mill and avoid using a chipped or worn drill as it could lead not only to less efficient work but also an accident.

(7) Move the end mill to the position where it does not touch the workpiece using the table's horizontal, back-to-front, and vertical operation levers. If you are not familiar with its operation, it is safer to use the operation handle rather than the operation levers.

(8) Check if the lock lever is released and the chuck handle is removed. Check if the main axis rotation speed, main axis rotation direction, and if using automatic feeding, the feeding speed are set at appropriate numbers for the material, shape, and purpose of processing of the workpiece before turning on the main axis rotation switch.

(9) Make sure that the end mill only touches the workpiece during the cutting and not the vise, fixing bolts, or pressure plate clamp.

(10) Do not touch the chuck, the workpiece, or the end mill under any circumstance during the milling. It is also strictly forbidden to bring a rag (waste cloth) close to these.

(11) Supply cutting oil to the cutting area with a nozzle if necessary. At this time, it is necessary to use a cover in order to prevent the oil from flying to the surrounding area. Be careful as visually checking the milling situation becomes more difficult.

(12) When using an automatic feed, pay extra attention to ensure that there is no abnormally when starting the milling. Do not leave the milling machine during the automatic feed and carefully observe the cutting progress.

(13) When you notice an abnormality, stop the main axis immediately and move the end mill to an appropriate position.

(14) When checking the measurement, changing the workpiece grip, or changing the milling tool in the middle of the milling work, properly remove the chips and burrs on the cut surface after the main axis has completely stopped.

(15) After the milling work, turn off every switch, remove and properly clean the end mill, and return it to its

original storage.

(16) Gather the chips on each part of the milling machine to the chip collector below the lathe base, and collect them after dropping sufficient cutting oil. Put them together with the chips that flew around the milling machine, sort them as trash corresponding to the type of the chips, and dispose them of.

7.3.5 Grinders

Generally, only iron material can be ground with grindstones. Do not use them on an aluminum alloy, copper alloy, or wood as they fill up the grindstone grains. Make sure that your fingers are not caught in the grindstone while working.

(1) Before starting the grinder, check if all its switches, including the main power switch, are turned off.

(2) Always wear protection glasses and dust mask while working. Never wear gloves.

(3) Check if the grindstone is properly secured on the main axis and there is an appropriate space between the support and the grindstone. Eccentricity or lateral deflection can cause the grindstone to crack. Only a person with special training required in the Ordinance on Industrial Safety and Health (Section 36) is allowed to change the grindstone test the changed grindstone.

(4) Never use a grindstone with cracks. When it breaks during the rotation, the stone pieces will fly in all directions at high speed, which is extremely dangerous.

(5) Before grinding, turn the grindstone on its own to check if the sound and vibration are normal.

(6) Start the polishing when the grindstone is in constant rotational speed. Each grindstone has the maximum rotational speed. Do not exceed that speed.

(7) Do not press the workpiece too hard to the grindstone and do not use the side of the grindstone. Moreover, do not remove the workpiece from the support while grinding.

(8) Be careful not to burn yourself as the workpiece become very hot during and immediately after grinding. If the measurement of the workpiece is small, fix it on another piece while grinding if possible.

(9) Avoid standing in front of the grindstone as much as possible while grinding.

(10) After grinding, clean the grinder and the surrounding area well after the main axis has completely stopped. Do not forget to set the grindstone.

(11) If a dust collector is installed (regular yearly inspection is obligatory), make sure to turn it on.

7.3.6 Hand drills

Its basic points of caution are the same as those for the drill press. In addition, the following points have to be taken into account.

(1) Check if an earth leakage circuit breaker is installed on the power source to connect the hand drill. Do not use an unnecessarily long electric code.

(2) Never wear gloves while drilling.

(3) If the workpiece is small, use a jig or a vise to fix it on a stable ground.

(4) Drill in a stable position. Do not work in a place with bad foothold, narrow place, high place, and other

unstable locations.

(5) Mark the workpiece with a punch before drilling holes. Check if the drill is set straight in the chuck and make sure that the drill is always perpendicular to the workpiece. Adjust the force to press the drill according to the material and shape of the workpiece. Pay particular attention not to break the drill.

(6) Do not touch the drill chuck, the workpiece, and the drill during the drilling under any circumstance.

(7) In principle, do not switch to the continuous rotation mode. Drill while holding the rotation lever and make sure that the drill does not rotate while the hand drill is putting on the floor.

(8) Tidy up after the work. Do not bend the electric code of the hand drill too tight as it may cause electric leakage or the wire to break.

7.3.7 Friction saws

The grindstone of a friction saw may break and fly in all directions. Together with the grinder, it is a machine with the highest rate of accident, which is even more dangerous. Only a person with special training required in the Ordinance on Industrial Safety and Health (Section 36) is allowed to change the grindstone and test the changed grindstone.

(1) Before starting the friction saw, check if all its switches, including the main power switch, are turned off and there is no problem on the electric cable and other parts.

(2) If the grindstone is warped, cracked, scarred, or has other problems, change it to an undamaged one.

(3) When connecting a new grindstone to the main axis, sandwich both sides of the grindstone with thin papers and tighten it with the attachment screws in the designated torque using a flange. Note that the securing screw turns to the left (counterclockwise). Use safety cover. Do not use when the whole grindstone is exposed.

(4) Always wear protection glasses and a dust mask while working. Never wear gloves.

(5) Turn the friction saw once on its own before cutting in order to check if there is horizontal or back-to-front wobble.

(6) After changing the grindstone to a new one, press the grindstone to the workpiece lightly to prepare its circumference.

(7) Remove the workpiece after the main axis has completely stopped. Be careful as the workpiece is very hot after cutting.

(8) Remove the grindstone after the work and put it in the storage. Tidy up the surrounding area, and make sure that the grindstone does not warp during the storage.

7.4 Welding

7.4.1 Precautions

Only a qualified person or an expert is allowed to weld (gas/electric).

7.4.2 Gas welding

(1) Make sure that there is no flammable material or explosive in the work area, and if there are, remove them before the welding.

(2) Always wear gas welding protection glass, and use the protection glass to look at the welding area from immediately beforeand during the welding.

(3) Make sure that there are enough pressures left in the oxygen and fuel cylinders before welding. Check if there are problems with the pressure regulator, flashback arrester, and gas hoses. Attach the gas hoses securely and without leakage to the supply ports of oxygen and fuel of the blowtorch.

(4) Always use soap water to check the gas leak from the cylinder cap as using flammable substances such as oil or grease is extremely dangerous.

(5) Adjusting the gas supply pressure using the regulator according to the thickness of the workpiece. Turn on the fire on the nozzle by adjusting the oxygen valve and gas valve to the gas rich region. After starting fire successfully, adjust both valves to form a flame suitable for welding. Use a welding rod if necessary.

(6) Do not touch the sparks and the workpiece, which becomes very hot during the welding. Make sure the gas hoses do not touch anything hot throughout the welding.

(7) After welding, leave the workpiece alone to ensure enough time for it to properly cool down. Tidy up the blowtorch and gas hoses, and do not forget to close the main valve of the gas cylinder.

7.4.3 Electric welding

The basic precautions are listed below.

(1) Make sure that there are no flammable materials or explosives and start welding after removing them. Warn workers without protection mask in advance not to come close to the workspace.

(2) Always wear welding protection mask (either hand-held type or helmet type) and welding gloves and use the shading glass of the protection mask to view the welding area during welding. Looking at the arc light with naked eyes can cause blindness. If there are cracks on the shading glass of the welding protection mask or it is excessively dirty, change it to a mask in good condition.

(3) Electric welding can cause formation of slag on the welded parts or tiny metal balls to gather around the welded parts. It is necessary to remove these after welding. Wear protection glasses besides the protection mask when conducting this work.

(4) Electric welding can be categorized into shielded metal arc welding and shielding gas arc welding. When using the latter, check if the residual pressure of the shielding gas cylinder is sufficient and there are no problems on the gas hose before welding.

The following explains the process of shielded metal arc welding that does not use shielding gas.

(1) Make sure that all switches, including the main power switch, are turned off, and there are no problems with the power source, earth cable, welding rod holder, and grounding clip before the welding. Blow off the dust on the cables and other parts using dry compressed air. The dust may weaken the isolation and heat up the winding wire.

(2) Connect the grounding clip to the workpiece. If the workpiece is small and the clip would overlap with the

welded part, attach the workpiece to a thick steel plate with sufficient area, secure electrical conduction and connect the grounding clip to a steel plate.

(3) Turn on the main power switch and check if everything is in order. Following this, connect a welding rod to its holder. Make sure that the tip of the rod is in midair and is sufficiently distant from the surrounding objects before turning on the welder.

(4) Make sure to look at the tip of the welding rod through the welding protection mask. Slowly bring the tip of the welding rod to where the welding should start on the workpiece, and observe the emergence of the arc. Then start welding immediately.

(5) Make sure not to touch the sparks during the welding or the workpiece immediately after the welding as it is very hot. If you want to stop welding, remove the welding rod from the workpiece to stop the arc, and then turn off the welder. Do not put the welding rod holder on a steel plate before turning off the welder as it is extremely dangerous.

(6) Moreover, be careful when you finish welding if you are moving or detaching the workpiece from the steel plate, as the welding makes them extremely hot, in the same way you do when stopping welding in the middle of it. After the work, turn off the main power switch, organize the welding rod switch and cable, and store them in a state where they do not gather dust.

7.5 Carrying

7.5.1 Precautions

While it is better to use a cart or a crane to carry heavy objects, it sometimes has to be conducted by hand. It is also often conducted by a group instead of one person. Following are the general points of caution.

(1) Clothing

Wear appropriate clothes to minimize risks, for instance, working clothes or jeans. It is not suitable to work with white coat or suits. Wear gloves, safety shoes, and safety hat (helmet).

(2) Handling

Handle the object carefully. Do not throw or drop it.

(3) Loading

When loading the objects, load them as low and stable as possible. Take measures such as using a support or tying to the wall for objects that can easily fall. Moreover, follow the loading order such as putting small objects on large objects and light objects on heavy objects in order to avoid them from collapsing. In addition, it is advisable to put small objects in containers.

(4) Maximum weight

When carrying something by hand, do not carry anything too heavy. The maximum weight a person can carry on his own is 15 to 20 kg (for a woman, 10 kg).

(5) Carrying method

Following are the methods to lift a heavy object by hand.

(a) Hold as deep as you can, lower the hip as much as possible, and straighten your backbone.

(b) Flex your legs and shoulders and lift the object up as you straighten your elbows.

(c) Hold the center of the object as close to your body as possible in order to balance it.

(6) Communication

When you are carrying objects in a group, decide the leader and follow his/her instruction when moving. Moreover, signal each other, for instance, verbally, in order to ensure communication among the workers.

7.5.2 Carrying with cart

Clothing, loading method, and signaling are the same as the general points of caution discussed in 7.5.1. Following are the additional points of caution when using a cart.

(1) Check the weight and measurement of the object to be carried and use a suitable cart. Moreover, inspect the cart before the moving.

(2) Do not load in a way in which the objects would collapse. And make sure that the load is not larger than the cart. Do not carry anything unstable with a cart.

(3) If you are carrying a long object, it is advisable to attach a visible marker on its tip.

(4) Pay attention to where you are going, and secure enough space to work.

(5) Leave the cart in a designated spot. It is forbidden to leave carts behind.

(6) Use the wheel stoppers to prevent a cart from moving on its own.

7.5.3 Transport work using cranes and hoists

If moving an object whose hoisting load is 0.5 t or above, the crane operation and slinging must be done with a person with qualifications listed in Table 7.1. The points of caution using other, smaller cranes and hoists are discussed here.

(1) The designated person must operate the crane.

(2) Always wear gloves, safety shoes, and safety hat while working.

(3) Inspect the crane, the hook, the wire clasp, and the wire before using them, and check if the switch is working properly.

(4) Ensure proper communication between the crane operator and the slinging worker.

(5) Do not lift an object exceeding the safe working load.

(6) When lifting, slowly lift up so that the hook comes exactly above the center of the balance of the object and check if the wire is securely attached to the hook.

(7) When driving the crane, move slowly in order to prevent the load from swinging. When carrying an object that can bend significantly, or a long object, hang it to the height around one’s knee and move slowly. The same goes for when carrying a slippery object or liquid. Do not start or stop suddenly.

(8) Make sure that there is no one under the suspended load. When driving the crane while lifting an object, the operator must walk behind the object. In addition, always pay attention to where you are going.

(9) When putting down the load, stop first at about 10 cm from the floor, and then lower it slowly. Do not leave a load hanging.

(10) After the move, return the crane, the switch, the cable, and the wire to their designated storage.

7.5.4 Sling work

Besides the points of caution regarding the carrying using a crane, the following points of caution are necessary for slinging.

(1) A well-trained and authorized person must perform the sling work.

(2) Use a signal for slinging that was agreed upon in advance, and make sure that it is properly communicated to the crane operator.

(3) Make sure to use a wire rope without any problem. Use a wire rope that can be support a weight at least 120% heavier than the load to be carried. Use an appropriate hook and other auxiliary tools.

(4) Carefully estimate the center of balance and lift. Stop when the load is suspended about 10 cm above the floor to confirm that the hook is directly above the center of balance and that the load is balanced.

(5) The angle of the wire ropes should be 60° (angle between the two wires at the hook). Even if this angle cannot be achieved, the angle should never exceed 90°. Avoid suspending the load with one wire rope. This would cause the load to rotate, which is dangerous.

(6) When suspending an angular load, use pads to prevent the wire from being damaged.

(7) When unloading, stop lowering at about 10 cm above the floor; check the ground, and then lower the load. After unloading, make sure that it has been completely released from the wires. Do not leave the wires on the hook when moving the crane without a load.

(8) Use a chain instead of wire rope for carrying any load over a temperature of 100°C.

Crane operation and sling work are subject to the following regulations:

1. Industrial Safety and Health Law (Law No. 57, June 8, 1972)
2. Enforcement Order of the Related Industrial Safety and Health Law (Regulation No. 318, 1972)
3. Ordinance on the Related Industrial Safety and Health (Ministry of Labor, Ordinance No.32, 1972)

The above regulations stipulate that the special or technical trainings listed in Table 7.1 are required.

Table 7.1 Crane operation and slinging regulations

<table>
<tr><td rowspan="2"></td><td colspan="4">Lifting capacity</td></tr>
<tr><td>Less than 0.5 t</td><td>More than 0.5 t,
Less than 1 t</td><td>More than 1 t,
Less than 5 t</td><td>More than 5 t</td></tr>
<tr><td rowspan="2">Floor-operated crane</td><td rowspan="2">Common person</td><td colspan="2" rowspan="2">[S1] [A] [B] [C]</td><td>[B]</td></tr>
<tr><td>[C]</td></tr>
<tr><td>Slinging</td><td>Common person</td><td>[S2]</td><td colspan="2">[A] [C] [D]</td></tr>
</table>

[S1]: A person who has completed crane-operation special education.

[S2]: A person who has completed sling-work special education.

[A]: A person who has completed training stipulated in vocational training regulations.

[B]: A person who has completed floor-operated crane training.

[C]: A person who has crane operator's license.

[D]: A person who has completed sling-work training

The following locations in Fukuoka provide special and technical training.

1. Fukuoka Managerial Labor Welfare Association: Tel. 585-9650 (4-29-7 Ijiri, Minami-ku, Fukuoka-shi)
2. Fukuoka Central Labor Standards Association: Tel. 711-9132
3. Japan Crane Association: Tel. 471-7152
4. Japan Management Education Center: Tel. 481-3475

Chapter 8 Safety measures for electricity

8.1 Electric shocks and appropriate countermeasures

An electric shock is caused by an electric current running through a human body. It can happen instantly, and the mortality rate is very high. Shocks are often followed by secondary injuries (such as collapsing or falling). The physiological impact of an electric shock differs greatly according to the strength of the electric current (I), pathways in the body where the current runs, and the time span of the shock (t). If the electric current runs through central functions such as brain or heart, it is extremely dangerous. This impact can be shown as "Criticality = I^2t" and even a small amount of current can be critical if one is exposed to the shock for a long time.

The higher the voltage, the more dangerous is the shock. According to the past statistics, 40–60 V or higher of electric shock can cause death. Remember that "Forty Volts is Fatal". The strength of the current that runs through a body can be calculated from the voltage, the resistance of the human body, and the circuit resistance. However, the resistances of the body and the circuit can significantly vary according to the situation. Use the following figures to estimate the danger of electric shocks:

Critical current amount = 10 mA

Resistance of human body = 1,000 Ω

Resistance of circuit = 0 Ω.

For example, if someone standing on the ground with bare feet (circuit resistance = 0 Ω) receives a 100 V electric shock, the current that runs into the person's body is 100 V/1000 Ω = 100 mA, and failure to immediately evacuate would lead to an extremely dangerous situation.

Following are the preventive measures against electric shock.

8.1.1 Electric shocks from indoor distribution lines, electrical equipment, and leakage

Though the voltage of distribution lines is not very high (100–200 V), they still have the following potential risks:

(1) Electricity can flow even by just contacting a single wire. Be particularly cautious when you are working on a highly conductive floor (bare earth, concrete, or metal floor).

(2) It is capable of continuing to supply a large current until the circuit is cut off, leading to a long exposure to electricity.

(3) As one often touches the electric equipment while sweating in summer, an electric shock accident is far more frequent in summer statistically.

Electric shocks can occur not only by touching the wires directly but also by touching areas where there is an electricity leakage. Take the following measures to avoid such electric shocks:

(1) Install an earth leakage breaker. Note that the earth leakage breaker may not work if there is an insulation defect. Thus, measure the insulation resistance occasionally.

(2) Do not expose electric wires and terminals. The terminals such as a switch resistor or transformer are often

exposed. Cover them to ensure safety.

(3) Establish a grounding for the main body of an electrical equipment and its casing. At minimum, the following equipment always need to be grounded as they have high possibility of leakage:

(a) Equipment that cause dripping or water leakage and those used in a highly humid atmosphere or those that people may touch with wet hands.

(b) Equipment that vibrate strongly and those that are moved frequently, particularly portable electric tools.

(c) Old equipment.

(d) Equipment that are labeled as "安全のためにアース (Ground for Safety)" .

(4) When wiring a power strip from a 100 V switchboard, make sure that the wider blade of the plug is grounded if using a two-pole power strip with plug blade holes with different lengths. For a power strip with 3-pin sockets, use a 3-wire cord and make sure the grounding terminal is properly connected.

(5) When connecting a single-phase 200 V to a 3-phase 200 V switchboard, consider that the S phase is usually grounded and connected from the R-S or the S-T phases. When connecting a 3-phase 200 V board (especially in the case of 3-phase motor), use cables with colors matching each phase in order to avoid mixing the phase order.

(6) Do not open the cover of a high-voltage power supply carelessly. If you must touch the wiring or inside of the equipment, make sure to turn off the main power and use a grounding rod to ground. In addition, always check the safety using a tester or a spark-testing screwdriver.

(7) One wears short sleeve shirts and other clothes with more exposed skin in a hot season. Even if you are paying attention to your hands, you may be paying less attention to other parts of your body. Moreover, be careful not to let the metal parts of your watch touch the electric wires, as they make it easier for the current to flow during an electric shock.

(8) When wiring an electric code on the ceiling or high places, avoid weight from being applied to one point of the code. Especially avoid the code from bending at a sharp angle at that point.

(9) Do not use a code reel while the code is still wound. The heat could melt the rubber.

8.1.2 Electric shock from high-voltage equipment

In case of high voltage, also pay attention to the following points.

(1) If the voltage is greater than 300 V, you may receive an electric shock via an atmospheric discharge. If the voltage is even greater, the discharge can reach a person through unexpected pathways and lengths.

(2) Some devices can generate a voltage several times greater than its rated voltage due to an entry of abnormal voltage or a resonance.

(3) A high-voltage device has high energy and can be a source of strong noise. This often causes failures in safety devices.

(4) Even when a wire is broken, the electricity can still flow via spark discharge. This may delay the discovery of broken wires.

(5) Note that some insulation materials are not suitable for high-voltage electricity. For example, phenolic resins

may cause considerable current leakage, depending on the filler used.

Strictly adhere to the following points when handling high-voltage electricity. These measures only apply to smaller devices (less than 30 kV and 3 kVA).

(1) Always handle high-voltage electricity with two or more people. One person must focus mainly on monitoring. Do not participate in such an experiment if you are unwell, as you will not be able to concentrate.

(2) Secure the wires properly with screws in order to avoid them from becoming loose and touching humans. Avoid clips.

(3) Minimize the exposure of high-voltage components. Use cables and high-voltage cords. However, even high-voltage cables cannot guarantee 100% safety. Handle such cables in the same manner as bare cables in terms of their danger to humans. In addition, tightly seal the entire device with a metal cover (it grounds the device). If sealing is not possible, separate the device with a metal fence to prevent people from approaching the equipment carelessly.

(4) Switch on the warning light and sound the warning sound to let others know that high-voltage electricity is in use. Use a lockable switch for the power supply. The key for this lock must be managed by the person in charge of the operation and grounding.

(5) When touching the high-voltage part or when high-voltage equipment is not in use, always ground the high-voltage end. Be aware that the "grounding line is your lifeline," and never remove it while working. Do not use a coated thin wire as a ground line, because breaks in the wire may not be visible. Use a thick and strong wire or a hard steel wire.

(6) If the device has a capacitor (condenser), it remains charged even after the power supply is turned off. Make sure to ground the capacitor and never remove the grounding while working

8.1.3 Electric shock from electronic and IT devices

While most of the electronic and information technology (IT) devices have relatively small capacity, some of them have built-in high-voltage circuits. The fatality rate due to electric shocks from such devices may be low, but the reflexive movement of the human body from an electric shock can cause injury.

(1) Do not touch parts labeled "高電圧危険 (High Voltage, Danger)" carelessly. If the equipment is self-made, cover the high-voltage parts and clearly label them "危険" (Danger).

(2) Note that a capacitor remains charged even after the power is turned off.

(3) Even batteries are potentially dangerous, many of them are connected in series.

(4) When measuring the high-voltage parts, both electronic equipment and other devices, make sure that the connecting wires (such as probes and tester lead) do not come off and touch people.

8.1.4 Examples of easy-to-mistake wiring

Common errors in wiring and experiments that causes electric shocks are listed below (Fig. 8.1).

(1) Direction of knife switch is reversed. The knives connected to the power source are exposed when the switch is off. This is dangerous when changing the fuse.

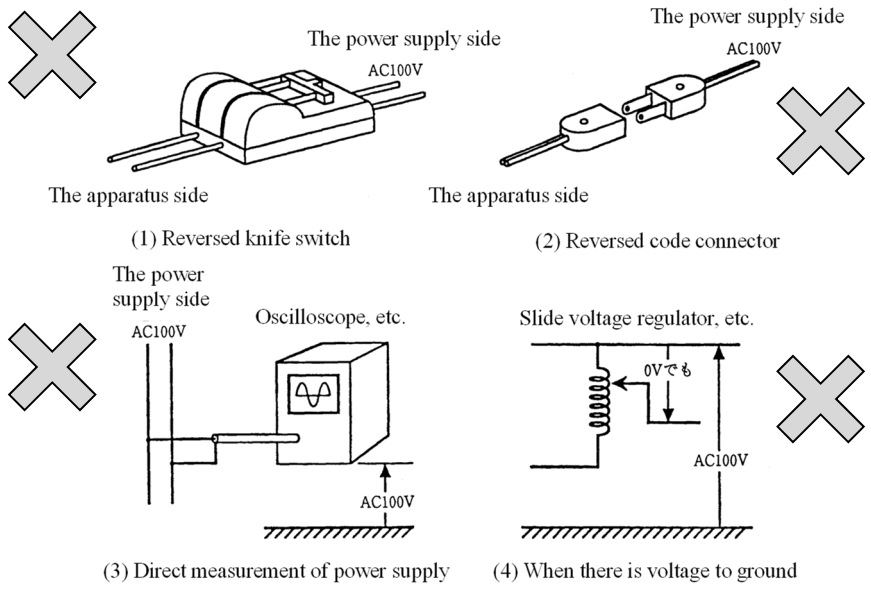


Fig. 8.1 Examples of easy-to-mistake wiring and measurement

(2) A code connecter is reversed. Connections to the power supply are exposed.

(3) Do not measure the power supply directly with a meter (e.g., an oscilloscope). The case of the meter can be applied voltage to the ground.

(4) Voltage of a sliding voltage regulator or an induction voltage regulator is floating. Even if the displayed output voltage is 0 V, the outlet terminal may have power-line voltage.

8.2 Notes on using OA equipment

While the equipment themselves have not much danger, their power supplies have potential danger in the following situations.

(1) There are often addition to and alteration of OA equipment arrangements. Thus, it is easy to connect too many plugs to an extension cable. Follow the rated current of an electricity cable or power strip. Never connect an extension code or two-way socket to another extension code or a two-way socket.

(2) The power for the OA equipment is often supplied via a power strip. Such a socket and cable tend to be left unsecured on the floor. This can cause the sockets and cables to be damaged by being stepped on or caught up by feet. Use a cabtyre cable for electric cables. If laying the power cable directly on the floor where people walk is unavoidable, protect the cable using cable covers.

(3) Some equipment may have no power switches, or stay powered even when their switches are turned off. Turn off the main power supply when no one is in the room.

8.3 Notes on reusing dormant equipment

It is necessary to be cautious when using equipment that have been unused for a long time. It could be lacking

lubrication or have problems with insulation. Carry out the following actions when restarting such equipment.

(1) Remove all dust and dirt.

(2) Measure the insulation resistance.

(3) Check its meters and safety devices.

(4) After restarting the equipment, observe it for a while to make sure it is operating normally.

8.4 Fires caused by overheating

The following are potential causes of overheating:

(1) Overheating due to short circuit

A large current flows when there is a short circuit, and temperatures can reach over 1000°C through arcing. In addition, the whole cable becomes hot and may ignite its insulation coating, causing a fire. If the fuse or breaker is not cut, it will certainly lead to fire.

(2) Overheated wires due to overcurrent

Running current above the rated limit through a cable leads to heating. In particular, connecting too many plugs to a power strip can easily cause overcurrent.

(3) Overheating by poor contact or half-broken wires

Even when there is no over current, a poor contact or half-broken wire can cause heating. A poor contact between an outlet (power strip) and a plug or a loose connection screw increases the connection resistance, and consequently, generates heat. In addition, a cable bent too much or crushed under a heavy object can easily become half broken. It is not visible if a cable is half broken from outside. Moreover, if the cable is fully broken, arcing may occur inside the insulation coat and cause internal destruction.

(4) Overheating by leakage

If the abovementioned heating continues for too long, it will lead to heating (leakage) – insulation degradation – leakage – internal destruction – short circuit and eventually fire. To avoid a fire accident, attention must be paid to the following points.

(a) Never supply a current above the rating, and use a wire thick enough to endure that rated current (Table 8.1).

Table 8.1 Example of the permissible currents for a 600 V, 3-core, rubber-insulated cabtyre cable

Nominal cross-sectional area (mm^2)	Permissible current (A)
0.75	11
1.25	15.5
2	19
3.5	27
5.5	35
8	43

(b) To minimize the energy released from a short circuit, do not use a fuse or breaker that has a capacity larger than necessary. Use a wire thick enough to endure that fuse/breaker capacity.

(c) Install an earth leakage circuit breaker. Be aware that the function of the earth leakage circuit breaker is different from that of common circuit breakers.

(d) Use heat-resistant cables for equipment that converts electrical energy into heat.

(e) See the cable specifications supplied by the cable manufacturer for details about the permissible current for each cable.

(f) When a high current above the rated current is supplied to a wire while it is still wound on a code reel, it can cause the wire to overheat and melt. Avoid using a wire while it is still wound on a code reel.

8.5 Flammable gas and electric spark

When a room is filled with flammable gas or vapor of ignitable liquid, even a small spark can start a fire. Be aware of the following points in a space with possible gas leakage.

(1) Contact (Switches): Use explosion-proof or semiconductor switches.

(2) Short circuit, leakage: Inspect regularly and discover problems in advance.

(3) Brushes in motor and generator: Even a small machine can generate sparks. Either use a sealed structure or machines without brushes.

(4) Frictional electrification: Use electrically conductive materials to prevent static electrification.

(5) Corona discharges from high-voltage components: Any conductor with a sharp end (both at the high-voltage end and the grounded end) can cause discharge. Keep such points rounded by, for instance, attaching a metal ball or a ring to its tip.

(6) Others: When nonconductive liquids or powders cause flow at a high speed, they become statically charged, generate sparks, and when they are flammable, cause an explosion.

8.6 Inspection items for accident prevention

By checking the following points regularly, most of the accidents can be prevented.

Inspection Checklist
“Electrical sensation” when touching equipment or pipes. ⇒ If this occurs, it means there is a leakage, which is extremely dangerous. Stop using the equipment, and contact a specialist.
② Broken insulation coating on cables. ⇒ Pay particular attention to where the cable is coming out from and old cables.
③ Look for loose connection screws.

⇒ They can lead to heating or short circuit.
④ Look for changed color or heating on cable. ⇒ Heat indicates poor connection, half-broken wire, or overcurrent.
⑤ Listen for a strange sound. ⇒ There is leakage, discharge, or a problem in the motor running (cause of overcurrent).
⑥ Check if there is a strange smell. ⇒ Insulation has degraded due to leakage, discharge, or heat.
⑦ Check if the grounding wire is properly connected. ⇒ This can be forgotten when moving a device.
⑧ Check if the equipment or wiring is flooded or being corroded by chemicals or gases.
⑨ Check if electric cables are being crushed under heavy equipment.

8.7 Electricity-related standards

Refer to the following standards for details about the electrical equipment and wiring.

(1) Japanese Industrial Standards (JIS)

(2) Japan Electrical Manufacturers' Association Standards (JEM)

(3) Standards by the Japanese Electrotechnical Committee (JEC), Institute of Electrical Engineers of Japan

(4) Electric Installation Technical Standards (Ministry of International Trade and Industry, Ordinance No. 52, 1997)

Chapter 9 Safety measures for light and radiation

9.1 Ultraviolet light and laser

Strong radiant energy (such as infrared light, ultraviolet light, or laser) can strongly affect human body through thermal shock or photochemical reaction. Among them, laser requires particular caution in its handling due to its extremely high energy density and characteristic absence of diffusion and attenuation. Thus, it is discussed in a separate section. Only ultraviolet is discussed as a common light source.

9.1.1 Ultraviolet light

When using an artificial light source for an experiment, it is necessary consider its effect on human body and to prevent its leakage. Effect of light on an organism, called photobiological effect, mainly involves damage to skin and eyes. Here, the effects of ultraviolet light (200 nm < λ < 400 nm) are discussed.

The lights in a spectrum are divided into categories of UV-A, B, and C mainly based on their effects on an organism. Table 9.1 shows their respective wavelength and main health hazard.

Table 9.1. Ultraviolet lights and their main health hazard

	Wavelength/nm	Damage (Skin)	Damage (Eye)
UV-A	315 ～ 400	Tanning, Pigmentation	Cataract
UV-B	280 ～ 315	Erythema, Skin cancer	Keratitis, Cataract
UV-C	200 ～ 280	Erythema, Skin cancer	Keratitis

The harmfulness of ultraviolet light strongly depends on their wavelength. The threshold limit values (TLV; the number that indicates the limit of exposure received repeatedly for 8 h per day without causing harm) proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) are shown in Table 9.2. These values are also adapted as the Japanese standard (JIS Z8812).

Unlike natural lights, artificial lights often contain UV-B and UV-C, and therefore, one must avoid exposure to them. Lights with 240–300 nm are particularly harmful. Commonly used germicidal lamps are often low-pressure mercury lamp (main radiation λ = 253.7 nm) and must be handled with care.

(1) Do not look into the light source directly or expose the skin to the light when ultraviolet light is on. Be particularly careful when using light outside the range of visible lights as it is difficult to notice.

(2) When ultraviolet light is on, notify the others of its usage by displaying “注意 (Warning)” or “危険 (Danger)” sign.

(3) Use an appropriate shielding wall to prevent an unexpected exposure of the people working or a third party.

(4) Ultraviolet light sources, especially the light sources that include light with wavelength below 200 nm, such as low-pressure mercury lamp or xenon lamp, produce large quantity of harmful ozone. Ventilate well when using them.

Table 9.2. UV wavelengths and TLV®

Wavelength /nm	TLV®[1)] mJ/cm^2	Harmful effect of relative spectrum[2)]
200	100	0.030
220	25	0.150
240	10	0.300
254[3)]	6	0.500
260	4.6	0.650
280	3.4	0.880
300	10	0.300
320	2,900	0.0010
340	11,000	0.00028
360	23,000	0.00013
380	47,000	0.000077

1) Permissible exposure for one day (8 h)
2) Relative value when light with 270 nm wavelength is set as 1.
3) Main radiation of low-pressure mercury lamp. Its TLV® is equivalent of 0.2 μW/cm^2 × exposure time (s).

9.1.2 Laser

Laser light is highly directional and travels a long distance through space without attenuation. Thus, even a laser with relatively low output has high energy per unit area, and can be significantly more dangerous than lights from other sources with the same power. Its careless handling could even lead to a loss of eyesight. There are cases where one does not notice one's blindness when one eye's retina is partially damaged (visual field defect). As one is not conscious of one's partial blindness, this can also lead to other accidents. The level of danger is different depending on the output, wavelength, and concentration (focusing). As shown in Table 9.3, laser equipments are classified according to their output levels. Table 9.4 shows the safety measures to be taken for each equipment. Use this for the safety guideline.

(1) Do not look directly into the light source when the laser is on. Even leaking light or reflection could cause a serious accident.
(2) When laser is on, notify others by switching on the warning lamp at the entrance of the room or by displaying a sign.
(3) Separate the area using laser with blackout curtains in order to prevent unexpected exposure of the operator of a third party.
(4) Appoint a person responsible for safety for the laser device that is Class 3 or above, and conduct a thorough technical instruction.

(5) Set the path of laser as low as possible. If you must crouch during an experiment, be aware of the heights of the beam and your eyes. Do not stand in the laser path.

(6) Always use a shielding window and wear protection glasses. Select the windows or glasses that is appropriate to the wavelength of the light you are using. (Some glasses with darker color may let ultraviolet light. As these will cause one's pupil to open due to reduced visible light, their usage will be more dangerous.)

(7) Remove highly reflective objects from the laser-beam path. Wristwatch or rings, in particular, must be removed during alignment of the laser path.

(8) A sample exposed to a strong laser may produce secondary X-ray. Be aware of possible X-ray. (See Section 9.2.4 for the handling of X-ray.)

(9) Be aware that a laser device uses a high-voltage power source when handling it. (See Chapter 8)

Table 9.3 Laser device classification

Class	Classification
1	Output 0.39 mW or less. Safe laser under predictable conditions.
1M	Output 0.39 mW or less. (Wavelength: 302.5～4000 nm) Safe laser under predictable and rational conditions, and as long as not observing the laser through lenses (safe to observe with naked eyes).
2	Visible light with output 1 mW or less (Wavelength: 400～700 nm) Safe owing to the reflexive resistance of the eyes, such as blinking.
2M	Visible light with output 1 mW or less (Wavelength: 400～700 nm) Safe as long as not observing the laser through lenses and if reflexive resistance of the eyes, such as blinking, is possible. The radiation level of the laser is the same with Class 2.
3R	Output 5 times larger than Class 2 (if visible light) or Class 1 (if invisible light).
3B	Output 0.5 W or less. Dangerous to see the laser directly or see the laser reflected on a mirror.
4	High output (higher than 0.5 W) Scattered light is also dangerous in addition to the direct and laser reflection on a mirror. It may cause damage to skin or fire.

Table 9.4 List of necessary measures for each class of the laser equipment

Measures to take (Headline only)			Laser equipment class				
			4	3B	3R		2M & 1M
					Invisible light*1	Visible light	
Appointment of laser equipment manager			○	○	○	-	-
Controlled area (Sign/Forbidden to enter)			○	○	-	-	-
Laser equipment	Laser path	Location of path	○	○	○	○	○
		Appropriate design/shielding	○	○	○	-	-
		Appropriate Terminal	○	○	○	-	*2
	Key controlling		○	○	-	-	-
	Emergency stop switch	Emergency stop switch	○	○	-	-	-
		Alarm device	○	○	○	-	-
		Shutters	○	○	-	-	-
	Interlocking system		○	○	-	-	-
	Sign warning of laser output		○	○	○	○	-
Operation management and health management	Operating position		○	-	-	-	-
	Measures during adjustment of devices		○	○	○	○	○
	Protection	Protective glasses	○	○	○	-	-
		Clothing with minimal skin exposure	○	○	-	-	-
		Use flame-resistant materials	○	-	-	-	-
	Inspection/maintenance		○	○	○	○	○
	Health and safety training		○	○	○	○	○
	Health management	Anterior eye examination (the cornea and crystalline lens)	○	○	○	-	-
		Fundus examination	○	-	-	-	-
Others	Notifications	Name of the laser equipment manager	○	○	○	-	-
		Points of caution regarding danger, toxicity,	○	○	○	○	○
		Sign announcing laser equipment installation	○	○	-	-	-
	Warning signs for high-voltage parts of the laser equipment		○	○	○	○	○
	Ban on explosives and flammables		○	○	-	-	-
	Measures against toxic gases and fumes		○	○	+	-	-
	Medical examination and treatment for suspected laser injury		○	○	○	○	○

*1 Invisible light (Laser outside 400–700 nm wavelength region)

*2 Only the laser equipment listed in JIS Standard 10.6 requires measures for its terminal.

Source:

http://www.mhlw.go.jp/file/06-Seisakujouhou-11200000-Roudoukijunkyoku/0000184700.pdf

Reference：JIS C 6802 : 2011

9.2 Safety measures for radiation

When handling radiation, radioisotope (RI), and radiation generator, various legal obligations must be met to ensure protection against radiation and safety management. Advance registration is required before using an RI or a radiation generator in your experiment. You are also required to acquire adequate specialized knowledge

concerning radiation safety management in advance. During the planning and execution of your experiment, you must conform to all radiation-related regulations and thoroughly recognize that safety is the primary concern.

9.2.1 Definitions: Radiation / RI / Radiation-generator

Radiation: Particles with high kinetic energy (alpha ray, deuteron beam, proton beam, beta ray, electron beam, and neutron beam) and electromagnetic waves with high energy (gamma ray and X-ray) that can directly or indirectly ionize air.

Radioisotope (RI): The relation of elements that have the same atomic number but have different neutron numbers is defined as an isotope. An RI is unstable among isotopes and undergoes radioactive decay over time into a stable isotope while emitting radiation. There is a strict regulation when handling an RI that exceeds the concentration and quantity defined in "Law Concerning Prevention from Radiation Hazards due to Radio-Isotopes, etc. (Radiation Hazard Prevention Law)". There are sealed RI and unsealed RI. Be cautious of the external exposure when handling a sealed RI and of contamination when handling an unsealed RI.

Approved device with certification labels: A device with high safety that has received a design certificate among devices equipped with RI. For instance, there is "alpha ray source 162CE" with isotope Am241. The only requirement to use it in a common laboratory is to notify the Nuclear Regulatory Commission. However, it cannot be used for purposes other than correction of radiation and radioactivity meters, verification of their function, experiment, research, and education (approval condition). They must be handed to the Japan Radioisotope Association when being disposed.

Radiation generator: The Radiation Hazard Prevention Law defines the following accelerators as radiation generators. There are conditions for their installation, and it is obligatory to seek permission for it. Cyclotron, synchrotron, synchrocyclotron, linear accelerator, betatron, Van de Graff accelerator, Cockcroft-Walton accelerator, transformer-type accelerator, microtron, or plasma generator for deuterium–deuterium nuclear reaction research. X-ray devices regulated by the Ordinance on Prevention of Ionizing Radiation Hazard, and not within the scope of radiation safety management.

9.2.2 Notes on using radiation / RIs

Usage of radiation and RI is regulated through registrations and safety management processes required by several laws and regulations. Fig. 9.1 shows their main points, and the following explains their overview.

· Laws and university regulations

The handling of radiation and RI is regulated by the Radiation Hazard Prevention Law and Ordinance on Prevention of Ionizing Radiation Hazard. In addition, Kyushu University has its own Regulation for Radiation Hazard Prevention in accordance with these laws. Based on this regulation, graduate schools, research institutes and centers have their own "Radiation Hazard Prevention Rules". A person handling radiation or RI must adhere to these laws and regulations.

· Registration for usage (user registration and educational training)

Radiation user registration is required to use RI or a radiation generator within Kyushu University or at another university campus or institute. A medical examination (including an interview and blood, skin, and eye tests) and educational training are prerequisites for this registration. Individuals who will not enter the management area (for example, a user of an X ray generator with an interlock whose management area is only inside the device) are exempted from the medical examinations.

Kyushu University's Regulation for Radiation Hazard Prevention, based on laws, stipulates that, regarding educational training, prospective users must take an introductory educational training course for radioactive substance handling or X-ray handling that is held in April, July, and October of each year by the Central Institute of Radioisotope Science and Safety Management, as well as a seminar provided by each department on radiation hazard prevention regulations. For the educational training, the prospective user must take seminars on ①Effects of radiation on the human body, ②Safe handling of radiation, RI, and radiation generators ③Relevant regulations, and ④ Radiation hazard prevention rules. Radioactive material handlers have more training content than those who only handle X-ray generators, so seminar times are also longer.

The person who registered after receiving a health check and educational training will receive a "Kyushu University Radioisotope User Handbook" (hereafter User Handbook). As a radioactive substance handler is legally required to take a course again within one year, he/she must take a re-educational training held at the end of the academic year (January and February). Please check with your instructor or the Research Support Office of the Administration Department for detail.

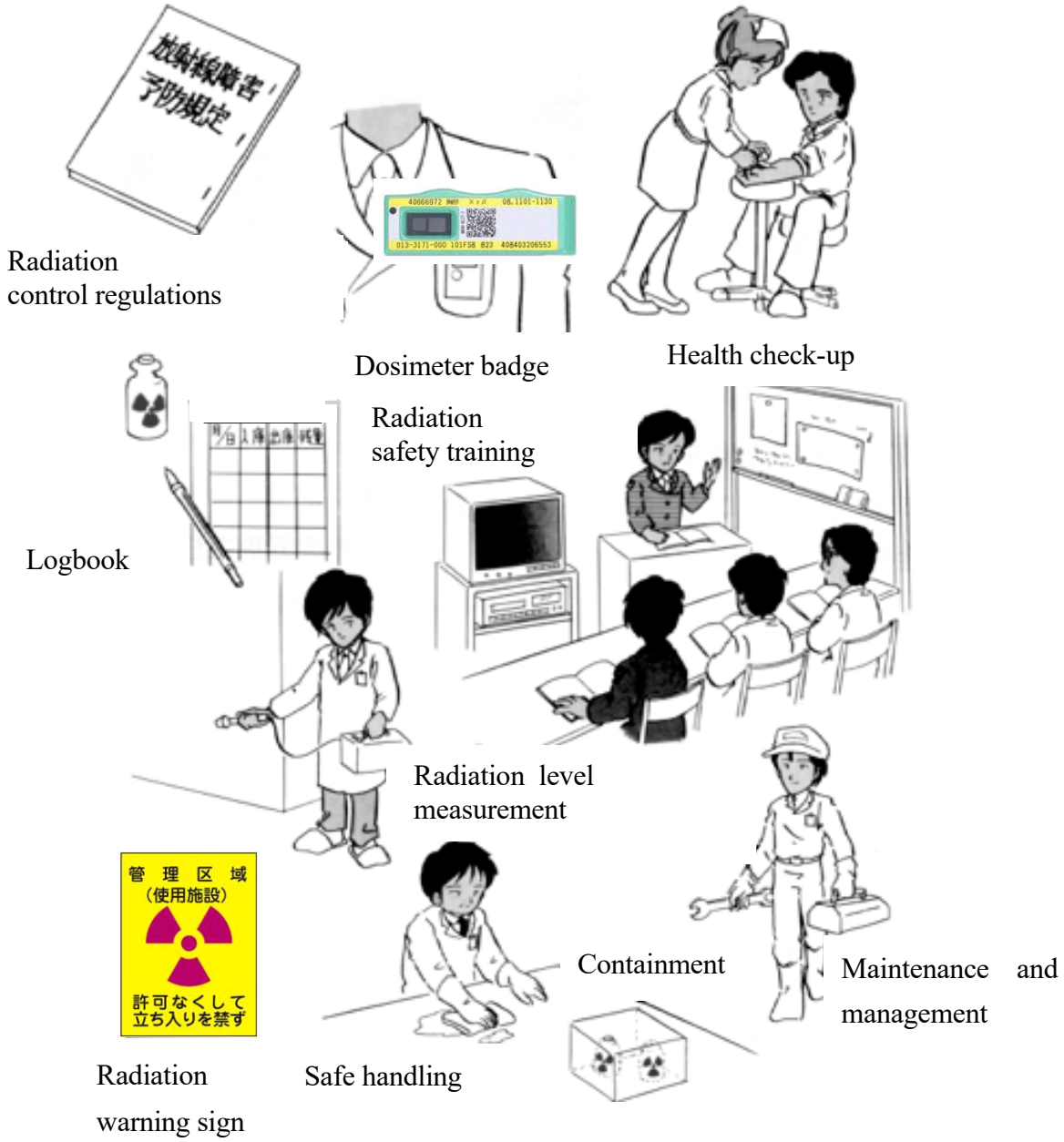


Fig. 9.1 Summary of radiation safety management

9.2.3 Principles for protection against radiation

It is essential to handle radiation as safely as possible in order to avoid unnecessary exposure. In order to prevent radiation hazards and ensure protection of human body against radiation exposure, an experimenter must consider (1) the safety of the person who is handling radiation directly and (2) the protection of the people nearby who are not directly handling the radiation but could be exposed to radiation due to diffused RI or the radiation leak from the radiation source. Below is the summery of the principle of protection against external and internal exposures.

The three main principles for ensuring protection against external exposure from sources such as X-ray are

① Shield the radiation by using a shielding wall or other shielding objects (Shield).
② Maintain a distance between the RI or radiation generator and the human body by using remote-control equipment (Distance).
③ Minimize the time for which the human body is exposed to the radiation (Time).

When using an unsealed radiation source (RI in liquid, particle, or gaseous state not sealed in a closed container), one must be cautious of both internal and external exposure. The RI entry routes can be categorized as ingestion, inhalation, and absorption (especially through skin). Measures against internal exposure include the following:

(1) Handle unsealed RIs using a specified hood or a glove box.
(2) Use a specified safety pipette filler to handle a solution that includes RI. Do not suck through pepette by mouth.
(3) Use appropriate protective clothing, cap, shoes, rubber gloves, and protective mask against dust.
(4) Keep the laboratory clean and tidy, and avoid food, drink, smoking, and cosmetics in the laboratory.

In addition, attention must be paid to prevent contamination, and its spreading when using an unsealed radiation source. Following are the main points of caution.

(1) Conduct the same experiment without using RI (cold run) in order to practice the operation procedure until you become familiar with the entire process.
(2) Check for contamination regularly during the experiment using a survey meter in order to discover contamination while it is still small-scale and easier to decontaminate.
(3) Use RI signs to distinguish the RI source and contaminated materials from uncontaminated materials.
(4) If a contaminated material is generated, categorize and seal it immediately and isolate it by storing it in the waste storage.
(5) Always conduct a contamination test after an experiment (surface contaminate test of floor/experiment table and internal contamination test).

As discussed above, regular monitoring of the safety of the handlers, radiation handling locations, and the surrounding environment is necessary to ensure the safety of both the radiation handlers and the people around. Following is a basic overview of such radiation safety management.

・Safety management of individuals

A radiation handler who has to work inside the management area must wear a glass badge dosimeter as an individual exposure dosimeter, measure the external exposure dose, and regularly ensure that the accumulated dose does not exceed the dose limit. Moreover, he/she must ensure that there is no possibility of internal exposure by calculating it from the concentration of radioactive materials in air. Radiation handlers must record and store the results of individual exposure dose measurements and the above-mentioned physical examination results by attaching them to a notebook.

・ Environmental safety management (Radiation controlled areas, the boundaries of radiation controlled areas, and premises)

The air dose rate of both inside and outside the management area that uses radiation must be measured using a survey meter, and there should be a regularly check that it does not exceed the legal limit. Moreover, in case of an

unsealed RI facility, measurement of surface contamination must also be conducted, using either the direct method (survey meter) or the indirect method (smear method).

9.2.4 X-ray generators

The main radiation generators inside our campus are X-ray generators (such as X-ray diffractometer or X-ray fluorescence spectrometer). Moreover, we possess approved equipment with certification (Am241 neutralizer equipped with radioisotope).

Following are the points of caution for handling them.

(1) Always keep the area around the device clean and tidy, and do not bring in unnecessary equipment or measuring instruments.

(2) An inexperienced radiation user must not operate alone.

(3) When using an X-ray device, always follow the instructions of the "X ray operation chief" or the "X ray hazard manager" in charge.

(4) When using approved equipment with certification labels, follow the instructions of the "approved equipment manager", who manages the device.

(5) A user of approved equipment with certification labels must comply with the technical standards and certification requirements of the equipment.

(6) Always wear a glass dosimeter when using an X-ray generator. However, you are not required to wear a glass badge dosimeter when using an X-ray generator with an interlock whose management area is only inside the device.

(7) When using an X-ray generator or approved equipment, fill in the usage record in the designated logbook. (Do not use a pencil.)

(8) When using an X-ray generator, turn on the display lamp indicating its usage.

(9) Check if the window shutter is closed or there is sufficient shielding before supplying power to the generator.

(10) Check if the shielding is sufficient after supplying power and opening the window. Use a radiation survey meter (ionization box type, NaI scintillation survey meter, etc.) to check that there is no X-ray leakage, especially when using an old device or a device you made.

(11) The handler must use the most appropriate shielding in order to minimize the external exposure dose on human body.

(12) In the event of an accident or if any abnormality is detected in the device, turn off the power supply immediately to stop X-ray generation and contact the person responsible for X-ray hazard prevention for instructions. If you suspect that you have been excessively exposed to X-rays, follow the same procedure.

9.2.5 Precautions when using radiation facilities inside and outside the university

If you are planning to carry out an experiment using an RI or radiation generators at another radiation facility of Kyushu University, another university or institution, you must attend the legally required educational training and safety education carried out at that campus/university/institution. Note that for individual exposure dose

management while using an external facility, one must bring one's own glass badge dosimeter provided by the Kyushu University, and therefore, register at one of the radiation facilities beforehand. Check with the responsible laboratory staff or the Research Support Office of the Administration Department for detail.

9.2.6 References

· *Kyushu University Radioisotope User Handbook*

・"Regulations for Protection against Radiation Hazard" by the Interdisciplinary Graduate School of Engineering Sciences, Kyushu University.

・"Radiation Safety Management in Academic Institutes", edited by the Academic Radiation Facility Association, Maruzen (1998).

・"Basic Radiation Safety Fundamentals, (2^{nd} Edition) ", Kunihide Nishizawa Ed., Nagoya University Publication Society (2004)

Chapter 10 Computer and network security

Computers and networks themselves rarely threat human life unless they are connected to some experimental equipment. This perhaps lessens people's awareness of computer security and often leads to careless use of computers. However, such careless use of computers carries with it the risk of losing important data or of system failures and can result in serious losses in research and educational activities.

Many computers today are linked together over networks, which allows the problem to spread easily all over the world, often resulting in massive damage. In addition, there is the possibility that someone may break into your computer and further use it as an agent to intrude into other computers while you are not aware of it, which is called "cracking" (popularly referred to as "hacking"). Therefore, you should regularly check your computer's security. Cracking is carried out using software that automatically scans a tremendous number of computers on the network. Your computer can be easily found and targeted for hacking if there is any weak point (security hole) in your computer. Hacking programs are simple and small but quite sophisticated. Never imagine that your computer is safe from threats without taking adequate security measures. Moreover, installing security software is not enough. It is important to maintain security measures against new attacks. The operating system (OS) and application software sometimes have potential weaknesses that allow unauthenticated access. These are called "security holes" and are often found only after the software has been released to the public. Hackers vigorously search out and attack these security holes. Thus, high security can never be achieved unless you actively maintain up-to-date security measures.

When you use a computer, therefore, bear in mind that you can be the cause of a large amount of damage without knowing it and that security circumstances change daily. In addition, you need to pay the same or greater attention as you would handle experimental equipment and chemicals.

10.1 Notes on handling computer hardware

(1) Handle the computer hardware with care, as it is vulnerable to shock and vibration.

(2) A sudden shutdown of an operating computer can cause serious damage to its system. Follow the specified shutdown procedure when turning of a computer. If a power blackout is planned, shut down computers beforehand and turn their power off.

(3) Some computers have high-voltage components inside their casing. Unplug the computer when you need to open the main casing and work inside, such as when adding a memory board.

(4) Smoking, eating, and drinking are prohibited in some computer rooms. Never undertake these activities in such a designated computer room. Computers are vulnerable to dust and liquids, which can easily cause damage.

(5) Pay attention to waste disposal regarding equipment, such as some printers, that use special inks, as their ink cartridges require a specific disposal method.

(6) Video display terminals (VDTs) can hurt your eyes. Take regular breaks when using a computer for a long

time.

(7) When handling computer hardware, take anti-static measures, such as taking off your sweater and wearing an anti-static band. Computers are extremely vulnerable to static electricity.

10.2 Notes on PC use

This and the following sections describe precautious measures to be taken when using computers in various situations. The role of the computer is greater than ever in today's research and education, and you cannot avoid using a personal computer (PC) in an academic environment. Points of cautions in this section apply to everyone and must be kept in mind as the minimum requirements. If you use one computer exclusively for yourself, you are also responsible as the administrator of that computer. See Section 8.4, "Points of caution for the administrator", for details one must pay attention to.

10.2.1 Basic rules

(1) Never access a computer for which you have no authorization under any circumstance. Simply attempting an access is strictly forbidden, and an unauthorized usage of a computer is a criminal action (Law Concerning the Prohibition of Unauthorized Access: Enacted in 2000).

(2) If you find that a computer is not operating correctly, report this to the system administrator. It is recommended that you include the following information in the report:

What: Type of problem that is experienced.

When: The time when the problem occurred and the duration. If the failure was recurring, also report its frequency.

Where: Which machine is having the problem. If the problem is network-related, where is the computer connected to.

Who: Whether you are the only one experiencing the problem, or if others are experiencing the same problem.

Why: The purpose and intention of the operation that preceded the failure.

How: The procedure you were performing in the operation.

The information of the network protocols (Table 10.1) activated in the computer will be useful to resolve the problem.

(3) Network-related problems can be influenced by many factors, and resolving the problem may involve several administrators. For example, if you experience a problem whereby you cannot read your e-mail, its cause could be (a) your computer, (b) the network, or (c) the mail server. In such a case, first contact your computer's administrator and ask for instructions.

(4) If a bug is found in the OS or in the program, immediately take an appropriate measure (halting the corresponding service or application of a correction program). One should assume that an uncorrected PC will be the first target of a cracker.

(5) In particular, it is desirable for a computer operated by Windows to install a virus check software. (See

Section 10.2.4.) At minimum, regularly check using an online scan.

(6) The most basic and effective measure against many troubles is to backup regularly. Especially for data and programs made by yourself, there is no other way to restore than having a backup.

It is advisable to make a habit of acquiring basic knowledge about the hardware and the software relevant for you.

Table 10.1 Main network protocols

SMTP	Used mainly for e-mail transfer. After an e-mail is sent from an smtp client, the smtp server delivers the e-mail to its destination.
POP	Used mainly for a PC to receive e-mails. The e-mail is first received by a pop server, and then, the PC (pop client) downloads the e-mail from the server.
APOP	An improved version of POP. It encrypts password handling.
DNS	It converts host names (e.g., www.kyushu-u.ac.jp) and IP addresses (e.g., 133.5.1.2). When there is a problem to communicate when specifying the host name, even during communication through a specified IP address, it is often due to the failure to conduct this communication.
SSH	A shell-based command that enables connection to a remote computer, allowing the sending of commands to a remote computer and the receipt of result in an encrypted manner within the established connection (session).
FTP	It sends data files to remote machines, and receives data files from them. (SFTP conducts encrypted communication.)
LPR	Conduct outputs to remote printers.
HTTP	Mainly used for transmission between web browser and web server (world wide web page, HTML text).

10.2.2 Copyright infringement

Do not copy or install charged software without permission. Unauthorized copying is an infringement of copyright. Even if software is free (not requiring a fee), it must not be used, copied, or modified without the consent of the copyright holder. Kyushu University also prohibits the use of file exchange software (often called P2P) that may lead to illegal acts such as copyright infringement or leakage of personal information. There are a wide range of variants of prohibited software such as Winny, WinMX, Share, Gnutella, etc., so please check the latest information on the Information Infrastructure Initiative's website (http://www.sec.kyushu-u.ac.jp).

10.2.3 Notes on e-mail use

E-mail is used daily, and the percentage of e-mailing in the usage of PC is thought to be generally very high. Due to this, 90% of the virus infection of a computer is reported to originate from e-mails. Here, the points of caution in using e-mails are discussed. Especially, considering that many computer virus infections come through e-mails (especially from attached files), anti-virus measures require utmost attention.

(1) Your university e-mail account is for academic purposes only. You should get your private e-mail account yourself outside the university.

(2) Hankaku Kana characters (single-width Japanese characters) and platform-dependent characters (such as "①," "②"…, "I," "II",…, "ミリ," "㎏," or "㈱") should not be used because these characters may not be displayed properly on the recipient's computer.

(3) If you are reading your e-mail through POP, do not use the setting that leaves the e-mails in the server, which results in too many e-mails getting stored in the server. This makes the server unstable and may cause trouble in loading your, or others', e-mails.

(4) Unless it is necessary to do otherwise, e-mails should be sent in plain text format (normal e-mail that is not attachment). If the layout is necessary for a text, send it as an attachment of word processor text. In addition, avoid using HTML mails as much as possible as they could be routes for virus infection. Do not set the e-mail software to create HTML format automatically and do not open HTML mails automatically.

(5) Encode the attached file as text and then send it as an e-mail. There are several text-encoding methods such as BASE64 (mainly for Windows), BinHex (mainly for Mac), and uuencode (mainly for UNIX system). Unless it is processed appropriately, the file will be broken. Thus, it is desirable to write down the encoding method of the file to the main text of the e-mail.

(6) Do not send a large file as an attachment. Though most of the time, up to 5 MB is fine, this limit size is different from server to server. Check it in advance. Be aware that you must check not only the limit of the mail server you are using but also that of the recipient of your e-mail. One can bring down the recipient's mail server by sending a large e-mail exceeding its limit. Use *Proself*, the file sharing system of Kyushu University, for sending large files.

(7) Never open suspicious attachments (file sent from unknown address, attachment with incomprehensive file name, etc.) as they are likely to be computer virus. Note that some software has a setting to open attached files automatically. Never use such a setting.

(8) Even if an e-mail has no virus, do not respond to it if its message is strange. (Rumors, donation requests, prize-winning notices, introduction of a lover, Ponzi schemes, etc.) Spyware and phishing to steal important personal information (bank account, credit card number, etc.) are widespread on the network.

(9) If your account is becoming invalid, for instance, due to graduation, make sure to stop the subscription to mailing lists and change your registration information.

10.2.4 Notes on using WWW browsers

WWW browsers such as Internet Explorer or Firefox are used daily as much as e-mails by most people, and are equally common to cause troubles such as virus.

(1) Avoid sending important information as much as possible (use fax, phone, or post), or send it via an SSL-encrypted communication compatible page.

(2) Some viruses can infect a computer just by accessing a certain website. Disable JavaScript, Java, and ActiveX. If these functions are necessary, turn them on only when they are required.

(3) Use proxy servers only for legitimate reasons, such as for their caching functions. Never use them to conceal the origination of access.

(4) As many academic thesis databases include contractual prohibitions against mass downloading, do not install any software that might download a large amount of data. There were cases in which Internet-connection “accelerator” automatically downloaded data in a mass, causing access from that domain to be severely restricted.

10.2.5 Security softwares

Security software is provided on the homepage of Kyushu University’s Information Infrastructure Initiative, so please be sure to install the appropriate security software.

The Information Infrastructure Initiative also issues manuals such as “Information Security Safety Measures”. Please make efforts to improve computer and network safety by referring to the URL information below. Further, in the unlikely event of information security damage or victimization, the discoverer is obliged to promptly notify the Kyushu University CSIRT of the Information Infrastructure Initiative. http://www.sec.kyushu-u.ac.jp/

10.3 Notes on using the server as a general user

When using a computer shared by many users, such as a super computer for calculation or various servers, the following points must be considered in addition.

(1) Manage your password well. Use different passwords for different computers, and memorize them correctly. Using a simple English word as a password or using a password with few letters should be avoided, as these can be easily cracked. Create an alphanumeric password that comprises uppercase and lowercase letters, numbers, and symbols. Keep in mind that the consequences of an intercepted password affect not only you but also other users and computers. (Needless to say, unauthorized access is illegal and will be punished.)

(2) Be aware of who is the administrator of the computer you are using in case there is a problem.

(3) Be fully aware of the restrictions on each computer, and do not violate these restrictions.

(4) Be aware of the scale of the computer resources available to you. Avoid expend all the shared disc and crash the computer, or using excessive memory so that other users run out of workspace.

(5) Consult with the administrator when planning to use services that charge fees (such as supercomputers and some databases), and plan their usage well. Pay attention to the details of your usage (connection time, disk usage volume, etc.) in addition to the charges being incurred.

10.4 Notes on being an administrator

When you become the administrator of a server used by multiple users (root user), be extremely attentive as the position’s considerable authority means that the problem caused by your carelessness will have serious consequences. Previously, the administrator was responsible for expensive computers such as SUN and other workstations. However, today, affordable computers with the same function can be purchased as PC-Unix such as Linux and FreeBSD, reduce the motivation for strict system administration. Note that if an individual owns a PC, that person is also its administrator, and therefore, must be aware of the responsibility of the position. One must

possess the same level of knowledge in the service provided as default for the widely used Windows and Macintosh as the administration of a workstation, and be equally careful.

(1) Know your computer and the connected network that you administrate. The information you need to know includes the following:
  - User accounts (always delete unused ones).
  - The usage situation of the CPU, memory, disk, and other peripheral devices.
  - Models and versions of the installed OS and applications, and the records of their settings.
  - If connected to a network, necessary settings such as host names, IP addresses, DNS addresses, and gateway addresses.
  - If connected to a network, the outline of the network configuration, and if a firewall is installed, its settings.

(2) Be aware of who are the administrators of the related facilities nearby (network, mail server, infrastructure center, and other places you may login), and keep their contacts.

(3) If you are going to be absent from the university for an extended period, leave your emergency contact to the member of the laboratory in case there is a problem.

(4) If you are not using a computer continuously, turn its power off while not using.

(5) Limit access as much as possible. Especially, accesses from outside the university should be restricted, for instance, through their IP addresses (e.g., only allow communications from specific addresses).

(6) Keep a log of all accesses and inspect it regularly.

(7) Do not start unnecessary services. Especially, a service to deliver emails (SMTP) can be used as a server to send spam e-mails, so start it only when it is absolutely necessary.

(8) It is advisable to use encrypted communication such as APOP or SSH to take measures against password theft. It is also recommended to use one-time passwords.

(9) When you discover a bug in an OS or programs, immediately take an appropriate measure (halting relevant services, application of correction program).

(10) Back up the system regularly.

(11) Learn the fundamentals of hardware and software.

Chapter 11 Gene recombination experiment, handling of laboratory microorganisms, and animal experiment

11.1 Introduction

Gene recombination experiments, handling of laboratory microorganisms, and animal experiments have been conducted through the ethic and self-restraint of individual researchers. However, legal regulation came to be demanded due to the universalization of experiment methods and increase in their social influences. Especially, with regard to gene recombination experiments, the legal structure shifted from the previous "Guidelines for Recombinant DNA Experiments", notified by the Minister of Education, Culture, Sports, Science and Technology, to "the Act on the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (enacted on February 2004, final revision May 31, 2017)", which is accompanied by punishments, and the experiments came to be regulated by this law. In addition, because many genetic modification experiments use research microorganisms, it is necessary to acquire the knowledge and skills for handling them. When handling research microorganisms, the "Act on Prevention of Infectious Disease and Medical Care of Infectious Patients ("Infectious Disease Act." Enforced in April 1999, final revision on March 26, 2020)" must be complied with.

The law "Act on Welfare and Management of Animals (enacted on April 7, 1979, final revision June 19, 2019)" is for the prevention of cruelty toward animal. When animal experiments are carried out, this law must be strictly observed.

11.2 Gene recombination experiment

Those who are conducting gene recombination experiments at Kyushu University must follow laws such as "the Act on the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (the Cartagena Protocol)" and "the Ministerial Ordinance Providing Containment Measures to Be Taken in Type 2 Use of Living Modified Organisms for Research and Development", as well as "Kyushu University Gene Recombination Experiment Guidance", "Kyushu University Gene Recombination Experiment Safety Management Regulation", and "Bylaw for Kyushu University Gene Recombination Experiment Safety Management Regulation".

Genetic modification experiments should only be conducted in authorized laboratories (with diffusion prevention measures in place) (excepting P1). Also, upon implementation, the above three points should be taken to be the basic principles:

- Approval must be obtained for the experiment
- Only those who have undergone education and training may conduct the experiment.
- Everything from handling of the modified organisms to inactivation must be conducted within the authorized laboratory (as a general principle).

Relevant laws should be complied with as well.

（http://ura.kyushu-u.ac.jp/dna/）

(1) When conducting a gene recombination experiment, submit an experiment plan to the president of

Kyushu University to be examined and receive his approval in advance, as stipulated in the gene recombination experiment of the university. Be aware that a gene recombination experiment with uncertain safety may require an approval from the government minister.

(2) The experiment participants must receive an educational training, as stipulated in the gene recombination experiment of the university. In addition, receive a re-training once every five years.

(3) The experiment participants must receive a health checkup regularly, as stipulated in the university regulation.

(4) The person responsible for the experiment must submit an experiment report after completing the experiment, or when cancelling it.

(5) Upon transforming or receiving recombinant organisms, both organizations involved must provide information and report to the President after the transfer is completed.

(6) When conducting experiments using animals classified as mammals, birds, or reptiles, submit an animal experiment application to the Animal Experiment Committee, undergo a review by the committee, and obtain approval from the President.

See below for information about the Cartagena Protocol.
http://www.maff.go.jp/j/syouan/nouan/carta/about/

11.3 Handling of research microorganisms

Following rules must be strictly observed when handling laboratory microorganisms.

(1) When handling research microorganisms, please ensure safety and acquire the necessary knowledge and skills relating to pathogenic microorganisms.
Kyushu University laboratory microorganism safety management regulation
（http://ura.kyushu-u.ac.jp/dna/biseibutu/biseibutukisoku.pdf）
Bylaw for Kyushu University laboratory microorganism safety management regulation
（http://ura.kyushu-u.ac.jp/dna/biseibutu/biseibutusaisoku.pdf）

(2) When handling laboratory microorganisms, either notify the director of Management Department or submit a request to the dean via the director of Management Department and receive an approval, depending on BSL, as stipulated in the laboratory microorganism safety management regulation of the university.

(3) When conducting an experiment, receive educational training and health checkup, as stipulated in the laboratory microorganism safety management regulation of the university, and conduct the experiment in the facility appropriate for the BSL of the experiment.

(4) When using a specific pathogen for the experiment, receive a permission of the facility in advance.

(5) Process a laboratory microorganism in a disinfection/sterilization method appropriate for its BSL category.

(6) The experiment participants must receive health checkup regularly, as stipulated in the laboratory microorganism safety management regulation of the university

11.4 Animal experiments

When caring for/managing laboratory animals, or conducting an animal experiment, at Kyushu University, strictly observe “Act on Welfare and Management of Animals”, “Law Concerning the Protection and Control of Animals”, “Fundamental Guidelines for Proper Conduct of Animal Experiment and Related Activities in Academic Research Institutions”, “Regulation for Animal Experiments at Kyushu University”, and “Bylaw for Implementation of Regulation for Animal Experiments at Kyushu University”. Especially, for safety, pay particular attention to amphixenosis, anaphylaxis, bites, and scratches, and refer to the contents of the animal experiment manual. (http://ura.kyushu-u.ac.jp/animal/)

(1) Treat animals properly following the laws on laboratory animals, such as the Act on Welfare and Management of Animals (1978, law nr. 105), the Law Concerning the Protection and Control of Animals (2006, notification nr.88, Ministry of Environment), Fundamental Guidelines for Proper Conduct of Animal Experiment and Related Activities in Academic Research Institutions (2006, notification nr.71, Ministry of Environment), 2006, notification nr.88, Ministry of Environment, and others.
(2) A person involved in animal experiments, as well as care and management of laboratory animals, must take an educational training and request registration as an experiment participant to the president.
(3) A person involved in an animal experiment must submit an animal experiment request form to the president via the dean of the school he/she belongs to and receive an approval before the experiment. Moreover, when changing the plan of the animal experiment, he/she must submit an animal experiment plan change approval request form to the president via the dean of the school he/she belongs to and receive an approval.
(4) When planning an animal experiment, properly examine methods that do not require laboratory animals first. If the usage of laboratory animals is necessary, conduct an animal experiment based on the spirit of animal welfare and limit the experiment to the extent necessary for achieving the research goal.
(5) When selecting a laboratory animal for an animal experiment, choose a species that is suitable for the experiment purpose, set the suitable minimum number of the animal that is necessary for achieving the accuracy and repeatability of the experiment result, and pay attention to the genetic and microbiological quality. Conduct a medical examination if necessary.
(6) Use appropriate retention, anesthetic, and other methods during the experiment operation in order to make as much effort as possible to avoid suffering of the laboratory animals.
(7) If you are not going to care for the laboratory animal for the rest of its lifespan after the experiment, arrange euthanasia as soon as possible.
(8) Make as much effort as possible to prevent the carcass of laboratory animals and its waste products from causing environmental contamination until their final processing such as burning.
(9) When conducting an animal experiment that requires particular attention to safety management, for instance, an experiment that uses harmful physical/chemical materials such as radioisotope, hazardous material or poison, or pathogen, strictly observe the relevant laws and university regulations, ensure the safety of the experiment participants, the people nearby, and the animals, and prevent environmental

contamination.

(10) If using a narcotic drug or a psychotropic drug for the experiment, gain legally required approval and use it appropriately.

(11) Make as much effort as possible to use a suitable facility and equipment properly maintained and managed for conducting an animal experiment.

(12) The person responsible for the animal experiment must report the results of the experiment to the president via the dean of the school when completing the experiment, or when cancelling it.

(13) The person responsible for the animal experiment must notify the director of the department immediately when an accident such as infection or environmental contamination occurs during the experiment.

(14) When using a genetically modified animal for the experiment, make a necessary separate arrangement with the Kyushu University gene recombination experiment safety committee in advance.

(15) After the experiment, its participants are responsible for the laboratory and animal materials until their final processing is complete.

(16) The person responsible for caring and managing laboratory animals must consider the physiology, ecology, and habit of each animal from scientific and animal welfare perspectives; feed them; give them water appropriately; always monitor their health; give them appropriate treatment if necessary; and ensure their safety.

11.5 Inquiries

[Administration Bureau]

Section / Division / Department	Phone number / Extension	E-mail address
Safety Management Section, Environmental Safety Management Division, General Affairs Department	092-802-2387 Ito (90)2387 Outside of office hours: 090-9952-5758 (Official)	gjgseimei@jimu.kyushu-u.ac.jp

[Departments, etc.] (Persons in charge of genetic modification experiments, handling research microorganisms, and animal experiments)

Section / Division / Department	Phone number / Extension	E-mail address
[Graduate School of Social and Cultural Studies]	092-802-5762	hbssyomu@jimu.kyushu-u.ac.jp
General Affairs Section, Administrative Office for the	Ito (90)5762	

Graduate School of Integrated Sciences for Global Society, etc.		
[Faculty of Science] Academic Planning Section, Administrative Office (Science)	092-802-4007 Ito (90)4007	rixkenkyo@jimu.kyushu-u.ac.jp
[Graduate School of Medical Sciences / Graduate School of Dental Science / Graduate School of Pharmaceutical Sciences・Medical Institute of Bioregulation / Hospital / Center for Cardiovascular Disruptive Innovation / Center for Clinical and Translational Research] Bioethics Section, Academic Research Cooperation Division, Administrative Office (Medical Sciences, Dental Science and Pharmaceutical Sciences)	092-642-6772 Hospital (91)6772 Hospital (91)6774 Hospital (91)7134	ijkanimal@jimu.kyushu-u.ac.jp
[Graduate School of Engineering / Research Center for Advanced Biomechanics / INAMORI Frontier Research Center] Promotion Section, Scientific Research Support Office, Administrative Office (Engineering, Information Science, Electrical Engineering and Integrated Frontier Sciences)	092-802-2790 Ito (90)3890	koegsuisin@jimu.kyushu-u.ac.jp
[School of Design] Planning and Public Relations Section, General Affairs Division, Administrative Office (Design)	092-553-4570 Ohashi (95)4570	gkskenkyo@jimu.kyushu-u.ac.jp
[Faculty of Agriculture / Biotron Application Center] Strategic Initiatives Section, Administrative Office (Agriculture)	092-802-4507 Ito (90)4507	noxsenryaku3@jimu.kyushu-u.ac.jp
[Institute for Materials Chemistry and Engineering] Research Support Section, General Affairs Division, Administrative Office (Chikushi Campus)	092-583-7917 Chikushi (93)7917	srskenkyu@jimu.kyushu-u.ac.jp
[Center for Advanced Medical Innovation]	092-642-4982	mdtsien@jimu.kyushu-u.ac.jp

Management Support Section 2, Research Support Division, Administration Department (University Hospital)	Hospital (91)4982	
[Central Institute of Radioisotope Science and Safety Management] Central Institute of Radioisotope Science, Hospital Campus laboratory	092-642-6194 Hospital (91)6194	rimed-info@ric.kyushu-u.ac.jp
[Faculty of Arts and Science] General Affairs Section, Education Support Division, Student Affairs Department	092-802-5921 Ito (90)5921	gazsomu@jimu.kyushu-u.ac.jp
[International Institute for Carbon-Neutral Energy Research] I2CNER Research Support / International Cooperation Group	092-802-6934 Ito (90)6934	wpikenkyu@jimu.kyushu-u.ac.jp

Chapter 12　What to do when an accident occurs

12.1 How to respond when an accident occurs

12.1.1　Assessing and Addressing the Accident Situation

When a personal injury has occurred in an accident or disaster, do not panic and keep calm. Address the situation safely, quickly, and simply. When an accident has occurred, follow the procedures below to address the situation.

① Assess the accident situation
② Ensure and verify participant safety
③ Ensure rescuer safety
④ Approach victims
⑤ Ensure rescuer and victim safety
⑥ Verify condition of victim injuries
⑦ Notify 119 or transport victim to medical facility
⑧ Perform emergency resuscitation (first aid, basic life support)

Never address the situation alone in an accident or disaster. Instead, delegate responsibilities by designating, for instance,

- Someone who leads, i.e. supervises everything and issues instructions
- Someone who performs emergency resuscitation on victims
- Someone who acts to prevent the further spread of damage from the accident or disaster
- Someone who notifies 119 and communicates with medical facilities

While the course administrator will generally serve as leader, there may be times when the course administrator is a victim. Consequently, when the pre-determined assignment of roles cannot be followed, either backup assignments should be deployed or the roles of leader and assistant should be determined on the spot based on the conditions.

If assistance can be obtained from non-participants in the area, ask for their help.

(1) Assessing the Accident Situation

Gain an understanding of the accident situation as quickly and as accurately as possible.

(2) Ensuring and Verifying Participant Safety

Verify risks and safety at the accident site. Based on conditions, evacuate participants, ensure participant safety, and verify the safety of participants.

(3) Ensuring Rescuer Safety

When deciding whether to directly provide rescue aid to a victim, keep safety foremost in mind and make a reasoned decision that considers whether you can give aid and whether you may end up a secondary victim.

Whenever providing rescue aid to victims, always ensure your own (rescuer) safety first. The number one principle whenever attempting a rescue is ensuring the safety of the rescuer.

(4) Approaching Victims

Once rescuer safety has been ensured, methods of approaching the victim(s) should be examined. If it is determined that the victim can be approached safely, then do so. If the victim cannot be safely reached, then do not approach the victim and instead notify 119 and wait for the fire department or other specialized rescue unit to perform the rescue.

(5) Ensuring Rescuer and Victim Safety

After reaching the victim(s), move as needed to a location that ensures both rescuer and victim safety (see section 13.2, “Ensuring Victim Safety, Victim Position”).

(6) Verifying Condition of Victim Injuries

Speak to the victim to verify consciousness (responsiveness). Notify 119 or transport the victim to a medical facility promptly when the following symptoms are present (The University of Tokyo Division for Environment, Health and Safety Fieldwork Accident and Disaster Measures Working Group, 2011).

- Is unconscious or confused (response is slow even when spoken to in a loud voice)
- Breathing is weak or is rapid and chaotic
- Cannot stop coughing
- Is sweating and face has lost color
- Keeps partially yawning
- Significant bleeding (will not stop even when pressure is applied)
- Four limbs are paralyzed (motion is impaired)
- Fractures or dislocation suspected
- Extensive burns (entire upper limbs, half or more of lower limbs, 1/4 or more of body)
- Facial burns caused by flames
- Eye injury

(7) 119 Notification or Transport of Victim to Medical Facility

Request assistance when a rescue or medical transport is needed. [119 for emergencies, 110 for police, 118 for marine accidents]

When notifying 119 to request assistance, be prepared to provide accurate information to the following kinds of questions.

- Fire or emergency?
- Accident or sudden illness?
- What happened to whom? (Accident situation)
- Victim's gender and age

- State of injuries, conscious or unconscious
- Caller's name and phone number

When calling from a mobile phone, the call may not always be directed to the nearest fire station. Keep calm and explain as accurately as possible the location of the incident (the address and, as needed, landmarks, signs, geographical features, etc.). Once 119 has been notified, follow the procedures below to coordinate with the ambulance.

- Await the ambulance.

  If there is a rescuer to coordinate with the ambulance, have the person wait for the ambulance near a landmark or noticeable location near the accident site. If there is no rescuer to coordinate with the ambulance, place a sign to identify the accident site near a landmark or noticeable location near the accident site (share this information when notifying 119).
- Once the ambulance arrives, provide the following information.
  - Treatment applied prior to arrival of the ambulance
  - Victim's condition prior to arrival of the ambulance
- Ride together in the ambulance

  If there is a rescuer to coordinate with the ambulance, have the person ride together in the ambulance.

(8) Emergency Resuscitation (First Aid, Basic Life Support)

As needed, emergency resuscitation (first aid, basic life support) should be performed on the victim. Emergency resuscitation should be performed using the emergency resuscitation procedures provided in chapter 13. If emergency resuscitation instructions are provided over the call to 119, follow those instructions.

12.1.2 Contacting the university + on-site response to an accident

The course administrator or leader (hereinafter, “leader”) will give first priority in an accident to ensuring participant safety and victim aide, and then make arrangements to contact the emergency contact of the Department Student Affairs Section（Information can be found in the Activity Notification (Form 2)).

When communicating with the emergency contact, make clear that it is an emergency communication, and provide information on the accident situation, including the following.

- Date, time and location of the incident.
- Victim's full name (student or employee)
- Description of the accident
- Victim's condition
- Where the victim was transported
- Leader’s full name
- Full name of local contact
- Contact information for local contact (e.g., a phone number where calls can be received at any time)

The leader should appoint a record-keeper at the site who will maintain a log of information relating to the

items below (descriptions, time, etc.).

- Accident
- Response
- Contacts
- Treatment at medical facilities

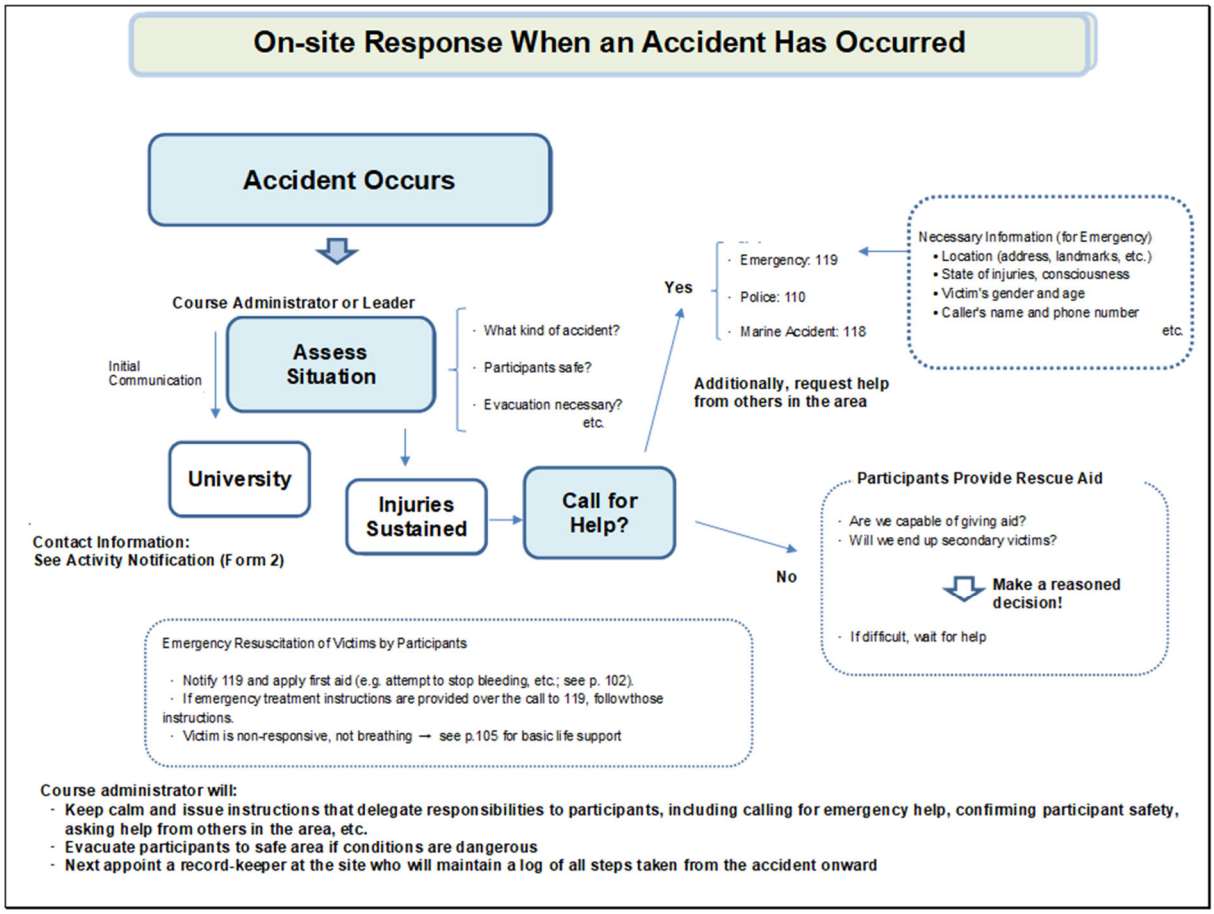


Fig. 12.1 On-site Response When an Accident Has Occurred

12.2 University Response to an Accident

12.2.1 Receiving the Initial Report

① Once the school's emergency contact liaison has received the initial communication from the local site, the liaison will confirm the following and then inform the dean (chief administrator) via the emergency contact network within the school.

- Accident description
- Date, time, and location of the incident
- Victim's name (student or employee)
- Condition and where transported
- Local contact's name and place of stay
- Phone number to contact at any time

② The dean (chief administrator) will ensure a means of contacting the local site, etc. at any time and prepare the subsequent response (e.g. creation of a response team).

③ In the event of a serious accident (e.g. fatal accident, a wreck, victim is in critical condition, etc.), the school will immediately contact the university headquarters communication liaison (Deputy Head, Student Affairs Planning Division).

[Contact Information] During business hours: 092 (802) 5917

Outside business hours: Each school to be notified separately

④ The university headquarters communication liaison will use the emergency contact network to report essential information to the Executive Vice President of Education and the President via the relevant the parties within the university.

12.2.2 Creation of a Response Team

① In the event an experiment participant has a serious accident (e.g. fatal accident, a wreck, victim is in critical condition, etc.), not only will the school dean create a response team but the university headquarters may also, depending on the circumstances of the accident, take organizational action in consultation with the school as needed to respond to the situation.

② To avoid complicating the post-accident on-site response, communications between the university and the site will generally be channeled through the response team.

③ After the initial communication, the response team will actively gather information on and issue instructions to the local site and will undertake measures to provide necessary support after consulting with the local site and university headquarters.

④ The response team will maintain a log of all activities related to the accident and provide information as appropriate to relevant parties on campus.

⑤ The response team will make every effort to provide the victim's legal guardian(s) with detailed information.

⑥ Any necessary coordination with mass media will be performed by the university headquarters (General Affairs Division).

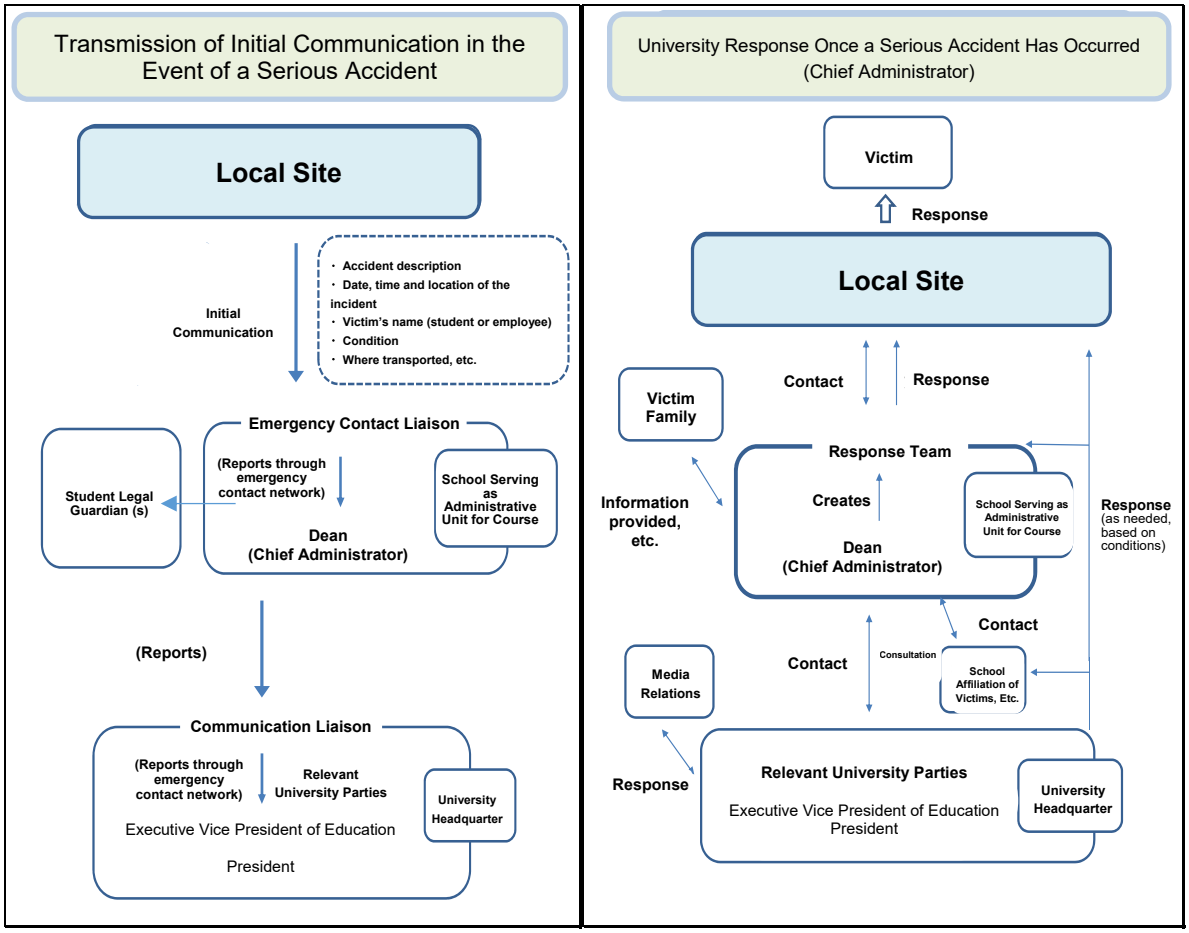


Fig. 12.2 Communication and Response Structure When a Serious Accident Has Occurred

12.2.3 Other

Even with minor accidents, it is advisable for schools to require submission of accident reports, etc.

12.3 Actions to take in an emergency

Think of your safety above everything else, and respond calmly

Measures to take in an emergency

(1) When there is an accident, notify the people around you with a loud voice.

(2) Do not try to solve the situation alone.

(3) Move the injured people to a safe place.

(4) After ensuring your own safety, take measures to prevent the accident from spreading, if possible.

- Turn off the switch.
- Close the main gas tap.

(5) Specific measures for fire(s).

- Keep appropriate early fire extinguishing measures in mind.

- Press the fire alarm.
- If the fire is too severe to handle, evacuate promptly and call the emergency contact.

  (See the emergency contacts on the back of the front cover.)

(6) Specific measures against gas poisoning (including oxygen deficiency caused by nitrogen).

- Do not enter a room filled with gas without making preparations.
- Close the main tap.
- Open the windows.

(7) Specific measures against electric shock.

- Turn off the switch.
- Do not touch the person who has suffered electric shock without making preparations.
- When touching the person injured by electric shock, protect yourself from the electric shock using a dry wooden stick, cloth, or insulated gloves.
- If necessary, administer artificial respiration or cardiac massage.

(8) Specific measures in case of severe bleeding.

- Raise the bleeding part higher than heart.
- Press an artery closer to the heart than the injury to stop the bleeding.

12.4 Response to fire

(1) First, notify as many people as possible by shouting loudly. Do not try to respond on your own.

(2) Next, remove the flammable materials, especially those that cause fire to spread vertically, such as curtains, away from the fire by, for instance, pulling them off and stop the supply of fuel by closing the main gas tap, or turning off the electric switch or the tap of the gas cylinder.

(3) Stay calm, and attempt early response to fire by using a fire extinguisher or a water bucket. However, be cautious as water or a fire extinguisher cannot be used for some types of chemical fires.

(4) Fire can be extinguished by an extinguisher only up to the level where the wall interior material is burning. When fire has spread to the ceiling, it is difficult to extinguish it with an extinguisher.

(5) When it has become difficult to extinguish with early measures, for instance, when the fire has reached the ceiling or it becomes difficult to stay near the fire due to thick smoke or gas, make an emergency call immediately and promptly evacuate to a safe location.

(6) When a person’s clothes catch fire, remove the clothes immediately or roll around on the floor (if the person cannot do this on his/her own, others must push him/her down to the floor), and extinguish the fire by pouring water, or first wrap him/her in a blanket and then pour water. Do not remain standing or run, because it will cause the fire to become stronger.

(7) It is common to stop the ventilation when a fire occurs in a draft in order to prevent the vertical spread of fire and for its fire extinguishing effect. However, there are situations wherein continuous ventilation

is advisable, for instance, when there is heavy smoke or poisonous gas. Make a decision according to the burning substances and the situation.

(8) When a fire is started by the emission of flammable gas from a gas cylinder, evacuate to a safe place and notify others. When attempting to prevent the damage from spreading, remove the surrounding flammable materials and cool the cylinder down by pouring water.

(9) When the fire reaches gas cylinders, evacuate promptly as there is a danger of explosion.

(10) When flammable gas is leaking without causing fire, try to remove the sources of ignition by, for instance, turning off the electricity or closing the main gas tap from a position as far as possible from the gas. Following this, attempt ventilation by, for instance, opening windows. If possible, close the emission.

(11) When there is a possibility of the fire being accompanied by poisonous gas, wear protection such as a gas mask when extinguishing the fire. At a minimum, stay upwind while extinguishing the fire.

(12) When you become aware of fire in another laboratory, first ensure the safety of your own department and then head to the room where the fire is with an extinguisher or other fire-fighting tools.

12.5 Response to gas poisoning accident

Do not carelessly enter a contaminated environment without making preparations. When recusing someone, enter the room without breathing in the poisonous gas, open the windows and doors, let fresh air in, and move the patient to a safe place.

When gas is leaking, pay constant attention to signs of fire, and if possible, close the tap and open the windows.

Breathing in a small amount of inert gas (carbon dioxide, nitrogen, argon, etc.) or cryogenic liquefied gas (liquid nitrogen, liquid argon, liquid helium, etc.) is harmless. However, when using a large quantity, be cautious of hypoxia. When the oxygen concentration in the air is below 18%, signs of hypoxia start to appear. When it is below 10%, one faints and seizures start, and it becomes impossible to escape on one's own. When it is below 6%, one becomes unconscious and both breathing and the heart stop. Thus, it is extremely dangerous and proper ventilation is required.

12.6 First aid

Take the following measures before the patient is taken to a hospital or an ambulance according to the level of the accident.

12.6.1 Gas poisoning

The following measures should be taken only when the situation of the victim is clear.

In other words, attempt rescue only when the type of gas that is causing the accident is known and protective measures against it are possible. When the cause is unknown, focus only on preventing the damage from

spreading. In either case, request an ambulance first.

(1) Anoxia: When it is caused by insufficient ventilation, it is important to attempt a rescue after sufficient air supply or ventilation is secured and the oxygen concentration is checked. When ventilation is not possible, a rescue attempt without an oxygen mask or an air supply mask would lead to a secondary accident. Move the patient to a safe place, check his/her consciousness, and secure the airway or administer cardiac massage if necessary.

(2) Carbon monoxide poisoning: When ventilation is not possible, wear a protective mask for carbon monoxide when attempting a rescue. A laboratory that uses carbon monoxide should keep protective masks outside the laboratory. After the rescue, move the person immediately to a place with fresh air and make sure that he/she is resting and kept warm. If his/her breathing is weak or has stopped, patiently continue artificial respiration. Early symptoms of poisoning include headaches and nausea.

(3) Halogen gas poisoning: When inhaling chlorine, let the patient breathe in a 1:1 mixed vapor of ether and alcohol. When inhaling the vapor of bromine, move the person immediately to a place with fresh air and let him/her breath in thin ammonia water in order to mitigate the irritation of nose and throat.

(4) Hydrogen cyanide poisoning: It is highly poisonous and likely to cause death within a few minutes. When poisoned by hydrogen cyanide, let the patient rest, soak gauze or another cloth in amyl nitrite, and let him/her breathe it. Continue this for 15 to 30 s every minute. When breathing stops, administer artificial respiration immediately.

(5) Sulfurous acid gas poisoning: Exposure to sulfurous acid gas (sulfur dioxide) causes severe irritation of mucosa in the eyes or throat. When eyes are exposed, wash with plenty of water, and when the throat is exposed, gargle repeatedly. Throat candy is recommended to stop coughing. When inhaling a large quantity of the gas, rest for a while. The same measures can be taken for nitrogen dioxide poisoning.

(6) Hydrogen sulfide poisoning: If ventilation is not possible, wear a protective mask for hydrogen sulfide when attempting a rescue. A laboratory that uses hydrogen sulfide should keep protective masks outside the laboratory. Move the patient to a place with fresh air, wash his/her eyes, and let him/her gargle and rest.

(7) Organic solvent poisoning: Follow the same procedure in case of gas poisoning. Move the patient to a place with fresh air and let him/her rest for a while. It is advisable to take a liver protectant just in case.

12.6.2 Swallowing poisonous substances

(1) Swallowing a hazardous substance: First, let the patient vomit the poison by sticking fingers into his/her throat. Make the patient gargle repeatedly. Letting the patient drink a large quantity of warm water or salty water in order to dilute the poison and then letting him/her vomit is also effective. Following this, move the patient to an emergency medical facility promptly. In particular, when the patient has swallowed the substance intentionally, it is important for two or more people to be with the patient while he/she is receiving medical treatment. When the patient has swallowed a substance that is highly corrosive to mucosa (e.g., strong acid and strong base), forced vomiting may worsen the damage on mucosa and cause ulcers. Thus, move the patient immediately to an emergency medical facility when the

first response does not lead to sufficient vomiting reflex. Commonly, drinking 15 g of 1:1:1 mixture of activated carbon, magnesium oxide, and tannin is effective as a universal absorption antidote for swallowing a chemical by mistake.

(2) When the skin is exposed to a hazardous substance: When the chemical gets into one's eyes or one's skin is exposed to it, immediately wash the contaminated part with plenty of running water.

12.6.3 Burns

Depending on their degree and size, burns can be fatal. Even if it appears to be not serious, let the patient be treated at an emergency medical facility when it covers a large area of his/her body. Moreover, when the burn is caused by the patient's face exposed to fire, request an ambulance as there is a high likelihood of an inhalation burn.

In any case, cool the burn with plenty of water and further cool with ice wrapped in a towel.

When the burn is light, apply Vaseline or put on a sterilized gauze or a band-aid as exposure to air can hurt.

When it is a second-degree burn where the inner skin is injured, blisters have appeared, and there is severe pain, continue the cooling, protect the wound surface, and have the patient treated at a medical facility. Leave the blisters alone. Do not break them. When a blister breaks, thickly apply an ointment with an infection-preventing agent, such as Terramycin ointment, on the wound. Make sure that there are no wrinkles. Do not apply oils as they help bacteria to spread.

When it is a third-degree burn where the skin surface is charred, bring the patient immediately to an emergency medical facility as skin grafting is required. When the patient is thirsty, let him/her drink water as long as there is no burn on the face.

12.6.4 Injury

When bleeding is not severe, wash the wound thoroughly with running tap water or with 3% hydrogen peroxide water. When the wound is dirty with oil, wipe it with alcohol. The thorough cleaning of the wound affects the subsequent recovery. Make sure to clean the wound properly. In the case of a cut or scratch, put disinfected gauze or a band-aid on the wound and wrap it with a bandage after cleaning the wound. When using disinfected gauze and other disinfected items, use disinfected tweezers to handle them. When tweezers are not available, do not touch with bare hands the part of the gauze which will contact the wound. Badly dirtied or deep wounds must be treated by a doctor immediately. When it is a stab, it is better to be treated by a doctor as its depth is sometimes unknown.

When bleeding is severe, immediately hold the bleeding part higher than the heart of the patient and keep it there. Press the artery that is closer to the heart than the wound with fingers or gauze. When using a bandage to stop bleeding, do not tie it too tight as it may damage the tissue around the wound wrapped by the bandage.

Use a cold compress for bruises. When the patient has hit his/her head, make sure that he/she is checked by a doctor even if no damage is visible from the outside. Make sure that someone accompanies the patient when he/she is going to see a doctor.

When a bone is broken, lightly set the part with the broken bone to prevent it from moving and bring the

patient to an orthopedist.

12.6.5 Electric shock

Free the victim from the electric circuit either by turning the switch off or destroying the equipment. When removing the electric wires, use a perfectly dry stick, cloth, or insulated glove.

When the electric injury has caused burns, administer treatment for burns.

Check the breathing and pulse of the patient, and when both have stopped, secure the airway and administer the basic life support (BLS) until an automated external defibrillator (AED) arrives. Switch to treatment with an AED when it arrives. Please refer to Section 13.4 for specific treatment examples.

12.7 Evacuation

12.7.1 Fire

(1) When you decide that the fire is too severe to put out with the first response, evacuate immediately and call the emergency service.

(2) A fire extinguisher is effective for the sort of fire where the inner material of the walls is burning. If the fire has spread to the ceiling, it is difficult to put it out with an extinguisher.

(3) Close the main gas tap when evacuating from the room. If possible, take measures for hazardous materials, make sure that no one is left in the room, and close the door while leaving. Do not lock the door.

(4) When the fire has reached the ceiling, or when it is not possible to stay near the source of fire due to thick smoke or gas, evacuate from the room immediately, escape to a safe place, and make an emergency call.

(5) Unless information is available through the PA (public address) system, check the movement of the smoke and select the windward escape route when evacuating through the corridor. The speed of smoke indoor is 3–4 m/s vertically and 0.5–0.8 m/s horizontally.

(6) Do not use lifts as they are stopped during an emergency such as fire.

(7) Stairs will be the route for the smoke to travel, and thus, is dangerous. Be aware of your escape routes at normal times and check the structure of the building and emergency exits in advance.

(8) Cover your mouth with a towel, etc., and take a lowered position while escaping through smoky areas. Stay calm as it requires considerable time for the smoke to reach the floor.

(9) In an urgent situation where emergency stairs, fire ladders, or other such facilities cannot be used, escape through the windows and by walking on the terrace. Be careful as some terraces do not have handrails.

(10) Though the rooftop is a relatively safe spot, do not evacuate there unless necessary.

(11) Before closing fire doors in the corridor, make sure that no one has been left inside. However, the doors can also be opened again by strongly pushing or pulling them.

When evacuating during an emergency, such as fire, follow the display lamps of the emergency exits.

12.7.2 Earthquake

(1) Immediately evacuate to a safe open space such as a parking lot, where there are no falling objects.

(2) When evacuating from a room, turn off electric switches and close the main gas tap in order to prevent fire.

(3) Do not use lifts as their operation is stopped during an emergency.

(4) When moving to an evacuation site, protect your head with a helmet or hood and take a route as far away from the outer walls of buildings as pieces of glass or walls may fall.

Participate in regular emergency drills and conduct the following inspections and environmental preparations.

(5) Check if there is a danger of buildings or concrete block walls collapsing, or signboards falling.

(6) Check if hazardous materials are properly stored.

(7) Constantly make sure that the fire extinguishers or evacuation facilities are properly functioning.

(8) Check whether devices that can explode, such as gas cylinders, are safely fixed on the floor or the walls in order to prevent them from falling.

(9) Check if the experiment devices and machine tools are suitably secured. Also, check if the pipes and wires are properly connected so that they do not detach.

(10) Check that heavy objects such as book vaults or safes are properly secured and will not move.

(11) Check whether unnecessary chemicals, unusable machines, and unnecessary papers are left in storage. Regularly organize/clean the laboratories and living spaces.

Chapter 13 Emergency resuscitation

When a personal injury has occurred in an accident or disaster, emergency resuscitation makes it possible to stop injury and sickness from worsening. Emergency resuscitation includes first aid and basic life support. First aid refers to the first actions taken to help someone who is injured or has fallen suddenly ill. Basic life support refers to emergency life-saving treatment to help someone whose heart or breathing has stopped by using an AED (automated external defibrillator) and CPR (cardiopulmonary resuscitation) involving chest compressions and artificial respiration.

13.1 Basics of emergency resuscitation

When a personal injury has occurred in an accident or disaster, do not panic and keep calm. Address the situation safely, quickly, and simply. Emergency resuscitation should be performed according to the steps below. Emergency resuscitation can be performed relatively easily even by someone without a special credential, but be sure that notification to 119 and transport to a medical facility are not delayed for that reason.

(1) Assess the accident situation
(2) Ensure and verify participant safety
(3) Ensure rescuer safety
(4) Approach victims
(5) Ensure rescuer and victim safety
(6) Verify condition of victim injuries
(7) Notify 119 or transport victim to medical facility
(8) Perform emergency resuscitation (first aid, basic life support)

13.2 Securing the victim's safety + body positions (Resuscitation Committee of the Japanese Foundation for Emergency Medicine, 2015)

After approaching the victim(s), move as needed to a location that ensures both rescuer and victim safety.

Help the victim keep still in a comfortable position. If CPR is necessary, lay the person on their back (supine position). While laying the person on their back, be sure to support their head so that their head and neck (cervical vertebrae) do not twist.

If the injured person is unresponsive but breathing normally, lay them on their side (in the recovery position) to prevent the air passage at the back of their throat from contracting or becoming blocked by vomit. With the person in the recovery position, extend their under-side arm straight in front of them and bend their upper-side arm so as to rest their head on the backside of their hand. To stabilize the person's position on their side, bend their upper-side leg 90º at the knee and extend it forward (see Fig. 13.1).

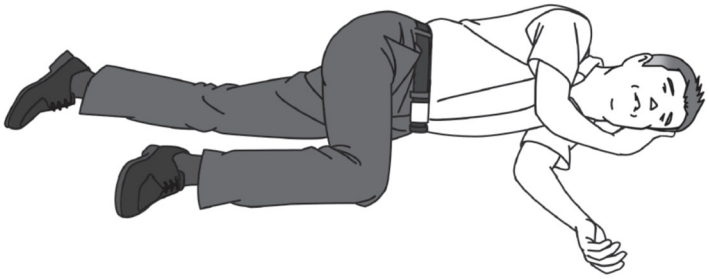


Fig. 13.1 Recovery Position

(Ministry of Health, Labor and Welfare, 2015)

If a person has been hit by a car, fallen from a high elevation, or otherwise severely injured their face or head, there is a chance they have hurt their neck (cervical vertebrae). In such cases, it is necessary to keep the injured person's neck still. Using both hands to support the injured person's head on both sides, make sure their head moves as little as possible (Fig. 13.2). Do not pull on their head or attempt to straighten their neck if it is bent. Rather, keep it just where it is.

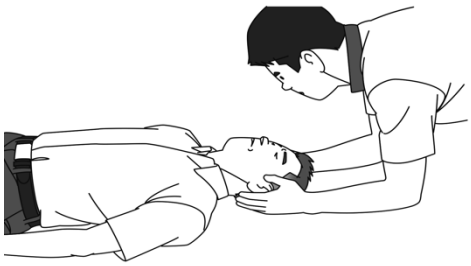


Fig. 13.2 Using Two Hands to Support the Head so it Does Not Move

(Ministry of Health, Labor and Welfare, 2015)

13.3 First aid (Resuscitation Committee of the Japanese Foundation for Emergency Medicine)

13.3.1 Scratches and cuts

If left uncleaned of dirt and sand, wounds can fester and not heal properly. There is also concern that tetanus may occur later if a person has not been immunized or their immunization was long ago. If possible, the wound should promptly be washed thoroughly with tap water or other clean, running water. If the cut is deep or extremely dirty, keep the rinsed wound as clean as possible and seek prompt medical attention.

13.3.2 Bleeding

Significant blood loss from an injury can be life threatening so it is best to stop bleeding as quickly as possible. Once the source of the bleeding is found, attempt to stop the bleeding by applying direct downward pressure using gauze, handkerchief, or towel (direct pressure method). If bleeding will not stop even when pressure is applied, it may be that the pressure is not directly over the source of the bleeding or that the pressure is not strong enough. Continue to apply firm pressure to the source of the bleeding until emergency medical services arrive.

Although the risk is very small that a rescuer will contract an infectious disease from contact with the injured person's blood while attempting to stop the bleeding, it is a good idea for the rescuer, if possible, to wear plastic gloves or use plastic bags instead of gloves Fig. 13.3).

With plastic gloves on, gauze or other material is used to apply pressure to the bleeding area

Plastic bags can be used instead of gloves

Fig. 13.3 Direct Pressure Method (Ministry of Health, Labor and Welfare, 2015)

When direct pressure fails to stop the bleeding, a belt or other such item can be used as a tourniquet to stop the flow of blood through the arm or leg, but given the risk of nerve or other damage, this method is only recommended for use by people who have undergone training.

13.3.3 Sprains, bruises, and fractures

Ice sprains and bruises (contusions) using a cold pack or ice water. Icing injured areas reduces internal bleeding and swelling. When using a cold pack, keep a thin cloth between it and the skin so they do not come into direct contact.

If the leg or arm is misshapen from the accident, a fracture is likely. Immobilizing the misshapen leg or arm serves to reduce pain while moving and protect it from further injury. A splint or triangular cloth can be used to immobilize the injury. It is unnecessary to put the misshapen limb back into shape.

13.3.4 Heat-related illnesses

Extreme symptoms of heat-related illness are a life-threatening emergency. If symptoms are limited to lightheadedness, cramps, and heavy sweating, cool the sick person's body by having them keep still in a cool place and consume liquids containing sodium (e.g. oral rehydration solution, sports drink, etc.). If symptoms include headaches, nausea, and exhaustion, seek medical attention. If the person's consciousness is weak or body temperature extremely high, immediately telephone 119 and continue to cool the person's body until emergency medical services arrive.

When using an ice bag or cold pack to cool the person's body, apply them to the armpits, base of the thighs, and neck; but a safer, more effective method is to remove the person's clothes, wet their body, and blow air at them using a hand fan or electric fan.

13.3.5 Burns

Immediately cooling burns prevents them from getting worse and accelerates healing. Promptly cool burns

in running tap water until the pain subsides (at least 10 minutes). Icing burns with ice or ice water can make the burns worse. If the burns are over a wide area, seek medical attention as soon as possible. In such cases, the person's body temperature can drop precipitously if cooled for too long, so avoid excessive cooling.

Blisters serve to protect the wound. If blisters appear, cool the area gently without touching them to keep them from popping.

13.3.6 Frostbite

Frostbite is a condition in which extremities and skin are damaged from exposure to very cold temperatures. Begin by stropping body temperature from dropping further by removing all wet or damp clothing and covering the person in dry blankets or clothes. Next, without rubbing the affected area, warm it in lukewarm water, unless there is a chance the frostbitten area may be exposed to cold temperatures again or if a medical facility is nearby. In that case, seek prompt medical attention without warming the area. Do not compress the affected area. If legs are affected, do not put any weight on them.

13.3.7 Drowning

Rescuing a person who is drowning should generally be left to firefighters, lifeguards, or other professional rescuers. If you see someone drowning, contact 119 (or 118 if at sea) to notify professional rescuers. If the person is floating at the surface and calling for help, throw them something they can hold onto to float. If a rope is available, throw them the rope and pull them in. If the person sinks, figure out some marker to identify where they sank. When the professional rescuers arrive, tell them about the marker.

If the environment is a safe one (e.g. shallow pool) in which to perform a rescue, then do not wait for professional rescuers and instead pull the sunk person from the water. Do not enter the water if there are currents, the bottom is not visible, or the water's depth is unknown. Once the person is pulled from the water, follow the procedures for basic life support (see Chapter 13.4) and check if the person is responsive and breathing. There is no need to press on the person's abdomen to force them to spit up water.

13.3.8 Anaphylaxis

A severe allergic reaction to a particular substance is called anaphylaxis. Anaphylaxis can be life threatening when it prevents breathing by restricting the airway (passage that provides air to the lungs) or causes a severe drop in blood pressure. Immediately notify 119 if such symptoms occur.

If it happens, adrenaline (epinephrine) should ideally be administered as soon as possible. For this reason, persons who have had severe anaphylactic symptoms in the past will sometimes carry an adrenaline (epinephrine) auto-injector (EpiPen®: Fig. 13.4) prescribed by a physician (e.g. forest workers with a high probability of being stung by bees/wasps, people with food allergies, etc.). If the sick person cannot operate the device on their own, assist them in using the EpiPen®.

Press the EpiPen® against the skin

Fig. 13.4 EpiPen® (Ministry of Health, Labor and Welfare, 2015)

13.3.9 Other

As needed, information will need to be collected on field-specific concerns that require consideration, including things like altitude sickness, photokeratitis (“snow blindness”), decompression sickness, and vector-borne diseases.

13.4 Basic life support

BLS (Basic life support) refers to emergency treatment, including CPR (cardiopulmonary resuscitation) and the use of an AED (automated external defibrillator), that is given to help individuals whose heart or breathing has stopped. In the context of BLS, this section explains, respectively, how to perform CPR and how to use an AED.

13.4.1 Cardiopulmonary resuscitation (CPR) procedure

(1) Verify safety

If you witness someone collapse suddenly or discover someone who collapsed, first verify that the surrounding area is safe. Depending on the conditions (e.g. cars are passing by, smoke is filling the room), take appropriate steps to ensure safety. Ensuring your own safety takes priority over helping the afflicted person. If you are at risk of being assaulted, getting caught in a fire, or being electrocuted, it is often best not to approach the afflicted person and instead wait for police and firefighters to arrive.

(2) Verify responsiveness

Once safety has been verified, check if the afflicted person is responsive. If, when you gently pat their shoulders and speak to them in a loud voice, they respond by opening their eyes or moving with purpose, then they are determined to be “responsive”. Immediately after sudden cardiac arrest, the person may experience twitching (spasms), but since they are not responding to your voice, they are determined to be “unresponsive”.

If you determine them to be “unresponsive” or your determination is uncertain, act as if the person may have experienced cardiac arrest. In a loud voice, call for help (“I need help! Someone has collapsed!”)

(3) Notify 119 and prepare AED

If someone is nearby, ask that person to notify 119. If an AED is located nearby, also ask that person to bring it. Use concrete language, if possible, when making the request (“You, please call 119”, “You, please bring an AED”, etc.).

Remain calm when notifying 119 and not only communicate the location as precisely as possible but also inform them that the person is not responding to your voice. If known, the person's approximate age and condition (e.g. “collapsed suddenly”, “has spasms”, “body is not moving”, “face has lost its color”, etc.) should also be communicated.

When notifying 119, you and others helping you will be given instructions over the phone about what steps to take. They may also be able to tell where to find an AED, if one is located nearby. You will be asked over the phone if you can perform chest compressions. If you are unsure, ask for instructions and follow them calmly.

If, even after you have screamed for help, no one comes, then you will have to notify 119 and prepare the AED on your own before beginning CPR. Knowing that you have to leave the person alone while you fetch the AED may worry you. If you know where a nearby AED is located, you should go and fetch yourself.

(4) Observe breathing

When the heart stops, normal breathing stops, too.

To observe the afflicted person's breathing, watch their chest and abdomen for movement (they will rise and fall as the person breaths). If the chest and abdomen are not moving, the person is determined to be not breathing. If the person is not breathing, their heart has stopped and chest compressions should be started.

On the other hand, it is not uncommon immediately after sudden cardiac arrest for there to be “agonal respiration”, characterized by a convulsive gasping for air. Such breathing should be taken as evidence of cardiac arrest and chest compressions should be started. If you are uncertain whether breathing is normal, begin chest compressions.

Observe breathing for no more than 10 seconds. If you remain unable to decide after 10 seconds, assume that breathing is not normal and that their heart has stopped.

If the person is unresponsive but breathing normally, keep an eye on them and wait for support and/or emergency medical services. Pay special attention to their breathing and, if you no longer observe breathing or the person's breathing is no longer normal, assume that their heart has stopped and immediately begin chest compressions.

(5) Perform chest compressions

If you determine based on an observation of a person's breathing that their heart is stopped, immediately begin chest compressions.

① Compression point

Directly in the middle of the chest is a long, flat bone called the breastbone. Pressure is applied to the lower

half of this bone. Locate this bone at the midpoint (midpoint between the two sides, as well as between the top and bottom) of the chest (Fig. 13.5).

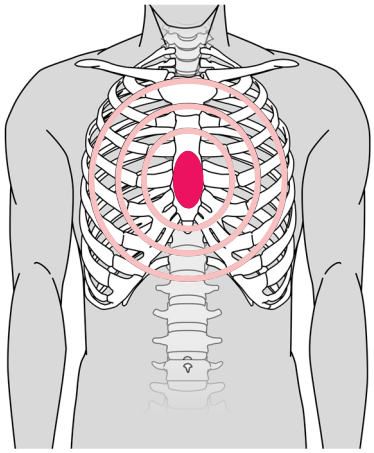


Fig. 13.5 Chest Compression Placement (Ministry of Health, Labor and Welfare, 2015)

② Compression method

Place the heel of one hand on the lower half of the breastbone and rest the other hand on top of the first one. It can help to lock fingers. Pressure is applied using not the entire palm of the hand but rather just the heel. Applying pressure to the breastbone with the fingers or entire palm is not good. Adopt a posture that applies your weight downward by straightening your arms with your shoulders directly over the compression point (your palms).

③ Compression depth and tempo

Press repeatedly at a rapid pace on the afflicted person's chest with enough strength to depress it approximately 5cm (Fig. 13.6).

Compression will not be effective if you do not press hard enough, so press hard. In the case of children, press the chest enough to depress about 1/3 the thickness of the child's chest. Timidly pushing on a person's chest, whether adult or child, will not be effective because the compressions will not be deep enough.

Be sure to use strong, rapid pushes. However, on small bodies, two hands may be too strong. In that case, use one hand.

The tempo should be around 100-120 pushes per minute. To the extent possible, chest compression should be performed continuously without interruption.

④ Releasing pressure

Between compressions (when pressure is not being applied), it is important to release pressure sufficiently so the chest can return to its normal height. However, there is a risk of losing the compression point if one's hands are removed entirely from the afflicted person's chest to release pressure, so careful attention is required.

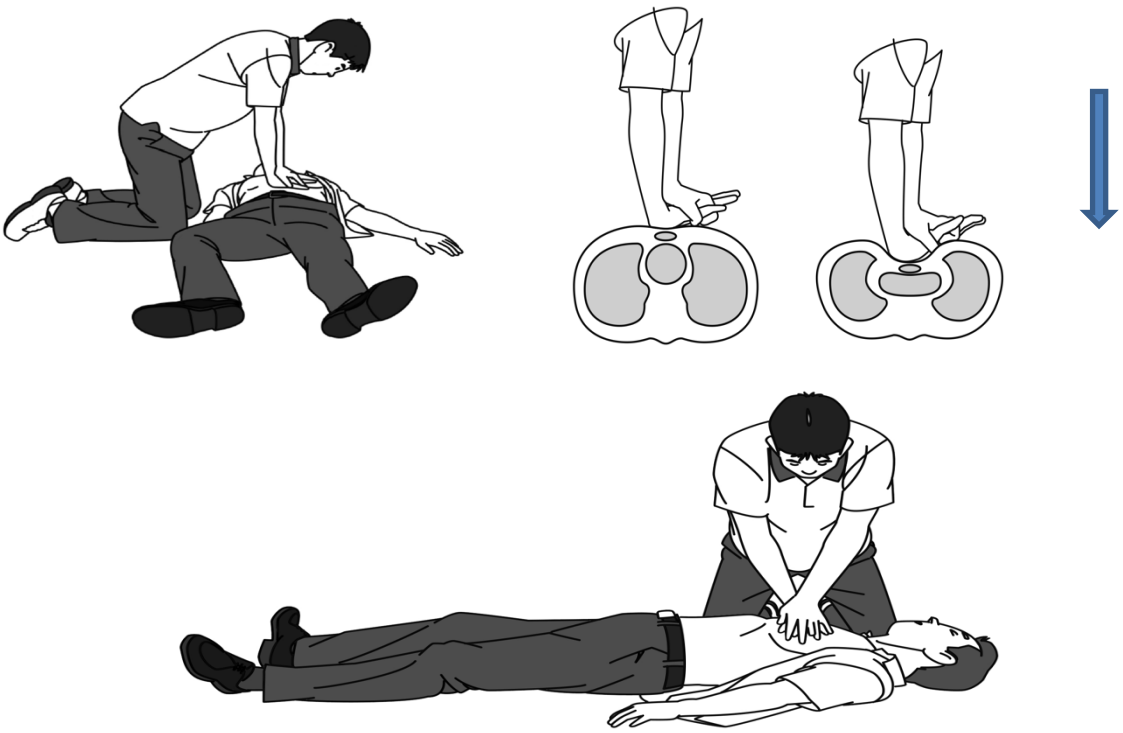


Fig. 13.6 Chest Compression Method (Ministry of Health, Labor and Welfare, 2015)

⑤ Substituting rescuers

It takes stamina to repeatedly apply enough to depress an adult's chest by 5cm. As a rescuer tires, they will tend to push with less force and their tempo will grow slower without even realizing it, so always keep it in mind as you make strong, rapid pushes. If someone else is there to help you, switch roles every 1-2 minutes. It is critical to keep to a minimum interruption during the switch. Rescuers will tire even more quickly when chest compressions are being performed without artificial respiration, so substitutions will need to be performed more frequently.

⑥ Combining 30 rounds of chest compression with two rounds of artificial respiration

If someone who has taken classes and learned artificial respiration techniques decides to use artificial respiration, then artificial respiration can be combined with chest compressions. The ratio of chest compression to artificial respiration is 30:2 and this combination should be repeated continuously until emergency medical services take over.

If you do not have the confidence to perform artificial respiration or are hesitant to touch your mouth to the mouth of the afflicted person, then just continue to perform chest compressions.

⑦ Using an AED

The AED has audio messages and lights that provide instructions on the steps to be followed. Unless unavoidable, as when using the AED for electro-cardiogram (ECG) analysis or to deliver an electrical shock, it is important to continue chest compressions uninterrupted if possible, even when using an AED.

Please review “AED Use Procedures” below.

⑧ Continuing CPR

It is important to continue CPR until emergency medical services take over. Even if you think it is having no effect, do not stop.

If the afflicted person begins to breath normally and responds to your voice or moves with purpose, CPR should be suspended; but if in doubt, do not stop. If you suspend CPR, continue to check the person's responsiveness and breathing as you wait until emergency medical services arrive. If the person stops breathing or their breathing is no longer normal, immediately resume CPR.

13.4.2 Procedure for using AEDs

(1) Retrieve AED

In most cases, AEDs are found in dedicated boxes with prominently displayed AED logos, as shown in Fig. 13.7. When the box is opened to remove the AED, an alarm will sound. It is fine to let the alarm continue to ring, so return immediately to the afflicted person.

Fig. 13.7 Examples of Installed AED Boxes (Ministry of Health, Labor and Welfare, 2015)

(2) Prepare AED

During CPR, switch immediately to preparing the AED once it arrives. Place the AED near the afflicted person's head (Fig. 13.8).

Fig. 13.8 AED Placement (Near Afflicted Person's Head) (Ministry of Health, Labor and Welfare, 2015)

(3) Switch power on

Turn on the AED. Depending on the model, it will be either the type that has a button that needs to be pressed to power the unit on or the type that will power on automatically once the lid is opened (and has no power button).

Once the power is on, operate the AED according to its audio messages and lights.

(4) Apply defibrillator pads

Expose the afflicted person's chest by removing clothing from the person's chest area. If buttons and hooks prevent you from removing the person's clothing, you will need to cut the clothing away.

Remove the defibrillator pads in the AED case from their bag. Referring to the illustration included on the defibrillator pad bag (Fig. 13.9), apply the two defibrillator pads directly to the person's skin as shown (Fig. 13.9). The illustration will show that one pad should be placed in the upper right area of the person's chest (below the collarbone on the right-hand side of breastbone) and the second pad placed under the person's left breast (5-8 cm below the armpit, diagonally below the nipple). Continue chest compressions even as the defibrillator pads are being attached.

Attach the defibrillator pads securely to the afflicted person's skin. Pockets of air between the defibrillator pads and skin can impede the flow of electricity (Fig. 13.10).

Depending on the model, you may need to plug the wires from the defibrillator pads into the socket in the AED device. Follow the AED's audio messages to operate the device.

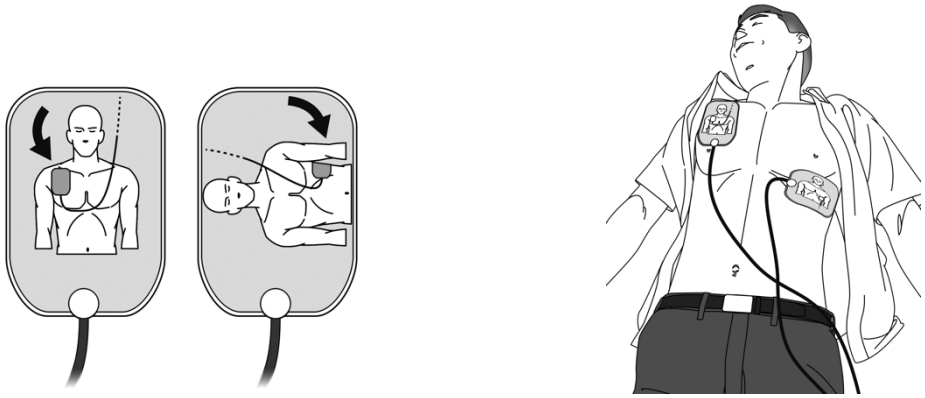
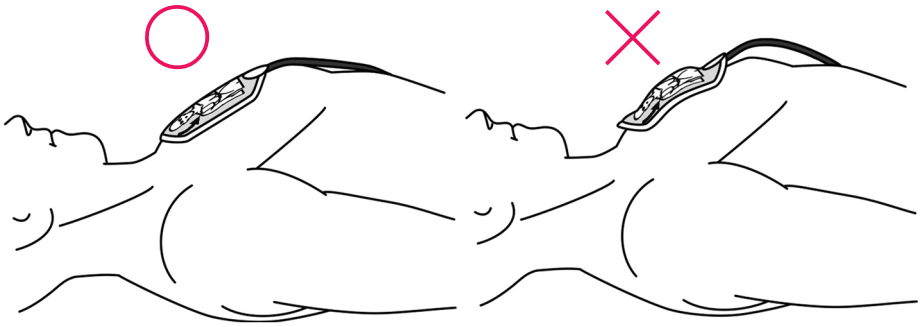


Fig. 13.9 Defibrillator Pad Placement
Expose the person's chest and apply the defibrillator pads to the skin.
(Ministry of Health, Labor and Welfare, 2015)



This is no good because of the gaps.

Fig. 13.10 Attach the Defibrillator Pads Securely to the Skin

(Ministry of Health, Labor and Welfare, 2015)

(5) Electro-cardiogram analysis

Once the defibrillator pads are securely attached, the AED will automatically detect the connection and initiate electro-cardiogram (ECG) analysis with an audio message telling you to back away from the person's body.

Tell anyone else near the afflicted person to back away and verify that no one is in contact with the person's body. If anyone is touching the afflicted person's body, ECG analysis may not function properly.

(6) Deliver electrical shock and resume cardiopulmonary resuscitation

① If Electrical Shock is Indicated

The AED automatically analyzes the ECG and determines if electrical shock is necessary. If it is, the AED will automatically begin charging with an audio message telling you that an electrical shock is necessary. Tell the people nearby not to touch the afflicted person's body and verify once more that no one is in contact with the person's body.

Once charged, the AED will begin beeping and the shock button light will come on, together with an audio message telling you to press the shock button. Press the button to deliver the shock as indicated. When the button is pressed, a strong electrical current will pass through the afflicted person's body, causing it to tense briefly.

After the shock, immediately begin chest compressions to resume CPR, as indicated by the audio message telling you to begin chest compressions immediately.

② If Electrical Shock is Not Indicated

If the AED audio message indicates that a shock is not necessary, immediately begin chest compressions to resume CPR. Just because a shock is unnecessary does not mean that CPR is unnecessary. Do not get confused.

(7) Repeat cardiopulmonary resuscitation and AED procedures

The AED will begin automatic ECG analysis every two minutes. Each time, an audio message will remind you to back away from the body. During CPR, listen carefully for this audio message and, when you hear it,

remove your hands from the afflicted person and tell the people around you to back away as well, then verify that everyone has backed away.

Keep repeating these CPR and AED procedures.

(8) Transfer to emergency medical services

Keep repeating the CPR and AED procedures until emergency medical services takes over.

If the afflicted person begins to breath normally and responds to your voice or moves with purpose, suspend CPR and observe their condition. Because the AED may still be needed if their heart stops again, do not detach the AED defibrillator pads from the person's chest and leave the power on.

13.5 First aid kit

Any emergency supplies that are believed to be necessary to have stored in the laboratory, department office and so forth for laboratory activities, should be managed so that they can be used as needed. Also, strive to increase awareness of their storage location. For reference, below is a list of general first aid items that should be prepared during laboratory activities. (The University of Tokyo Division for Environment, Health and Safety Fieldwork Accident and Disaster Measures Working Group, 2011).

(1) Band-aids (multiple sizes, small to large)
(2) Clean gauze (in unopened packages)
(3) Bandages
(4) Elastic bandages (for immobilizing joints in case of sprains, etc.)
(5) Sling (for fractured or dislocated shoulders or arms)
(6) Poison remover (to be used on bee stings, snake bites, etc.)
(7) Rubber gloves and plastic gloves (to treat injured people who are bleeding, etc.)
(8) Thermometer
(9) Sterile distilled water (for washing wounds)
(10) Iodoform-based disinfectant (e.g., povidone-iodine disinfectant)
(11) Hydrogen peroxide disinfectant (oxydol disinfectant, pyrozone disinfectant, etc.)
(12) Poultices, anti-inflammatory ointments
(13) Antihistamine ointments (for insect bites, etc.)
(14) Corticosteroid ointments (for rashes, etc.)
(15) Antibiotic ointments

If possible, it is advisable to prepare the following as well.

(16) EpiPen auto-injector (to be used for anaphylactic shock due to bee/wasp stings, etc.)

13.6 Psychological First Aid

If an accident or disaster causes a personal injury or a feeling of physical or mental danger, psychological support is needed for those affected by the accident. The following are notes on psychological support when an accident

occurs during off-campus activities.

(1) Target person

The reaction and feeling of encountering a crisis event vary from person to person. Upsets may be greater if you have a similar painful experience in the past or if your physical and mental health is poor at the time of the crisis.

(1) Persons who have experienced accidents or crisis situations

(2) Who witnessed it

(3) Person who was shocked by seeing and hearing closely

are also included. In addition to dealing with the full range of people affected by the crisis, there is a need for individual engagement with those who are particularly upset.

(2) How to get involved

The key is to be close to them and just listen ~~to them~~ if they are trying to talk, or accept them if they are silent. It is inappropriate to force them to talk about the experiences and ~~or~~ feelings ~~experienced~~ or to ask them many questions. It is reasonable to ask, "Do you have anything that you are concerned about?"

(1) Try to nod so that they know you are listening to their story.

(2) When listening individually, ensure their privacy.

(3) Providing water and snack (or light meal) may ease their tention.

(4) There are times when the other party wants to know the information. Rather than guessing the answers, it is better to be honest and say “I’m afraid that I don’t know” .

(3) Managing caregiver’s own mental and physical condition

In crisis, caregivers themselves are often anxious, upset, or physically and mentally fatigued. It is important to be aware of your mental and physical condition and try to rest and not to overdo it.

(4) Take over to Campus Life and Health Support Center

After leaving the area, take over to the Campus Life and Health Support Center.

Reference URL

・WHO Psychological First Aid (PFA)
https://apps.who.int/iris/bitstream/handle/10665/102380/9789241548618_eng.pdf;jsessionid=2CB5E787E17A9D161C993F22CFA71607?sequence=1

Citations

Resuscitation Committee of the Japanese Foundation for Emergency Medicine (editors): Emergency Resuscitation Guidelines 2015 (Edition for General Public)
https://www.fdma.go.jp/neuter/topics/kyukyu_sosei/sisin2015.pdf

The University of Tokyo Division for Environment, Health and Safety Fieldwork Accident and Disaster

Measures Working Group (editors): Outdoor Activity Safety and Health Management and Accident Prevention Guidelines, 1st Edition

Chapter 14　Risk assessment – – Examples of chart creation – –

As mentioned in “Before commencing laboratory activities”, faculty members and students who conduct laboratory activities at Kyushu University must conduct risk assessments in order to prevent accidents and damage to health. The purpose of risk assessment is to identify “hazards (risk factors)” and to take “necessary and appropriate measures” in response, in order to reduce risk and avoid danger. Where there are multiple risk factors, it is also necessary to consider the order of priority of countermeasures. For this purpose, an “evaluation of the magnitude of risk” is performed for each factor. These are collectively called risk assessment.

When conducting laboratory activities, risk assessment should be carried out in advance to prevent accidents or damage to health. However, the types of risk that exist will be different for each laboratory and each participant. Thus, risk assessment must be done for each individual, under the supervision of the person in charge of the laboratory.

What follows are examples of risk assessments conducted for specific students with various research themes (chemistry/materials-science, electricity, physics/applied physics, mechanical science, and environment). While referencing these examples, a risk assessment table should be prepared at the beginning of the year or when there is a change in research method. The table should be posted in an easily visible place in the laboratory so that safety measures can be confirmed.

The faculty members in each laboratory shall check the risk assessment table and provide instructions. Also, if there are any near-miss cases in the laboratory (cases where an accident was imminent but fortunately did not occur), they should review the risk assessment table and take countermeasures.

Due to the revision of the Occupational Safety and Health Act in June 2015, it is now obligatory to conduct a risk assessment using safety data sheets (see Chapter 3) before using substances that have a certain degree of risk or harmfulness. This is because, while there exist individual regulations, JIS, etc., for machinery and other hazards, there are no such standards for chemicals, excepting some, and thus it is not possible to cope with the diversity of chemical substances.

Regarding risk assessment that corresponds to the above-mentioned revision to the law, implementation methods and so forth are currently under consideration. However, considering the fact that many chemicals used for research at the university do not have safety data sheets, or are not accompanied by safety assessment data, the experimenters must be cautious with regard to using chemicals.

14.1 Risk Assessment Example: Chemistry/materials-science students

Research subject: Synthesis of inorganic materials using vacuum Schlenk lines

Dangerous factor	Danger	Countermeasure
Chemical substances	Ignition, flash, inflammation of the skin, loss of eyesight	When weighing and mixing the materials for synthesis, wear glasses, mask, and gloves in accordance with their danger. Do not leave your seat when heating reaction mixtures, in case of violent reactions.
Glass equipment	Injury	Check to be sure that the glass equipment is not damaged before using them. When connecting to the vacuum line, apply vacuum grease to connecting parts.
Vacuum glass line	Injury	Beware of accidents due to damaged glasses. Do not open and close a cock forcibly. It may damage the cock. Treat it carefully, for instance, by checking if grease was applied to the cock.
High-pressure gas	Explosion, suffocation	Install the gas cylinders in a fixed container stand. Use a pressure regulator properly. Check for a gas leak in the flow passageway to prevent leakage of the gases formed during the reactions to the outside.
Liquid nitrogen (for cold trap)	Explosion, suffocation, frostbite	To prevent a liquid nitrogen container from unusually high pressure, do not close it completely. On the other hand, if the container is opened completely, oxygen in the air can enter the container and form explosive liquid oxygen; thus, put a cover on the container when using. Wear leather gloves to prevent frostbite when transferring liquid nitrogen to another container.
Vacuum pump	Injury, fire	Be aware of the opening/closing situation of the valves of the vacuum system when operating the vacuum pump. Be careful of overload operation due to leaks in the lines, which cause heat generation and fire.

14.2 Risk Assessment Example: Students who handles organic compounds

Research theme: Functional group conversion (synthesis reaction) of organic compounds and analysis of products using gas chromatography

Risk factor	Risks	Countermeasures
Chemicals	Ignition, catching fire, skin irritation, blindness	When weighing and mixing synthetic raw materials, wear glasses, protective masks, masks, or gloves in accordance with the danger. Do not leave your seat during the experiment, in case an intense reaction occurs. Ventilate the room. Work in a draft chamber as needed, based on assessing the chemicals.
Glassware	Injury	Check glassware for damage before use. Be cautious of accidents caused by damaged glass.
Liquid waste	Skin inflammation, burdening the environment	Appropriate treatment of liquid waste. In particular, exercise caution when using chlorine-based organic solvents for extraction work, and handle the water layer in the same way as the chlorine-based organic solvent liquid waste.
High-pressure gas	Explosion, suffocation	Install cylinders on fixed container stands. Use pressure regulator properly. Check the gas flow passage for leaks, and prevent gas generated by the reaction from leaking out of the system. Ventilate the room.
Vacuum pump	Injury, fire	Operate the pump while always being aware of the open/close status of the vacuum valve. Be aware of and cautious of the fact that overloading the pump can lead to overheating and fires.
Wiring to instruments, use of analytical instruments	Fire, current leakage, electric shock	For analytical instruments that require large amounts of power, use dedicated breakers for the wiring. Wire the cords where people do not pass through. Watch out for device abnormalities (abnormal sounds, abnormal operation, etc.)

14.3 Risk Assessment Example: Students in the electric system

Research subject: Diagnosis of atmospheric pressure for short-pulse high-voltage discharge-plasma using laser spectroscopy.

Dangerous factor	Danger	Countermeasure
Class-4 laser	Loss of eyesight, burn by irradiation of skin, fire	The safe terminal of the laser beam, measures to avoid contacting a beam, shielding of the scattering light, and wearing safety glasses. The laser path should be made lower than the eye level.
High-voltage circuit	Death caused by electric shock, burn, fire	Isolate a high-voltage section. Conduct the experiment in a group and check each other's safety. When checking circuit elements, make sure that the power is turned off and the short circuit between the electrodes of the capacitor.
Low-voltage electronic circuit	Electric shock, fire	When checking circuit elements, make sure that the power is turned off and short circuit between the electrodes of the capacitor. Remove dust.
Wiring to the apparatus	Fire, electric leakage, electric shock	Do not plug several extension cables to a power strip. Install earth leakage breakers. Protect or install cords away from people's path to prevent tripping. Cords must be kept away from water and flammable substances.
High-pressure cylinder	Explosion, fire, suffocation	Install the gas cylinders in a fixed container stand. Use a pressure regulator properly. Install ventilation and fire prevention facilities. Do not use flammable gases near fire. Use soap to check for a gas leak from the piping.
Vacuum system	Injury, fire	Be careful about heat generation by the overload of an oil rotary pump or a turbo molecular pump. When exhausting combustible and toxic gases, pay particular attention to the exclusion device and ventilation.
Remodeling and relocation of a device	Injury	When remodeling or moving an experiment device, plan it well and handle it with several people if it is a heavy device, in order to prevent injuries. When hiring a professional handler to conduct these, prepare a risk-assessment list together in advance.

14.4 Risk Assessment Example: Physics/applied-physics students

Research subject: Radiation measurement experiment using large-scale radiation generator such as particle accelerators

Dangerous factor	Danger	Countermeasure
Accelerator facility	External radiation exposure, taking radioactive materials out to a non-controlled area	Do not turn off automatic indication or interlock of the accelerator operation. Always enter the room as a group, and always wear a personal dosimeter. Check the position of the accelerator's emergency stop button. Measure the air dose rate in the area near the beam line and the irradiation room after the operation by survey meters. Reduce the radiation-exposure dose by following the three principles of external radiation exposure protection: "distance, time, and shielding". When taking goods from the controlled area, check for contamination.
Sealed radioactive source for calibration of detector	External radiation exposure, contamination by damage, loss or theft	Reduce the radiation-exposure dose. During the operation, wear a personal dosimeter and measure the dose with a survey meter. Visually check for the preservation of air-leakage efficiency. After use, keep the sealed radioactive source in a storeroom to prevent loss or theft. Complete the logbook (including the date, your full name, and the source name).
Irradiation sample (or target)	External and internal radiation exposure, radioactive substance leak	As there might be radiation exposure caused by residual radioactivity after irradiation, measure the dose rate near the surface using survey meters and reduce the radiation-exposure dose. Wear gloves when treating the radioactive sample.
High-voltage apparatus	Death caused by electric shock, burn, fire	Do not approach high-voltage units (accelerator and ion sources) carelessly. Follow the instructions of the accelerator operator and do not operate it alone.
Crane operation	Injury, death, machine damage	Ask for help from a qualified staff member during crane operation when carrying objects heavier than 0.5 t. Do not load an object that exceeds the weight capacity of the crane. Do not operate the crane alone. Be sure that no one is under the crane load.
Wiring to the meters	Fire, electric leakage, electric shock	Do not plug several extension cables to a power strip. Protect or install cords away from people's path to prevent tripping. Cords must be kept away from water and flammable substances.
Vacuum pump system	Injury, fire	When the old-type oil rotary pump (rubber belt drive) is in operation, you must be careful that the rotating belt does not to catch your clothes. Wear appropriate clothes. Be aware of the opening/closing situation of the valves of the vacuum system when operating the vacuum pump. Be careful about heat caused by over-capacity driving of the pump: check the cooling operation (water/air cooling system).

14.5 Risk Assessment Example: Mechanical engineering students

Research subject: Experiments on flow and gas diffusion using a wind tunnel

Dangerous factor	Danger	Countermeasure
Wind tunnel	Injury, machine damage, fire	Strictly follow the operational procedures when starting the blower. Confirm that the rotating systems work regularly by checking the noise of the systems. Properly secure the objects in the wind tunnel
Automatic moving machines	Injury, machine damage	Be sure to turn off the power supply to the machine before entering the moving area of the machine.
Wiring to the meters	Fire, electric leakage, electric shock	Do not plug several extension cables to a power strip. Protect or install cords away from people's path to prevent tripping. Cords must be kept away from water and flammable substances.
Laser system	Lost eye-sight, burns by laser irradiation	Install a safe terminal of the laser path. You must not come into contact with the laser beam. Wear appropriate eye-protection glasses.
Tracer/gas	Explosion, machine damage, suffocation	Install the gas cylinders in a fixed container stand. Connect pipes securely. You must use the ventilation system when discharging the gas.
Crane operation	Injury, death, machine damage	Ask for help from a qualified staff member during crane operation when carrying objects heavier than 0.5 t. Do not load an object that exceeds the weight capacity of the crane. Do not operate the crane alone. Be sure that no one is under the crane load.
Machine tools	Injury	Understand well the following risk assessment for experiments using machine tools.

An example of the risk assessment of students using machine tools

Dangerous factor	Danger	Countermeasure
Lathe, drill press, milling machine	Injury	Properly secure the workpiece. Maintain an appropriate rotation speed. Prevent being caught in the machine. (Wear appropriate clothes, shoes, but not gloves) Wear protection glasses against flying objects.
Grinder, high-speed cutting machine	Injury, inhaling smoke and tiny particles	Visually inspect defects in the grindstone. Check the noise of the rotating machine. Properly secure the workpiece. Check the safety covers. Wear eye-protection glasses. Use the dust collector or wear masks. Installation of a ventilation system is recommended. A qualified person must change the grindstone.

14.6 Risk Assessment Example: Students conducting simulation research

Research subject: Numerical modeling on ocean tidal circulation

Dangerous factor	Danger	Countermeasure
Training ship	Falling into the sea	Wear life jacket. Do not go out onto the open deck of the ship at night, especially if you are drunk.
Extended PC use (VDT work)	Fatigued eyes, physical problems such as headache and stiffness (VDT syndrome)	Take a break at least once every hour during the work to rest your eyes.
Maintenance work on computers	Electric shock	Pull out the plug from the power socket. Also, be careful about the uninterruptible power supply (UPS) system.
Computer virus infection	Keep in mind that virus infection damages not only your own PC but others' as well.	Install virus-monitoring and detection software.
Illegal acquisition of a video file	Copyright violation	Do not install P2P file-sharing software.
Late and night-time departure from the university	Violence, robbery	For your safety, travel on safe streets and avoid dark tunnels. Leave your lab as early as possible, especially if you are a woman.
Participation in conferences held in a foreign country	Poor safety	Be careful about safety. Avoid going out in the evening or narrow streets as much as possible. Be particularly careful when you are alone.

14.7 Risk Assessment Example: Students conducting biological research

Dangerous factor	Danger	Countermeasure
Autoclave	Burns, Heating without water due to steam leak, etc.	Use waterproofed heat-resistant gloves. Do NOT use knit work gloves. Do NOT shake or mix solutions right after taking them out from an autoclave. Sterilize volatile chemicals with a filter.
Centrifuge	Injuries and equipment damage	Make sure of correct moment balance. Ensure no leakage of sample from the tubes. Do NOT open the lid during operation. Do NOT stop the rotor with hand(s).
Thermostatic chamber/Water bath	Electric leakage and heating without water	Do not splash water on the control unit. Especially check the water level, in cases of overnight run and unattended operation.
Dryer, Dry heat sterilizer	Fire and equipment damage	Do NOT place combustible (e.g., organic solvenets, combustible gas, plastic and paper) in the equipment. Pay an extra attention not to overfill samples in the containers.
Decompression operation	Injuries	Use pressure-resistant containers. Take measures against bumping.
Microwave oven	Burns	Use waterproofed heat-resistant gloves. Do NOT use knit work gloves. Take measures against bumping.
Ultraviolet lamp	Injuries	Wear safety glasses. Wear a face mask and/or other personal protective equipment in a case of working for long hours
Clean benches and safety cabinets	Fire and contamination	Be careful when handling a gas burner, an alcohol lamp, etc. Thoroughly sterilize with 70% ethanol, or the like. Roll up sleeves to the elbows.

Chapter 15 Examples of accidents

15.1 Electric shock

While a student was conducting an experiment using a thermal load device at about 8:00 pm on a weekday, a high-voltage breaker was shut down. When the student touched a high-voltage terminal of 20 kV with his finger while trying to recover the breaker, an electric current ran from the right hand to the left hand and he got a burn on the middle finger of the right hand and on the left palm. Another student who was collaborating on the experiment promptly contacted his supervisor and called for an ambulance, and the injured student was hospitalized and treated.

In order to check the high-voltage apparatus, it is necessary to carefully follow the cautions described in chapter 6 of this booklet.

15.2 Fire

A student burned his fingers on both hands by a fire during an experiment. He was studying the cooling characteristics of a thin metal wire by heating it with direct current and dropping it in a pool of ethanol.

The wire was heated in air to high temperature by a DC current. A DC power-supply connected to the thin metal wire was designed to automatically turn off immediately before the wire entered the pool with ethanol and then automatically turn on again 5 s after the wire was retrieved from the ethanol pool. However, this student mistakenly switched on the power supply and retrieved the wire from the ethanol, causing the ethanol on the heated wire to ignite. Subsequently, the drops of burning ethanol dropped into the ethanol pool and ignited it. Though the student tried to extinguish the fire immediately after ignition by closing the lid of the container, he was unsuccessful. He tried to move the container, but the ethanol was spilled out from the container, and all of the ethanol was ignited. Another student who was in the next room received an emergency call and used the fire extinguisher installed in the corridor to stop the fire.

When dealing with flammable solvents, it is necessary to carefully follow the cautions described in chapter 2 of this booklet.

15.3 Chemical injury caused by hydrofluoric acid

When a graduate student was washing a Si wafer in a draft chamber, a drop of concentrated hydrofluoric acid solution (46% hydrogen fluoride) remained on the tip of a Teflon pipette (total length approx. 380 mm) and fell directly on the instep of the student’s right foot. Because it was a small amount, the student ignored it. One hour later, the student realized that the area where the acid dropped had reddened, and he washed and cooled the burned part with running tap water. At the recommendation of the Campus Life/Health Support Center, he sought a treatment from a doctor. (Though the acidity of hydrofluoric acid is low, it has much stronger skin permeability than other halogen acids. Even though it irritates the skin less, it affects the bone and may cause systemic poisoning symptoms of calcium deficiency.)

15.4 Eye injury

When a student was injecting chloroform into the sample inlet of the GPC (gel permeation chromatographys) while holding the syringe with the left hand, the syringe containing chloroform splashed from below the left hand. The chloroform got into the eyes of the student, who was not wearing protective glasses.

15.5 Conducting experiments while wearing sandals

A student dropped hydrochloric acid (concentration of 35%) on his foot during a titration experiment and received a burn.

The student put the hydrochloric acid in small bottles to use for the experiment. He knocked over one of the bottles on the table, causing the acid to splash and some of it dropped on his foot. Though it would not have dropped directly on the student foot if he was wearing a pair of shoes, it was hot at the time and the student was wearing a pair of sandals, and thus, had some of his skin exposed.

15.6 Skin inflammation caused by liquid nitrogen

A student suffered frostbite when he went to get liquid nitrogen for an SEM observation.

Though he was wearing a towel or work gloves to prevent frostbite, he was not wearing leather gloves.

15.7 Conducting experiments when sleep-deprived

A student who has a late-night part-time job participated in an experiment on the day after his shift without enough sleep, and almost suffered burns because he fell asleep near a hot container. In addition, he almost injured his hand while using a sharp tool.

15.8 Exposure to short-wavelength ultraviolet rays

When an experimenter built an experiment device that integrated a low-pressure mercury lamp as a short-wavelength ultraviolet light source and conducted an experiment with it, he did not notice the leakage of ultraviolet light, was exposed to short-wavelength ultraviolet light (UV-C), suffered problems on his skin and eyes, and was treated by a doctor. This accident was caused because of the following reasons: (1) while a low-pressure mercury lamp generates strong ultraviolet light within the UV-C region, it does not produce such a strong light within the visible light region. Thus, it is difficult to recognize a leakage visually in a bright room. (2) The experimenter was not fully aware of the strong effect UV-C has on a living organism. (3) Ultraviolet light shielding check was not properly conducted when building the experiment device. A person conducting an experiment must acquire thorough knowledge of the experiment devices he/she is using before carrying out the experiment.

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