Safety Manual

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School of Engineering

Tohoku University

Chapter 1　Introduction

1.1. About Safety

Danger and Safety

There are many kinds of things in our daily life that could be considered dangerous. When we look around our apartments and houses, for example, we find knives, gas-ranges and microwave ovens in the kitchen. However, we do not have mishaps with knives usually because we are well aware of how to use them properly. We do not bring any fire hazards to gas ranges because we take care not to put flammable materials close to fire. We do not suffer gas poisoning when gas flame goes out during cooking because we turn off the main valve immediately or there is a device with a safety mechanism that shuts the gas off automatically. Though strong electromagnetic waves are used in microwave ovens, they do not cause any danger outside the oven because they are effectively shielded from an outside by metallic walls. Since the ovens can't recognize things put in, however, we have to understand which materials are inappropriate for microwave heating.

Principles and Rules

Let us consider safety from the perspective of the three examples described above. First, we have to consider the principles of these tools and appliances and their safety rules. In the case of the knife, we can easily figure out them. In the case of the gas range, a safety device which prevents gas poisoning is included in the range by engineers who understand the principles and safety rules and design it. The microwave oven is an apparatus in which foods are heated up as they absorb strong electromagnetic waves. A safety device is also included in them to keep these electromagnetic waves inside the oven. However, the understanding of the principles of how a microwave oven works only is not sufficient for appropriate usage of them. Unfortunately, there have been a number of accidents, and some of them resulted in disasters. Therefore, the basis of the framework for safety guidelines is indispensable for eliminating any disasters.

Safety Engineering

In order to study engineering and to be in a career as an engineer or a researcher, the knowledge of safety in engineering is essential to the elimination of any dangers and accidents. It is safety engineering that helps us in protecting both the public and the environment from risk. Even if each and every material is safe by itself, there is a

possibility of risk when they are mixed with each other. This is because a chemical reaction sometimes creates a new dangerous material. It is important, therefore, to learn both appropriate knowledge about all potential risks that cause the damage incurred in the case of an accident and the countermeasures for minimizing the concerned damages. Thus, when we take on new challenges, we should be careful for the anticipated risks. We should learn safety in engineering and assure the reliability of the technologies we will develop.

Safety is the First Priority

In the event of an accident, it may not just be ourselves who are damaged. In most cases others are also involved in the accident. In the worst case scenario, the damage causes environmental pollutions or takes our lives. Such accidents and disasters may terminate the research projects which give rise to them entirely. Therefore, safety management should be given top priority.

Make Accidents Public

When an accident occurs, do not conceal it. We should make them public immediately. The reason for the accident should be analyzed in detail. To prevent a similar accident from happening again, we should understand the chief factors that cause the accident and prepare the countermeasures for preventing similar accidents. Both undergraduate and graduate students should take safety education and training courses to ensure the followings:

(1) To protect themselves from danger.
(2) Not to harm others or the surrounding environment.
(3) To understand the principles and rules of things, and acquire basic knowledge of safety issues as they will be engaged in creating, using and spreading new technologies.

1.2 About the Safety Manual

Aim

Our aim is to make everyone involved in any research or educational activity in this campus have a profound understanding of the nature of dangerous materials, machines and equipment, and to acquire the necessary skills to have a safe time every day. Anticipated risks that might be encountered during research and education are

introduced in this manual. In addition, the important considerations necessary for carrying out research as safely as possible and minimizing the number of accidents are included in this manual. Furthermore, the appropriate countermeasures to deal with them in the early stages and thus, to minimize damages are also explained.

Scope

With this manual alone, it is impossible to cover all the instruments, equipment and hazardous materials that are dealt with in the research and education of different engineering fields. Thus, only the equipment and chemicals that need special care are described here. Note that there are other dangerous machines and chemicals that are not described in this manual. Also, there are materials that are potentially dangerous depending on how they are handled. Though there is a possibility that the direct cause of accidents and physical damage are degradation and defects of the safety device, most accidents occur due to a lack of expertise in safety, such as the mishandling of materials and poor judgment on the part of the experimentalist. It also should be borne in mind that restricted workspaces, unfit working environments, and inadequate safety education and training are also indirect causes of accidents. Therefore, expansion of the workspace, renewal of the equipment, repair of the safety device, improving the work environment, publishing a safety manual and thorough safety education and training are essential to the improvement of safety.

This manual is mainly intended for students in the Graduate School/Undergraduate School of Engineering, Graduate School of Science, Research Institutes, and Graduate School of Biomedical Engineering to allow them to safely carry out experiments while not being involved in hazards or accidents.

1.3 Indices (covering minimum-necessary issues for students to keep in mind)

This manual describes the minimum necessary information for students who relate to engineering equipment and hazardous substances used in an education and research site, disaster responses, emergency safety areas and so on. It is a matter of course to take a safety education program from supervisors and teachers before experiments. In addition, to settle your safety concerns, please carefully read the corresponding chapters of this manual that are related to you to improve understanding and expand knowledge on equipment safety, etc. The following are the indices that cover "minimum-necessary issues common to all students to keep in mind for their safety."

(1) Chapter 3 “Personal Accident Insurance for Students”

Be sure to take out the above insurance policy just in case.

(2) Chapter 14 “Natural Disasters” and Chapter 20 “Disaster Response in the Event of a Major Earthquake, Etc. ”

These chapters describe emergency responses in case of reoccurrence of a Miyagi Prefecture offshore earthquake that is predicted with a high possibility. Be sure to make yourself familiar with the “escape routes”, “emergency safety areas” and “emergency communications guideline.”

(3) Chapter 15 “Fire Extinguishing and Evacuation”

A fire broke out twice in the premises of the School of Engineering in 2007. This chapter refers to the prevention of the fire and response in the event of a fire since anyone may encounter a fire.

(4) Chapter 17 “First Aid”

When a friend of yours has an accident, etc. during the experiment or sports meeting, faculty/staff members and students shall provide first aid treatment until the ambulance comes to the accident site. How to provide the first aid treatment is illustrated.

(5) Chapter 18 “Emergency Communications Guideline in Case of Fire or Accident ”

The chapter notes guidelines on emergency response just in case when you suffer from or encounter an accident, emergency communications to the fire department, hospital and police office, and the directions to fill in the accident report.

Chapter 2 Safety Policy at the Graduate School/Undergraduate School of Engineering

*Hereafter Graduate School/Undergraduate School of Engineering are abbreviated as School of Engineering

2.1 Categories of Accidents and their Causes

2.1.1 Categories of accidents

In safety engineering, safety-related events are classified by the viewpoints of accidents and damage. An accident is a happening that can not be foreseen or intended and people suffer from injury or death and/or facilities are broken or destroyed due to failures of machines or the actions by individuals. The extent of accidents is generally measured by the extent of the damage incurred. The damage is measured by not only the cost of repair of the machines and loss of property but also the long-term effect on the environment and people at the site of the accident. Accidents can be categorized into two types, i.e., physical or material accidents and human accidents. Physical or material accidents include, for example, the collapse of structures, explosions, leaks of dangerous or harmful substances, fire, electrical leakage, etc., and can sometimes be caused by out-dated machines. On the other hand, typical human accidents are falling, collisions, pressure, electric shocks, radiation exposure, intoxication, suffocation, etc., and they tend to be caused by human error. Human accidents are often triggered by physical or material accidents, but are more likely to be caused by carelessness or ignorance of safety procedures.

2.1.2 Causes of accidents

There are indirect and direct causes of accidents. A direct cause implies that a cause leads to an accident without having any intervening agents, conditions, and so on. In human accidents, it damages the human body directly. Typical direct causes are as follows: deterioration of facilities/equipment, inappropriate safety equipment, immature skill and human error. The relationship between these direct causes and the resulting damage is so clear that it is usually easy to find who or what was responsible for the accident. On the other hand, typical indirect causes such as inadequate workspace, the lack of safety equipment, an inexpedient work environment and half-hearted or inadequate safety education are usually unclear. Since indirect causes are outside the cause-effect relationship, the issue of responsibility for the accident hardly emerges even though the indirect cause is very predominant.

In laboratories, students must be very careful not to get too close to equipment when

they are exposed to moving parts, and must follow instructions carefully when using chemicals because poisons might be involved. Also students must wear appropriate guard tools and clothing to prevent it, for example, from getting caught up in machines.

In general, since it is all but impossible to predict all the accidents, students must always keep in mind emergency measures including the emergency communications guideline and escape routes, and be prepared to take emergency actions just in case of an accident. (For fire, an accident and a theft, refer to the emergency contact information given in Chapter 18).

2.2 Prevention of Accidents

2.2.1 Causes

An inadequate environment on campus may be considered one of the causes of accidents, but, at the same time, most accidents are caused by human error in the form of improper procedure and carelessness, especially when handling instruments or materials for the very first time. It is required not only for students but also for staff and faculty members to make an effort to ensure safety preferentially.

Students, staff and faculty members must exercise common sense when it comes to safety. It is clear that human error is closely related to exhaustion, which significantly compromises not just our movement but also our ability to make good judgments and decisions. Students must avoid spending all night carrying out experiments. “The Heinrich law” is often referred to in the field of safety control. It states that a stochastic approach is necessary in safety control, and that the worst possible scenario must always be considered as a real possibility.

2.2.2 Prevention and countermeasures for accidents

(1) To prevent accidents

It is well known that carelessness often leads to serious accidents. Exhaustion and lack of sleep make it easy to become distracted, and even skilled people are capable of operating equipment in a dangerous manner when they are tired. Unless we are alert and cautious, accidents can easily occur. For example, when a student uses glass instruments without important information of chemical characteristics of materials in them, an unexpected chemical reaction could result in an explosion that could cause serious injuries and even blindness from flying pieces of broken glasses. Everyone should be well aware of the potential risks posed by every kind of material,

instrument and machine they encounter. In the School of Engineering, all the staffs in every department are directed to have an experimental procedure manual for experimental equipment and all the experiments must be carried out according to the manual. It is especially important to read and understand the experimental procedure before working with materials, instruments or machines, especially those unfamiliar to you.

Experiments can be carried out safely so long as you sufficiently understand the characteristics of the materials and machines you are going to handle and adequately make preparations including wearing safety gear.

(2) In the event of an accidents

Some toxic chemicals can cause injures to a part of the body they come into contact with, and others can cause serious problems or even death if they are inhaled or absorbed. These chemicals have to be kept in a safe place and treated with the utmost care. Chemical accidents must be dealt with promptly and the appropriate faculty should be notified. A system should be established to be ready to counter potential accidents that may lead to physical damage. It is important to improve safety in each department by routinely conducting safety inspection patrols, safety checks, safety education and training in addition to keeping inspection/check reports and making recommendations if necessary.

Accidents can be mitigated by lowering the risk of danger and by responding promptly and appropriately. In the School of Engineering, there are experimental procedures that students are required to comply with in order to maintain safety. Tohoku University is committed to keeping the study and research environment safe for everyone.

(3) Maintaining safety

The School of Engineering has various safety rules and maintains strict safety management. All the departments are required to conduct safety inspections of facilities and equipment, and to provide students, staff and faculty members with safety education and fire prevention training. Each department should observe the university's formal rules, including the Tohoku University Safety and Health Management Rules. Although these rules refer to staff and faculty, Tohoku University extends the same rights of safety and protection to students. Therefore, students are asked to keep healthy and safe by following the rules laid out in this document.

Staff and faculty members are required to review this manual and the Safety and Health Rules released at the website of the university so that they can improve their safety concerns not only in routine practice but also in emergency cases.

※The following are major rules relating to safety and health, and disaster prevention throughout Tohoku University and at the School of Engineering:

Ⅰ Safety and Health Management Rules
Ⅱ Aobayama Area Disaster Prevention Practices Work Rules
Ⅲ Safety Management Rules for DNA Recombination
Ⅳ Rules Concerning the Prevention from Radiation Hazards due to Radioisotopes
Ⅴ Rules Concerning the Handling of Wastes
Ⅵ Fine Points for Poisonous and Deleterious Substances Control
Ⅶ Electrical Facilities Safety Rules

Chapter 19 of this manual explains safety and health management for students and laboratories in detail.

2.3 Ensuring Safety in the Graduate School of Engineering

In July 2003, the School of Engineering founded a Health and Safety Management Office that deals with the planning of management, education, and training on safety and health, and disaster prevention. Subsequently, a Safety and Health Committee was launched in April 2004 to discuss safety and health issues for students and employees at the School of Engineering. The committee consists of professors representing each department of the School of Engineering, Graduate School of Environmental Studies, and the New Industry Creation Hatchery Center in addition to qualified technical staff members. The committee periodically revises and improves the safety education and safety management programs to prevent students and university employees from encountering accidents at the school and traffic accidents during commuting.

It also publishes a safety manual and reviews the disaster prevention practices in case of major earthquakes. The work of the committee is being realized in safety education for freshmen. Each department is also conducting concrete actions such as safety education and training, safety inspection and evaluation, as well as establishing a safety and health committee.

Chapter 3　Personal Accident Insurance for Students Pursuing Education and Research

3.1 What is Personal Accident Insurance for Students?

Even if you are being careful in preventing accidents in everyday laboratory activities, unexpected accidents do happen. The Personal Accident Insurance for Students Pursuing Education and Research (Gakusei Kyouiku Kenkyu Saigai Shougai Hoken) is a nation-wide insurance designed to cover such kinds of accidents that occur during school activities. This targets all students (including international students) studying in universities and junior colleges in Japan.

When you have inquiries about the insurance or want to take it out, please contact the Student Support Section at the Education and Student Support Department (Tel: 795-7766), or access the Japan Educational Exchanges and Services website (http://www.jees.or.jp/gakkensai/index.htm).

3.2 Accidents Covered by the Insurance

Students are insured for physical injuries and/or damage in the following cases:

1) During classes
Accidents that occur during lectures, experiments in the laboratory, laboratory training and related activities.

2) During school events
Accidents that occur during entrance ceremonies, orientation, graduation ceremony and other school sponsored events.

3) Inside the school facilities
Accidents that occur while inside the facilities owned by the school for educational purposes.

4) During official field activities outside the school facilities
Accidents that occur during cultural activities and sports events under the control of an internal university student group. The group should have been authorized by the university (excluding when a dangerous sport is being played).
This insurance does not cover cases where students unintentionally injure someone or damage someone's property at the site of the internship in which they are participating or the like cases. To be insured in such cases, please take out the "Compensation Insurance Plan (Gakkensai Futai Baishou Sekinin Hoken) as an additional plan. If you want to take it out, please contact the Student Support Section at the Education and Student Support Department (Tel: 795-7766).

5) While commuting
While commuting between a residence and school facilities.

6) Transit between school facilities, etc.
During transit between school facilities, and while moving between places to attend off-campus classes, school events and extra-curricular activities.

※Cases not eligible for insurance

Insurance does not cover injuries/damage deemed to have resulted from the following: malintent, fighting, crime, illness, earthquake, volcanic eruption, tsunami, riots, radiation exposure, driving without a license or under the influence of alcohol, and dangerous, extra-curriculer sports activities outside of school facilities. Accidents that are not considered to have occurred suddenly, haphazardly or caused by extrinsic reasons, such as acute alcoholism, are not covered by insurance either.

3.3 Examples of Incidents covered by Insurance

1) During classes
- During a chemical experiment, a flask exploded and pieces of glass got into the students right eye (insurance pay-out 200,000 yen).
- During gym class, a student damaged a joint ligament in his left leg after taking off for a long jump and sustained a partial fracture (insurance pay-out 320,000 yen).
- During a geological field study, a student fell off a 20 m-high rocky cliff. He cracked his skull and died (insurance pay-out 20,000,000 yen).

2) During school events
- While cooking at a food stand at a school festival, a kettle on the stovetop fell and burned a student's leg (insurance pay-out 242,000 yen).

3) Inside school facilities
- A student fell down the stairs and damaged a ligament in his right leg during a break (insurance pay-out 30,000 yen).
- During soccer team practice, a student collided with the goalkeeper and ruptured his spleen. He required a splenectomy (insurance pay-out 5,100,000 yen).

4) During official field activities outside of the school facilities
- While on a ski camp, a student fell and broke his left wrist (insurance pay-out 50,000 yen).
- During a rugby football game at the opponent team's stadium, a student was paralyzed after injuries sustained in a tackle (insurance pay-out 15,000,000 yen).

3.4 Who should be insured?

All students in Tohoku University are required to take out the Personal Accident Insurance for students Pursuing Education and Research when they start their courses. However, there are some students reluctant to take out this insurance. If you stay longer in school because of taking a year off from the university or repeating a year, you need to renew the insurance policy because the contract will end before graduation. It is also necessary to renew the contract when you enter graduate school. Since any mishap that occurs while participating in laboratory research or in extra-curricula activities without insurance may cost the students tremendously, they must make sure that they are insured. If students are involved in an accident and are not insured, they face the possibility of having to pay expensive hospital fees that would otherwise be covered by insurance. Therefore, students must not study or do research without being insured.

3.5 Insurance Process for Accidents

Accident ⇒ – Report to the Student Support Section at the Education and Student Support Dept.
-Treatment at the Tohoku University hospital or emergency room (after hours)

⇓

Treatment

⇓

After treatment

Claim (fill in the document)
- Get the required proof and fill in the claim form
- Doctor's certificate (or treatment status report)

⇓

Processed by the insurance company

⇓

Payment

3.6 Q & A: Insurance Coverage for Field activities Outside School Facilities

Q1. When students attend an academic meeting, is a "trip schedule form" considered sufficient for the official document? Do we need to submit another form besides the "trip schedule form" to be insured?

A1. A "trip schedule form" is sufficient as proof by the school when making an insurance claim. You do not need to submit any other documents.

Q2. Is Kawatabi Seminar Center considered a school facility for training?

A2. Yes. It is a university facility.

Q3. If there are special clauses for coverage against injuries while commuting to school or in transit between school facilities (Tsuugakucyu Shougai Kiken Tanpo Tokuyaku) as an additional premium, am I insured while commuting to Kawatabi Seminar Center?

A3. Yes. Tohoku University has Personal Accident Insurance for Students Pursuing Education and Research that includes special clauses for coverage against injuries while commuting to/from school or in transit between school facilities

Q4. When students carry out questionnaire surveys or land surveys in Sendai in order to get data for graduation or a master's thesis, are they insured if they report that activity to the school?

A4. In such cases, the questionnaire and land surveys are considered to be curricular activities. However, the students need to report that activity in advance since it is not in the University's regulated facility. Even if an instructor is not with them, the students are insured if they submit an official report to the school. The following items need to be included in the report (There is no official form for this report).
1) date of submission, 2) authorized instructor's name and stamp (sign), 3) objective, 4) schedule, 5) where, 6) transportation, 7) attending students' and instructor's names, and 8) all students' ID numbers and names and the instructor's name

Q5. When an instructor, who has submitted the "Trip Schedule Form" to the University, takes students to a field-study at a construction site in Tokyo or Osaka, which part of the trip is insured? The following are examples:

1) home - JR - meeting place - bus - site - hotel – another site - home
2) home – hotel – conference site – hotel - home

A5. In the case of example 1), visiting the site is the objective of the trip. Therefore, the meeting place is considered to be the part of the field trip and insurance covers the whole trip.
In the case of example 2), the hotel is not the final destination. Insurance covers the round trip between the hotel and the conference site, but not from home to the hotel. However, students will be insured if they go to the conference site directly from home, since it's the final destination.

Chapter 4　Dangerous Materials

4.1 Introduction

Many kinds of materials and chemicals are now used in laboratories along with technological progress, research and development of new materials and expansion of interdisciplinary research. These materials pose potential accident risks when they are used improperly. This chapter describes some basic rules for handling dangerous materials that have potential risks of causing fire or explosions.

General cautions before starting the experiment:

1. When using materials you are not accustomed to handling, be sure to carefully check their dangerous and toxic natures, ignition point, flash point, explosion range, extinguishing method (especially for substances that react violently with water) using the Material Safety Data Sheets (MSDS), data books, handbooks (see references listed at the end of the chapter) and other.
2. Review the appropriate responses to all possible situations and prepare sufficiently for the various types of accidents that may occur.
3. Create/confirm the experimental procedure and review the potential dangers which can occur due to the reaction heat and heat from mixing. Simulate what will happen in advance.
4. Share your knowledge about the dangerous or toxic nature of substances, which you are going to handle (or you are now handling), with others in the laboratory.
5. Keep in mind that you have full responsibility for the handling of the substances from obtaining, storing, using to disposal.

4.2 Dangerous Substances

4.2.1 General cautions

Dangerous substances are classified into 6 groups with similar characteristics as listed in Table 4-1, and the amount in storage is respectively limited. Dangerous substances in quantities beyond the above limitations have to be stored in a specific storeroom according to law. If you have an amount beyond 20% of the specified limitation for certain dangerous materials and an amount above the specified limitation for flammable solids, and if you keep statutorily stipulated dangerous substances, the fire department needs to be informed of the details (refer to the Sendai City regulation for fire prevention). To protect yourself, you should not keep quantities of these materials in excess of the limitations.

Some general cautions to be observed for dangerous chemicals when handling them in the laboratory:

1. Check the ignition point, flash point and the explosion range of all dangerous substances.
2. Confirm the location of fire extinguishers.
3. Do not experiment alone. Let others know about the content of your experiment.
4. Make a record of chemicals by entering the data of the procurement date/amount and the used /amount into the management system for lab chemicals.
5. Be sure to wear the safety gear such as eye protection, gloves, etc.

Table 4-1　Classification of dangerous substances under the Fire Laws

group	nature	product name	nature	example	specified quantity
1	oxidizing solids	1 chlorates		potassium permanganate	
		2 perchlorates	first-class oxidizing solids	sodium perchlorate	50kg
		3 inorganic peroxides		sodium perchlorate	
		4 chlorites		sodium chlorate	
		5 bromates	second-class oxidizing solids		300kg
		6 nitrates			
		7 iodates			
		8 permanganates	third-class oxidizing solids		1,000kg
		9 bichromates			
		10 the other materials designated by a government ordinance			
		11 materials which include the materials listed above in group 1			
2	combustible solids	1 phosphorus sulfide			100kg
		2 red phosphorus			100kg
		3 sulfur			100kg
		4 iron powder			500kg
		5 metal powders	first-class combustible solids		100kg
		6 mangesium			
		7 the other materials designated by a government ordinance			500kg
		8 materials which include the materials listed above in group 2	second-class combustible solids		
		9 flamable solids			100kg
3	pyrophonic materials and those which react violently with water	1 potassium			10kg
		2 sodium			10kg
		3 alkyl aluminum			10kg
		4 alkyl lithium		pyrophoric materials and water-forbidden materials	10kg
		5 yellow phosphorus			20kg
		6 alkali metals (excluding potassium and sodium) and alkaline-earth metals	first-class pyrophoric and water-forbidden materials	triethylboranelithium (powder, 30%)	10kg
		7 organometallic compounds (excluding alkyl aluminum and alkyl lithium)		calcium, sodium hydroxide	50kg
		8 metal hydrides	second-class pyrophoric and water-forbidden materials	diethylezinc, triethylaluminium(purity12%)	
		9 metal phosphides		barium, lithium(massive)	
		10 calcium carbides and aluminum carbides		diethylaluminumchloride	
		11 the other materials designated by a government ordinance	third-class pyrophoric and water-forbidden materials	sodium borohydride	300kg
		12 materials which include the materials listed above in group 3			
4	flammable liquids	1 special flammable materials		diethyl ether, carbon disulfide, pentane	50L
		2 first-class oils	water-insoluble liquids	acrylonitrile, gasoline, benzene	200L
			water-soluble liquids	acetone, pyridine	400L
		3 alcohols		ethanol, methanol, propyl alchol	400L
		4 second-class oils	water-insoluble liquids	kerosene, light oil, xylene	1,000L
			water-soluble liquids	acrylic acid, formic acid, acetic acid	2,000L
		5 third-class oils	water-insoluble liquids	heavy oil, creosote, aniline	2,000L
			water-soluble liquids	ethylene glycol, glycerin	4,000L
		6 fourth-class oils		gear oil, cylinder oil	6,000L
		7 animal and vegetable oils		olive oil, soy oil, ricinus	10,000L
5	self-reactive materials	1 organic peroides	first-class self-reactive materials	sodium azide	10kg
		2 nitric esters		barium azide	
		3 nitro compounds		diisopropyl peroxidicarbonate(95%)	
		4 nitroso compounds		benzoyl peroxide	
		5 azo compounds			
		6 diazo-compounds			
		7 hydrazinederivatives	second-class self-reactive materials	cumenhydroperoxide	100kg
		8 hydroxylamine		succinic acid peroxide	
		9 hydroxylamines		di-α-cumyl peroxide	
		10 the other materials designated by a government ordinance		picric acid	
		11 materials which include the materials listed above in group 5		benzoyl peroxide(51%)	
6	oxidized liquids	1 perchloric acid		hydrogen peroxide(50%)	300kg
		2 hydrogen peroxide		pentalfluoroiodide	
		3 nitric acid			
		4 the other materials designated by a government ordinance			
		5 materials which include the materials listed above in group 6			

4.2.2 Pyrophoric substances (Group 3)

White phosphorus, organic lithium, organic aluminium, reduction metal catalyst (Pt, Pd, Ni), silane are examples of substances that spontaneously ignite simply by coming into contact with air. Many substances of this type also ignite when coming into contact with water.

(Handling)

Use in a dry box purged by inert gases (nitrogen and argon) to prevent contact with air. Although caution in handling is indicated on the container for special active compounds (raney nickel, reduced palladium, etc.), use them under the guidance of a staff/faculty member who is accustomed to handling them.

(Extinguishing the fire)

Use dry sand or a powder fire extinguisher.

4.2.3 Water-prohibiting substances (Group 3)

When water-prohibiting materials come into contact with water, they ignite and combustible or noxious gas is generated. Metallic sodium, potassium, calcium carbide, calcium phosphide (poisonous gas generation), organic lithium and metal hydride are included in this group.

(Handling)

All care should be taken to ensure they do not come into contact with water or skin directly. The humidity in the inventory location needs to be noted.

(Extinguishing the fire)

Cover with dry sand or use the powder fire extinguisher. Never use water. Also, be careful not to use the carbon dioxide fire extinguisher, which is an aqueous extinguishing agent which forms bubbles.

4.2.4 Flammable liquids (Group 4)

Many organic solvents are dangerous substances since they are highly flammable. They are categorized as follows according to their flammability.

Table 4-2 Classification of flammable liquids

Special flammable materials	Diethyl ether, carbon disulfide and others with an ignition point of 100°C or lower in one atmospheric pressure, and substances with a flash point of -20°C or lower and a boiling point of 40°C or lower in one atmospheric pressure.
First-class oils	Acetone, gasoline and others with a flash point lower than 21°C in one atmospheric pressure.

Alcohols	Saturated monohydric alcohol (denatured alcohol is included) with one to three carbon atoms in one molecule. Composition is taken into consideration, and some are defined by the statute to be excluded.
Second-class oils	Kerosene, diesel oil and others with a flash point equal to or higher than 21°C and lower than 70°C in one atmospheric pressure. Composition is taken into consideration, and some are defined by the statute to be excluded.
Third-class oils	Heavy oil, creosote oil and others with a flash point equal to or higher than 70°C and lower than 200°C in one atmospheric pressure. Composition is taken into consideration, and some paints and other materials are defined by the statute to be excluded.
Fourth-class oils	Gear oil, cylinder oil and others with a flash point equal to or higher than 200°C and lower than 250°C in one atmospheric pressure. Composition is taken into consideration, and some paints and other materials are defined by the statute to be excluded.
Animal and vegetable oils	Oils extracted from the fat or meat of an animal, the seed or flesh of vegetables, with a flash point lower than 250°C in one atmospheric pressure.

(Handling)

1. Because special flammable materials such as ether (-45°C in flash point) and carbon disulfide (CS_2) (-30°C in flash point) ignite to a pilot-light and electric sparks even at a distance, the use of fire is strictly prohibited. Hexanes, acetone, and benzenes are first-class oils. When heating and distilling them, careful attention must be paid to prevent them from igniting. Although alcohol can be usually handled safely as long as there is no naked flame in the vicinity, pay attention when heating and distilling it.
2. Normally, you should handle as little liquid as possible, and not bring more into the room than necessary. Make sure the laboratory is well ventilated. In general, it is often the case that organic solvents with a low boiling point have a low flash point. Check the boiling point and the flash point of the solvent being handled.

(Protect yourself)

When using large amounts, wear a protective mask and gloves made of cotton.

(Extinguishing the fire)

Do not panic in the event of a small fire. Use a carbon dioxide fire extinguisher or a powder

fire extinguisher to put it out. If the fire keeps growing, it is advisable that you drench the fire with a large amount of water.

4.2.5 Self-reactive substances (Group 5, explosives)

Substances that explode or ignite by heat, impact, friction or light irradiation, for example. Examples of self-reactive substances are benzoyl peroxides, nitrate esters, nitro and nitroso compounds, azo and diazo compounds, hydrazine derivatives, and metal azides. Substances such as perchloric compounds that have many oxygen atoms in their molecular structures are especially dangerous, though they are not classified into Group 5. Especially, heavy metal perchlorates such as silver perchlorate are extremely sensitive explosives. Even a small amount of silver perchlorate can explode violently.

(Handling)

1. Minimize usage of self-reactive substances.
2. Keep away from naked flames, sparks, fire and heat. Store in a cool area. Protect from heat and impact.
3. Do not use metal spatulas or spoons. Do not use glass stoppers to cap containers.
4. Avoid storing peroxide-forming chemicals in oxidizing conditions or mixing them with strong acids (i.e., nitric acid) for long periods. It is dangerous to store a mixture of alcohol, hydrogen peroxide, especially at high concentrations (This mixture is often used for washing experimental apparatus).

(Extinguishing the fire)

When a small amount of self-reactive substance catches fire, it can usually be extinguished fairly easily. However, it might be impossible if there is a large amount of chemicals present. Extinguish the fire with a large amount of water or foam extinguishers. Evacuate as soon as possible if you feel there is an explosion hazard. Individual safety is the most important consideration.

4.2.6 Oxidizers (Groups 1 and 6)

Oxidizers can react violently when they come into contact with flammable chemicals, reducing agents, or metal powder (see also 4.2.7).

Oxidizing solids: chlorates, perchlorates, permanganates, inorganic peroxides, etc.
Oxidizing liquids: hydrogen peroxide, perchloric acid, fuming nitric acid, etc.
Oxidizing gases: ozone, fluorine, chlorine, etc.

(Handling)

1. Avoid direct sunlight, heating, and all forms of impact.
2. Avoid mixing oxidizing agents with other chemicals. Be especially careful with organic compounds and strong acid agents.

3. Oxidizers can react violently when they come into contact with water, and they readily release oxygen and heat. Therefore, carefully plan all procedures for working with oxidizing agents.

(Extinguishing the fire)

Water is generally used to extinguish fires involving oxidizers. The principle is that large amounts of water cool down the reaction. Dry sand should be used in case of inorganic peroxides such as potassium peroxide and calcium peroxide.

Table 4-3 Chemical bonds which lead to explosion easily

N-O		N-M	
-O-NO_2	nitrate esters	N-M_3	metallic nitrides
-NO_2	nitro compounds	M-NH	metal-imidos
>N-NO_2	nitramines	M-NH_2	metal-amides
N-HNO_3	amine nitrates	O-O	
-NO	nitroso compounds	-OO-H	hydroperoxide
-ONC	fulminates	-OO-	peroxide
N-N		CO-OO-H	peroxy acid
-N≡ N+	diazonium salts	-O_3	ozonides
-N=N-C≡N	diazocyanides	O-X	
(-N=N_2-S	diazosulfides	N-$HClO_4$	amine perchlorates
-N_3	azides	-$OClO_3$	perchlorate esters
		N-HClO	chloric acid amides
		C-$OClO_2$	chloric acid esters
		-ClO_2	chlorites

4. 2. 7 Incompatible combinations of chemicals

When some chemicals are combined, there is a risk of fire explosions, or poisonous gases being produced. A great number of combinations are known to involve the risk of various hazards.

In general, the following combinations are highly dangerous.

1. Mixtures of oxidizers and reducers:
   - Typical oxidizers: nitric acid, concentrated sulfuric acid, perchlorates, hypochlorites permanganates, bichromates, oxygen, and chlorine.
   - Typical reducers: amine derivatives, various alcohols, sulfur, phosphorous, hydrocarbons (organic chemicals), metal powders.
2. Mixtures of oxidizing salts and strong acids: e.g. combinations of strong acids (nitric or sulfuric acid) and perchlorates, chlorates or permanganates
3. Mixtures producing unstable chemicals: e.g. combinations of ammonia and iodine,

ammonia and silver nitrate, metallic sodium and chloroform (carbon tetrachloride), silver or copper salts and acetylene.

The above does not cover all dangerous combinations. There are many other incompatible chemicals.

(Handling)

1. Reference 4 “Handbook of Incompatible Chemicals” shown at the end of this chapter describes cautions regarding mixing and contact between various compounds. Typical reactions involving large amounts of heat of reaction, fire and explosive hazards are detailed. Please refer to this handbook before carrying out a procedure with the potential risk of an accident when trying to dissolve or mix unfamiliar chemicals.
2. It is essential that you observe the exothermic heats of mixing small amounts of chemicals as a trial. Once you have made sure your procedure is safe, the amounts can be increased, but very gradually.
3. Be aware that not only special exothermic mixing reactions but also general neutralization and dissolution can cause a relatively large heat evolution well beyond what you might expect.
4. Be especially careful of the hazards when you use such chemicals you do not use often.

4. 2. 8 Safe storage of chemicals

Fundamental cautions for the handling of chemicals are provided in the former section. In general, accidents do not simply “happen”, but are caused by a combination of rare mistakes and carelessness. It is required to take measures to protect accidents. The fail-safe concept is effective as a precaution although rigidly adhering to it is not always easy. In the laboratories where chemicals are stored, keep the following cautions:

1. During your experiment, put chemicals into small bottles or containers of the minimum size necessary, and use them on the testing bench or in the draft chamber, when necessary. On the testing bench, put the bottles on trays or the like that are compartmentalized by plastic plates to avoid tumbles and spills. Large bottles must be placed on the floor. (The spillage of organic chemicals from large bottles has been reported to result in fire disasters.) Also, put trays under bottles to avoid tumbling and spills on the floor as well.
2. In the storage cabinet, do not put incompatible chemicals close to each other, and make sure they are well partitioned, and that anti-earthquake procedures are observed. Strictly control the purchase and storage amounts of chemicals. Note that steel cabinets with sufficient partitions are available commercially (brand name: Lab-Cabinet). They are not cheap, but safety is a higher priority than the costs involved.
3. Make your experimental procedure known to others. Indicate on the plate the names of chemicals and put the plate close to them to attract the attention of others if you are carrying out a long heat treatment for distillation, reflux, etc.

4. Avoid the usage of old chemicals, and ask the Environment Conservation Research Institute (ECRI) for treatment.
5. Do not hesitate to ask when you have questions, or if there is something you are unclear about. (Newcomers to laboratories are strongly advised to do this.)
6. Emergency response procedures should be coordinated and uniformly announced to all students, staff and faculty in the laboratory. Emergency response drills are strongly recommended. Be sure to check where the fire extinguishers and sand bags are. Note that CO_2 accumulator-type extinguishers (reusable) can be used for small outbreaks of fire.
7. Do not allow the use of naked flames for heating laboratory rooms.

Table 4-4 Inorganic compounds which are dangerous when mixed

Main component	Sub component
Oxygen	Combustibles (especially H_2, oil)
Ammonia	Ag, halogen, $Ca(ClO)_2$
Halogen	NH_3, $CH \equiv CH$, olefin, petroleum gas, turpentine oil, C_6H_6, metal powder
Inorganic oxidizer	Reducing materials (ammonium salt, acid, metal powder, combustible organic matter, S, Bi(including its alloys))
Alkaline and alkaline-earth metals	H_2O, CO, CO_2, CCl_4, hydrocarbon halide, heavy metal chloride)
Metals (Cu, Ag, Hg))	$CH \equiv CH$, oxalic acid, tartaric acid, fumaric acid, ammonium compound, H_2O_2, fulminic acid
Ammonium nitrate	ROH, $RCOR^1$, HCN, CS_2, combustibles

Table 4-5 Organic compounds which are dangerous when mixed

Main component	Sub component
Acetylene	Cl_2, Br_2, F_3, Ag, Cu, Hg
Acetone	Mixed acid (HNO_3, $+H_2SO_4$)
Aniline	HNO_3, H_2O_2
Acetic acid	HNO_3, chromic acid, permanganate, peroxide
Oxalic acid	Ag, Hg
Hydrocarbon	Halogen, chromic acid, peroxide
Nitroparaffin	Chlorine, amine
Nitrobenzene	KOH
Hydrazine	H_2O_2, HNO_3, oxidizer
Acetic anhydride	Compounds with OH (ethylene glycol), perchloric acid, bromine
Organic peroxide	Organic acid, inorganic acid, amine

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5) “Safety Guideline of Chemical Experiment”, CSJ, Maruzen
6) “For Safe Experiments”, Kagakudojin editorial office, Kagakudojin
7) L Bretherick, “Handbook of Reactive Chemical Hazards 4th ed,” Butterworth, (1990); “Handbook of Dangerous Materials”, Maruzen, (1987)
8) “Dangerous Waste – Origination, Handling, Disposal”, Toray Research Center (1990)
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10) “Physics and Chemistry Dictionary”, Iwanami Shoten

Chapter 5　Hazardous Substances

5.1 General Cautions

All substances used in experiments are considered hazardous to some extent. In most cases, the amounts used are too small to pose any real harm unless they are taken internally. However, you must be very careful when handling toxic substances and highly volatile poisonous substances. It is of the utmost importance that you take the time to collect information on the toxicity of the substances you intend to use before using them.

5.2 Toxic Substances

5.2.1 Poisonous substances and deleterious substances

Poisonous substances and deleterious substances are defined as having dose LD_{50} (a lethal dose per 1 kg weight to kill half of the tested population) that kills 50% of the test animals (Table 5-1). Chemical substances with a lethal dose of 1.8 g or less are considered poisonous substances, and chemical substances with a lethal dose of 18 g or less are deleterious substances for adults (average weight 60 kg). This is as defined in the "Poisonous and Deleterious Substances Control Law" Article 2 (Table 5-2).

Table 5-1 Criteria for poisonous and deleterious substances

	Oral LD_{50}	Transderma LD_{50}	Inhalation LC_{50}		
			Gas	Vapor	Dust, mist
Poisonous substances	≦30 mg/kg	≦100 mg/kg	≦500 ppm (4hr)	≦2.0 mg/L (4hr)	≦0.5 mg/L (4hr)
Deleterious substances	30 mg/kg< and ≦300mg/kg	100 mg/kg< and ≦1,000 mg/kg	500 ppm (4hr) < and ≦2,500 ppm (4hr)	2.0 mg/L (4hr) < and ≦10 mg/L (4hr)	0.5 mg/L (4hr) < and ≦1.0 mg/L (4hr)

Table 5-2 Designated substances by the Poisonous and Deleterious Substances Control Law

No.	Classification	Definition (Poisonous and Deleterious Substances Control Law Article 2)	Main designated substances
1	Poisonous substances	Substances noted in Attached Table 1 except drugs and unregulated drugs; designated by items 1-28.	Hydrogen cyanide, sodium cyanide, mercury, selenium, nicotine, arsenic, hydrogen fluoride, etc.

2	Deleterious substances	Substances noted in Attached Table 2 except drugs and unregulated drugs; designated by items 1-94.	Ammonia, hydrogen chloride, hydrogen peroxide, sodium peroxide, potassium, cresol, chloroform, carbon tetrachloride, dichromic acid, oxalic acid, nitric acid, sodium hydroxide, picric acid, phenol, methanol, sulfuric acid, etc.
3	Specified poisonous substances	Poisonous substances noted in Attached Table 3; designated by items 1-10.	Octamethyl pyrophosphoramide, tetraalkyllead, etc.

Table 5-3 describes the classification according to the toxic effects by poisonous and deleterious substances

Table 5-3 Classification of toxic substances according to the effect

Effect	Typical examples
Dermal lesion	Skin cornification: arsenic, cobalt, dilute alkali solutions, etc. Skin coloration: picric acid, silver nitrate, iodine, etc. Pigment anomaly: tar, pitch, arsenic, etc. Acute dermatitis and rash: acid, alkali, chloro dinitrobenzene, formalin, tar, pitch, etc. Ulcers: chromium, nickel, acid, alkali, etc. Lesion of hair and sebaceous gland: mineral oil, tar, chloro naphthalene, etc. Hair lesion: thallium, manganese, etc. Lesion of nail and the surrounding skin: selenium, thallium, fluorine, etc.
Mucosa defects	Mainly affecting upper respiratory tract: aldehyde, alkalinity dust and mist, ammonia, chromic acid, ethylene oxide, hydrogen chloride, hydrogen fluoride, sulfur dioxide gas, sulfuric anhydride, etc. Affecting upper respiratory tract and pulmonary tissue: bromine, chlorine, chlorine oxide, cyanogen bromide, dimethyl sulfate, fluorine, iodine, etc. Affecting peripheral airways lower thoracic esophagus and pulmonary alveoli: arsenic trichloride, nitrogen peroxide, phosgene, etc.
Asphyxiation	Simple asphyxiation: carbon dioxide, ethane, helium, hydrogen, nitrogen, nitrous oxide. Chemical asphyxiation: carbon monoxide, cyanide, hydrogen cyanide, nitrile, aromatic nitro compounds(nitrobenzene, dinitrobenzene, etc.), aromatic amines (aniline, methylaniline, etc.), hydrogen sulfide
Anesthesia	Most organic solvents and many lipid soluble solids have a variety of aesthesia affects.
Nervous system lesions	Carbon disulfide, halogenated hydrocarbon, methanol, thiophene, tetraethyl lead, manganese, mercury
Liver and kidney lesions	Carbon tetrachloride, tetrachloroethane, hexachloronaphthalene, trinitrotoluene, dioxane (Especially for kidney) Uranium, cadmium
Blood lesion	Benzene, lead, radiation, phosphine, arsine, etc.
Hard tissue lesions	Acid mist, yellow phosphorus, fluorine, etc.
Lung lesions	Alveolus stimulant substances (lung edema, pneumonia), hardly soluble dust （pneumoconiosis）, free silicic acid （silicosis）, asbestos (asbestosis), talc (talcosis), agalmatolite (pyrophyllitosis), aluminum (aluminosis pulmonum), coal

	powder (coal miner's lung), graphite (graphitosis), welding dust (welder's lung), beryllium (pulmonary berylliosis), etc.
Others	Allergy: metallic oxide and fume, etc. Circulatory function defect: nitroglycol, nitroglycerine, etc.

Cautions regarding storing and handling

1. Poisonous substances and deleterious substances must be exclusively stored in sealed containers and put in a locked exclusive cabinet. When purchasing or using these substances, keep strict record in the logbook. Also, every time you purchase or use them, make an entry into the Management System for Lab Chemicals.
2. Collect information on the degree of carcinogenicity and toxicity from reference data. When you purchase poisonous and deleterious substances, the following information will be presented on the MSDS by the seller: ① The name and address of the seller who provided the information. ② Discriminate between poisonous substances and deleterious substances. ③ The name of the product, ingredients and contents. ④ Recommended first aid. ⑤ Action to be taken in case of fire. ⑥ Measures for leaks. ⑦ Caution regarding storage and handling. ⑧ Measures for the prevention of exposure and the protection against exposure. ⑨ Physical and chemical characteristics. ⑩ Stability and reactivity. ⑪ Information about toxicity. ⑫ Caution regarding disposal. ⑬ Caution regarding transport.
3. Handle substances inside a draft chamber equipped with a hazardous substances removal unit.
4. Wear safety gear such as protective glasses, a gas mask, gloves and other basic protective clothing.
5. Let others know what you are doing.
6. Be prepared to take countermeasures in case of spillage or any other type of accident.
7. Never dispose of poisonous and deleterious substances in the ground or ocean, and never burn them.

The law regulates storage and other issues for poisonous and deleterious substances. It applies to all workers, including researchers. The following is the rephrasing of the law to allow your easy understanding:

(1) You must take all measures to ensure that poisonous and deleterious substances cannot be stolen or lost. A staff or faculty member in charge shall strictly keep the keys.

(2) You must take all measures to prevent poisonous and deleterious substances from scattering, leaking, and draining. The measures include laying trays under the bottles. This applies when you take out or transport poisonous or deleterious substances from the facility.

(3) Never store poisonous substances or deleterious substances in containers that are usually used to keep food.

(4) You must put a notice board or seal indicating "Poisonous Substance for Non-Medical Use" in white letters on a red background, and "Deleterious Substance for Non-Medical Use" in red letters on a white background on every container, package, store chamber/shelf that keep poisonous and deleterious substances.

(5) You must dispose of poisonous and deleterious substances according to the designated way after asking the Environment Conservation Research Institute (ECRI) for treatment. You can also ask treatment to a waste management contractor approved by the Waste Disposal and Public

Cleaning Law.

(6) In the event that poisonous or deleterious substances are scattered, leaked, or drained, you must report it immediately to the staff or faculty member in charge, the Health and Safety Management Office, the police and the fire department, and take necessary, emergency measures to prevent health and sanitary damage from expanding.

(7) You must report to the staff or faculty member in charge, the Health and Safety Management Office and the police in the event that poisonous or deleterious substances are stolen or lost.

(8) Places where poisonous and deleterious substances are stored or displayed must be a special exclusive facility with locks, and they must be clearly separated from places where other materials are stored.

(9) The poisonous and deleterious substances storage or display facilities must be posted with a sign bearing "AUTHORIZED PERSONNEL ONLY" to prohibit public access and to prevent them from being stolen.

(10) You must check the delivery and receipt of the poisonous and deleterious substances and their inventories at regular intervals. You must keep strict records including data on the amount of each substance used.

Only "Specified Poisonous Substances Researchers" certified by the governor can manufacture specified poisonous substances. Furthermore, there are laws regulating importing, possessing, using and transferring specified poisonous substances. The "Poisonous and Deleterious Substances Control Law" and the "List of Poisonous and Deleterious Substances" and the "Specified Poisonous Substances" can be accessed at this website: (http://www.houko.com/00/01/s25/303.htm)

5.2.2 Carcinogenic Substances

The Japan Society for Occupational Health has accepted the carcinogenic substance classification by the International Agency for Research on Cancer (IARC) and has added other information in the form of a carcinogenic substance table to provide more information about industrial chemicals and related substances. "Group 1" includes substances carcinogenic to humans. "Group 2" includes substances deemed to be carcinogenic to humans. This group is divided into two groups: Group 2-A includes agents, mixtures and circumstances that are probably carcinogenic to humans, and Group 2-B includes agents, mixtures and circumstances that are possibly carcinogenic to humans. Table 5-4 shows the main carcinogenic substances.

Table 5-4 Main carcinogenic substances

＜Group 1＞	
Aflatoxin	Ethylene oxide
4-aminobiphenyl	Gamma ray irradiation
Arsenic and arsenic compounds	Formaldehyde
Asbestos	2-naphthylamine

Benzene	Neutron ray
Benzidine	Nickel compounds
Beryllium and beryllium compounds	Radionuclide that emits alpfa ray
Bis (chloromethyl) ether and chloromethyl ether	Radionuclide that emits beta ray
	Talc (containing asbestiform fibers)
Cadmium and cadmium compounds	Vinyl chloride monomer
Hexavalent chromium compounds	X-ray irradiation
Erionite	
＜Group 2-A＞	
Acrylic amide	Indium phosphide
ButadieneAcrylonitrile	Inorganic lead compounds
Diethyl sulfate	Methyl methanesulfonate
1,2-dimethylhydrazine	Tetrachloroethylene
Dimethyl sulfate	Trichloroethylene
Epichlorohydrin	Vinyl bromide
Ethylene dibromide	Vinyl fluoride
＜Group 2-B＞	
Acetaldehyde	Dioxane
Acrylonitrile	Lead
Carbon tetrachloride	Magenta
Catechol	Metal nickel
Chloroform	Nitrobenzene
Cobalt	Phenobarbital
Cobalt sulfate	Stylene
Dichloromethane	Vanadium pentoxide
Gasoline	

5.2.3 Specified Chemical Substances

The Industrial Safety and Health Law and the Ordinance on the Prevention of Hazards due to Specified Chemical Substances describe the responsibility of organizations to protect their employees from cancer, dermatitis, nervous system diseases and other health damage due to chemical substances. Employers are required to check the toxicity of substances, possible substitutions, the work procedures, the maintenance and improvement of facilities and ensure thorough health management, as well as other necessary measures. Table 5-5 shows the chemical substances that are designated by the Industrial Safety and Health Law. When handling these substances, it is required to have local ventilation equipment, dust collectors, an exhaust gas treatment system, a discharged liquid treatment system and a system to treat residuals from experiments. In addition, installing of two or more doorways and restricted areas, performing voluntary periodical inspection of machines, work environment measurement, prohibiting eating, drinking and smoking, medical examinations, wearing of safety gear, etc., must be adhered to.

Table 5-5 Specified chemical substances

1. Group No. 1 substances

1 Dichlorobenzidine or its salts	7 Benzotrichloride

2 α - naphthylamine or its salts 3 Chlorinated biphenyls(otherwise called PCB) 4 O-tolidine or its salts 5 Dianisidine or its salts 6 Beryllium or its compounds	8 Formulation and other substances containing more than 1% of its weight of substances from 1 through 6, or more than 0.5% of its weight of 7 (in terms of alloy, containing 3% of its weight of beryllium)

2. Group No. 2 substances

1 Acrylamide 2 Acrylonitrile 3Alkylmercury compouds (only substances in which alkyl group is methyl or ethyl group) 4 Ethyleneimine 5 Ethylene oxide 6 Chloroethylene 7 Chlorine 8 Auramine 9 Ortho-phthalodinitrile 10 Cadmium or its compounds 11 Chromic acid or its salts 12 Chloromethyl methyl ether 13 Vanadium pentoxide 14 Coal tar 15 Arsenic trioxide 16 Potassium cyanide 17 Hydrogen cyanide 18 Sodium cyanide 19 3.3' – dichloro – 4.4' - diaminodiphenyl methane	20 Methyl bromide 21 Dichromic acid or its salts 22 Mercury or its inorganic compounds (exclusive of mercury sulfide) 23 Trilene-diisocyanate 24 Nickel carbonyl 25 Nitroglycol 26 Para-dimethylaminoazobenzene 27 Para-nitrochlorobenzene 28 Hydrogen fluoride 29 β -propiolactone 30 Benzene 31Pentachlorophenol (otherwise called PCP) or its sodium salts 32 Magenta 33 Manganese or its compounds (exclusive of basic manganese oxides) 34 Methyl iodide 35 Hydrogen sulfide 36 Dimethyl sulfide 37 Formulations or other substances containing substances from 1 through 36 shown above, designated by Ministry of Health, Labour and Welfare Ordinance.

3. Group No. 3 substances (not subjected to work environment measures)

1 Ammonia 2 Carbon monoxide 3 Hydrogen chloride 4 Nitric acid 5 Sulfur dioxide 6 Phenol	7 Phosgene 8 Formaldehyde 9 Sulfuric acid 10 Formulations and other substances containing substances from 1 through 9 shown above, designated by Ministry of Health, Labour and Welfare Ordinance.

*Asbestos, which formerly belonged to Group No. 3, was removed from the "Designated Chemical Substances" in February 2005, and is now under the strict control by the new "Asbestos Damage Prevention Regulations "

5.3 Sarin and Other Specific Chemicals

The "Law on the Prohibition of Chemical Weapons and the Regulation of Specific Chemicals" was enforced on May 5th, 1995. Table 5-6 shows the substances that are subject to this law. (Besides the substances listed, organochemical and specific organochemical substances are also subject to this

law.) You must receive permission from the Minister of Economics, Trade and Industry before manufacturing or using the specific substances. The possession, and the giving and receiving of specified substances without permission is prohibited by law. It is mandatory to obey the law and to ensure that appropriate procedures are taken in the laboratory when researchers are handling these chemicals. It is important to note that if you synthesize any of those substances or their precursors without being aware of the relevant laws, you are still liable under the law and will be punished accordingly.

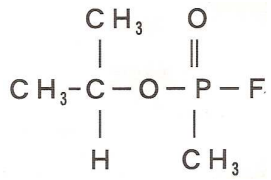
In terms of manufacturing, use and import/export of the specific materials, organic chemicals and specific organic chemicals, application to the Minister of the Economics, Trade and Industry is required depending on the group and amount of the target. When falling under this case, contact the Health and Safety Management Office in advance.

Table 5-6 Substances subjected to the Law on the Prohibition of Chemical Weapons and the Regulation of Specific Chemicals

		Toxic chemicals	Precursors
1	Specified substances	<Reagent 1A > See text	< Reagent 1B > See text
2	Group 1 Designated substances	< Reagent 2A > (1) O・O´-diethyl=s-[2-(diethylamino)ethyl]= phosphorothiorate (otherwise called amiton) and its alkyl salts, and protonated salts (2) 1.1.3.3.3 -pentafluoro-2-(trifluoromethyl)-1-propene (otherwise called PFIB) (3) 3-quinuclidinyl=benzilate (otherwise called BZ)	< Reagent 2B > (1) Compounds (except following substances) with a phosphorus atom that is not bonded with a carbon atom, except for those bonded to an alkyl group which is designated in the specified substances and which has three or less carbon atoms. a) substances described in 1 through 4 of column 3 and column 4 in the specified substances shown above. b) O-ethyl=s-phenyl=ethylphosphonodithionate (otherwise called fonofos) (2) N.N-dialkyl(Me, Et, N-Pr or i-Pr)phospholamidic= dihalides (3) Dialkyl(Me, Et, N-Pr or i-Pr)=N.N-dialkyl(Me, Et, N-Pr or i-Pr)phosphol amidates (4) Arsenic trichloride (5) 2.2-diphenyl-2-hydroxyacetic acid (6) Quinuclidine-3-ol (7) N.N-dialkyl(Me, Et, N-Pr or iPr)aminoethyl-2-chlorides and corresponding protonated salts (8) N.N - dialkyl(Me, Et, N-Pr ori-Pr)aminoethane-2 - ols (exemptions: N.N –dimethylaminoethanol and N.N-diethylaminoethanol) and corre-spond-ing protonated salts (9) N.N – dialkyl(Me, Et, N-Pr or i-Pr)aminoethane -2- thiol and corresponding protonated salts (10) Bis (2-hydroxyethyl) sulfide (otherwise called thiodiglycol) (11) 3.3-dimethylbutane-2-ol(otherwise called pinacolyl alcohol)

3	Group 2 Specified substances	<Reagent 3A> (1) Carbonyl dichloride (otherwise called phosgene) (2) Cyanogen chloride (3) Hydrogen cyanide (4) Trichloronitromethane (otherwise called chloropicrin)	<Reagent 3B> (1) Phosphoryl chloride (2) Phosphorus trichloride (3) Phosphorous pentachloride (4) Trimethyl phosphite (5) Triethyl phosphite (6)Dimethylphosphite (7) Diethyl phosphite (8) Sulfur monochloride (9) Sulfur dichloride (10) Thionyl chloride (11) Ethyldiethanolamine (12) Methyldiethanolamine (13) Triethanolamine

The chemical structure of sarin and other specific substances (toxic chemicals (Reagent 1A) and their precursors (Reagent 1B)). Toxic chemicals (Reagent 1A) have the following names: 1: sarin, soman and their derivatives, 2: tabun derivatives, 3 and 4: VX, 5-13: sulfur mustards, 14-16: lewisite, 17-19: nitrogen mustards, 20: saxitoxin, 21: ricin



Sarin
m.p. −57℃, b.p. 147℃
Lethal dose: 0.01 mg/kg
(Potassium cyanide:10 mg/kg)
(ie. 0.6 mg for 60 kg weight

5.3.1 Specific substances

Toxic chemicals (Reagent 1A)

(1) O- alkyl(≤C_{10}, incl. cycloalkyl) =alkyl(Me, Et, n-Pr or i-Pr)-phosphonofluoridates
$R^1OPO(R^2)F$
e.g. Sarin: O-Isopropyl methylphosphonofluoridate
Soman: O-Pinacolyl methylphosphonofluoridate

(2) O- alkyl(≤C_{10}, incl. cycloalkyl)=N,N-dialkyl (Me, Et, n-Pr or i-Pr) =phosphonylamide cyanidates
$R^1OPO(CN)NR^2R^3$
e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate

(3) O- alkyl (H or ≤C_{10}, incl. cycloalkyl) =S-2-dialkyl(Me, Et, n-Pr or i-Pr) aminoethyl=alkyl (Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylates and protonated salts
$R^1OPO(SCH_2CHNR^2R^3)R^4$
e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methylphosphonothiolate

(4) S-2- dialkyl(Me, Et, n-Pr or i-Pr) aminoethyl=hydrogen= alkyl(Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylated or protonated salts
$(R^1R^2NCHCH_2S)PO(OH)R^3$

(5) 2-chloroethyl chlormethyl sulfide
$ClCH_2$-S-CH_2CH_2Cl

(6) Bis (2- chloroethyl) sulfide (mustard gas)

$S(CH_2CH_2Cl)_2$

(7) Bis(2-chloroethylthio)methane

$CH_2(SCH_2CH_2Cl)_2$

(8) 1,2-bis (2- chloroethylthio) ethane (sesquimustard)

$ClCH_2CH_2S\text{-}(CH_2)_2\text{-}\ SCH_2CH_2Cl$

(9) 1,3-bis (2-chloroethylthio)-n-propane

$ClCH_2CH_2S\text{-}(CH_2)_3\text{-}\ SCH_2CH_2Cl$

(10) 1,4-bis (2- chloroethylthio)-n-butane

$ClCH_2CH_2S\text{-}(CH_2)_4\text{-}\ SCH_2CH_2Cl$

(11) 1,5-bis (2- chloroethylthio)-n-pentane

$ClCH_2CH_2S\text{-}(CH_2)_5\text{-}\ SCH_2CH_2Cl$

(12) Bis (2- chloroethylthiomethyl) ether

$O(CH_2SCH_2CH_2Cl)_2$

(13)Bis (2- chloroethylthioethyl) ether (o-mustard)

$O(CH_2CH_2SCH_2CH_2Cl)_2$

(14) 2-chlorovinyldichloroarsine (lewisite 1)

$Cl_2AsCH{=}CH_2Cl$

(15) Bis(2-chlorovinyl)chloroarsine (lewisite 2)

$ClAs(CH{=}CHCl)_2$

(16) Tris (2-chlorovinyl) arsine (lewisite 3)

$As(CH{=}CHCl)_3$

(17) Bis(2-chloroethyl) ethylamine (HN1)

$CH_3CH_2N(CH_2CH_2Cl)_2$

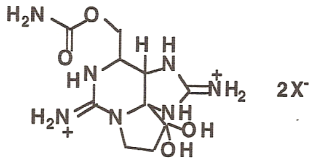
(18) Bis(2-chloroethyl) methylamine (HN2)

$CH_3N(CH_2CH_2Cl)_2$

(19) Tris (2-chloroethyl)amine (HN3)

$N(CH_2CH_2Cl)_3$

(20) Saxitoxin



(21) Ricin

The kind of albumin contained in castor-oil plant seed (protein)

Precursors (Reagent 1B)

(1) Alkyl(Me, Et, n-Pr or i-Pr)phosphonyl difluoride

R^1POF_2

(2) O-alkyl(H or $\leq C_{10}$, incl. cycloalkyl)=o-2-dialkyl(Me, Et, n-Pr or i-Pr)aminoethyl=alkyl(Me, Et,

n-Pr or i-Pr)phosphonites and corresponding alkylates and protonated salts
$R^1OPO(OCH_2CHNR^2R^3)R^4$

(3) O-2-dialkyl(Me, Et, n-Pr or i-Pr)aminoethyl=hydrogen= alkyl(Me, Et, n-Pr or i-Pr)phosphonites and corresponding alkylates and protonated salts
$(R^1R^2NCHCH_2O)PO(OH)R^3$

(4) O-isopropyl=methylphosphonochloridate (chlorosarin)
$((CH_3)_2CHOPO(CH_3)Cl$

(5) O-pinacolyl=methylphosphonochloridate
$((CH_3)_3C(CH_3)CHOPO(CH_3)Cl$

5.4 Manufacturing Prohibited and Restricted Substances

When using substances whose manufacturing is forbidden or restricted, you must comply fully with the required procedure according to the Industrial Safety and Health Law, Articles 55 and 56. Before using those substances, permission must be granted from the Chief of the Miyagi Labour Standards Inspection Office for the manufacturing prohibited substances, and from the Minister for Health, Welfare and Labour for the use of the manufacturing restricted substances. When falling under this case, contact the Health and Safety Management Office in advance.

5.4.1 Substances prohibited to be manufactured

The following substances are strictly forbidden to be manufactured.

(1) Yellow phosphorus matches
(2) Benzidine and its salts
(3) 4-aminodiphenyl and its salts
(4) Amosite
(5) Crocidolite
(6) 4-nitrodiphenyl and its salts
(7) Bis(chloromethyl)ether
(8) ß-naphthylamine and its salts
(9) Products that contain asbestos (exclusive of (4) and (5)) with 1% or higher by asbestos weight content
(10) Gum glue which contains more than 5% benzene (of the total solvent, including the diluent).
(11) Formulations and other substances containing more than 1% of the substances described in (2) through (8) by weight.

5.4.2 Restricted Substances

The following substances require a license in order to be manufactured.

(1) Dichlorobenzidine and its salts
(2) α-naphthylamine and its salts

(3) Polychlorinated biphenyl(PCB)
(4) Ortho-tolidine and its salts
(5) Dianisidine and its salts
(6) Beryllium and its compounds
(7) Benzotrichloride
(8) Formulations and other substances containing more than 1% of the substances described in (1) through (6) by weight, or formulations and other substances containing more than 0.5% of substances described in (1) through (6) by weight, more than 0.5% of substances described in (7) for its weight. (Alloys containing more than 3% of beryllium by weight.)

Chapter 6　Organic Solvents

6.1 Introduction

Organic solvents play a valuable role in experiments because of their ability to dissolve various substances. In laboratories specializing in organic chemistry, very large amounts of organic solvents are routinely used, and, even laboratories in other fields, they are kept in significant amounts. It should be understood that most of the organic solvents are harmful to some extent if they are absorbed by the human body, or come into contact with skin. This chapter summarizes the important points to remember when handling organic solvents. In the university, the Health Administration Center provides specific medical examinations to students who are handling organic solvents. They are encouraged to have a regular health checkup.

6.2 Hazardous Organic Solvents

Under the Organic Solvent Toxication Prevention Regulations of the Industrial Safety and Health Law, 55 kinds of organic solvents listed below are given detailed rules to be followed to prevent health damage (the solvents are classified into three depending on the level of the danger and hazard). These rules specifically refer to the equipment, ventilation system, work environment measurement, sign posting, indication, evacuation procedure, storage, protective safety gear, health checkups, etc. Failure to appropriately handle these organic solvents can cause health damage. Students are also required to keep these rules in mind.

Group No. 1 Organic solvents

14. Chloroform
23. Tertachlorocarbon
27. 1,2-Dichloroethane (dichloroethylene)
28. 1,2-Dichloroetylene (dichloroaccethylene)
32. 1,1,2,2-Tetrachloroethane (tetrachloroacethylene)
36. Trichloroethylene
38. Carbon disulfide

Group No. 2 Organic solvents

1. Acetone
2. Isobutylalcohol
3. Isopropylalcohol
4. Isopentylalcohol (isoamylalcohol)
5. Ethylether
6. Ethylene glycol mono ethylether (cellosolve)
7. Ethylene glycol mono ethylether acetate (cellosolve acetate)
8. Ethylene glycol mono-normal-buthylether (butyl cellosolve)
9. Ethylene glycol mono methyl ether (methyl cellosolve)
10. Ortho-dichlorobenzene
11. Xylene
12. Cresol
13. Chlorobenzene
15. Isobutyl acetate
16. Isopropyl acetate
17. Isopentyl acetate (isoamyl acetate)
18. Ethyl acetate
19. Normal-butyl acetate
20. Normal propyl acetate
21. Normal pentyl acetate (normal amyl acetate)
22. Methyl acetate
24. Cyclohexanol
25. Cyclohexane
26. 1,4-Dioxane
29. Dichloromethane (dichloromethylene),
30. n,n-Dimethylformamide, ,
31. Styrene
33. Tetrachloroethylene (perchloroethylene),
34. Tetrahydrofuran
35. 1,1,1-Trichloroethane
37. Toluene
39. Normal hexane
40. 1-Buthanol
41. 2-Buthanol
42. Methanol

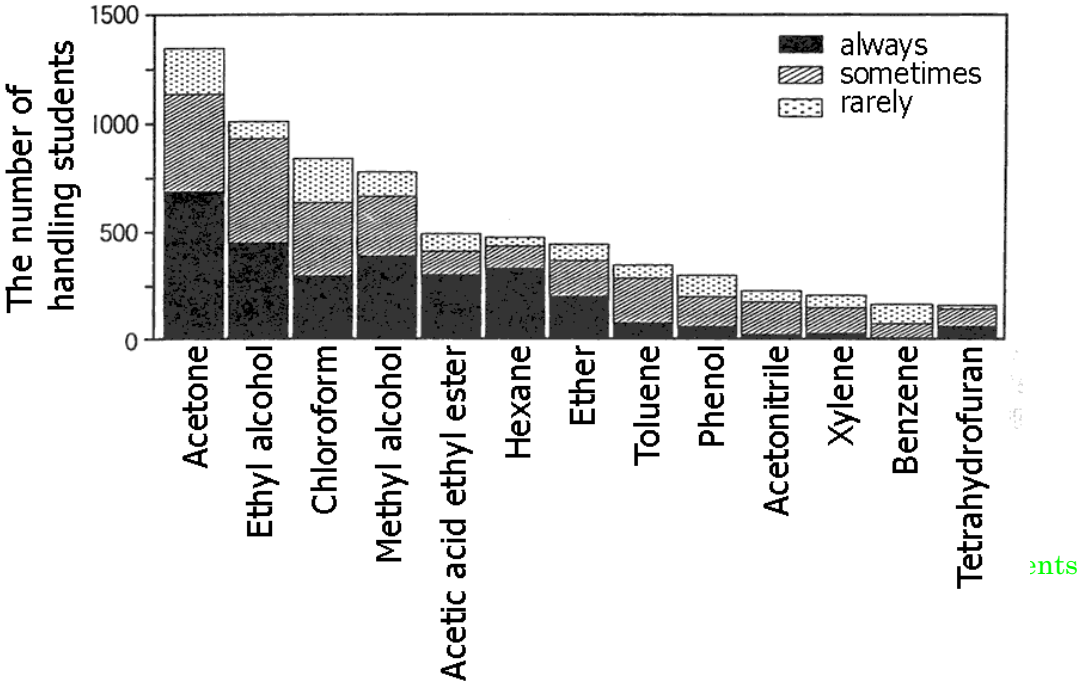
43. Methyl isobuthyl ketone
44.. Methyl ethyl ketone
45. Methyl cyclohexanol
46. Methyl cyclohexane
47. Methyl normal butyl ketone

Group No. 3 Organic solvents

48. Gasoline
49. Coal tar naphtha (including solvent naphtha)
50. Petroleum ether
51. Petroleum naphtha
52. Petroleum benzene
53. Turpentine oil
54. Mineral spirit (including mineral thinner, petroleum spirit, white spirit, and mineral turpentine)
55. Mixtures of the materials listed above (1-54)

6.3 The Main Organic Solvents Used in the University

The graph below indicates the most commonly used organic solvents in the university according to a survey taken in October 2000.



6.4 Health Problems from Inhaling Organic Solvents

Generally, organic solvents have high volatility, and accordingly their concentration in the air increases rapidly. As a result, a single or a combination of symptoms appear, i.e., a feeling of heavy-headedness, headaches, fatigue, giddiness, nervousness, nausea, vomiting, loss of appetite, stomachaches, a decrease in weight, palpitations, insomnia, anxiety, a loss of concentration, tremor, irritation of the upper respiratory tracts, irritation of the eyes, abnormalities of the skin and/or mucous membrane, acute pain in the extremities of the limbs, abnormal sensations, a decrease in grip strength, decreased tendon reflex, and altered visual acuity. Additionally, abnormal results from neurological examinations, liver disfunction, and leucopenia can be detected in the medical examinations.

6.5 Handling Organic Solvents

Organic solvents disperse rapidly in the air. A mistake made by one person when dealing with organic solvents may cause serious health problems not only to the person but also to others in the vicinity (Fig.1). In the laboratory, it is the most important that all students, staff and faculty carefully handle the organic solvents. You should pay much attention to the following concrete points and countermeasures:

Cautions

1. Ensure that the air flow is in one direction, and carry out all experiments upwind from the source of emission.
2. Do not touch the organic solvents with your bare hands. Rubber gloves and safety eye protection should be equipped when you treat them.
3. Cap the bottles and flasks containing organic solvents when you do not use.
4. Dispose of cloths in a hermetic plastic bag or waste container after cleaning the laboratory bench.
5. Monitor the amount of reagents through registering the Management System for Lab Chemicals when you purchase or use them.

Counterplans

1. Stop using the organic solvent, or use another organic solvent which is less harmful and/or less volatile.
2. Improve your experimental procedure so as to suppress emissions. The PRTR law

requires researchers to effort to minimize emissions.

3. Separate people from organic volatile compounds by sealing the equipment, automation or remote control.
4. Use a draft chamber, push-pull ventilation system, etc. to inhibit the dispersion of evaporated solvents.
5. Decrease the concentration of organic solvents in the air using whole room ventilation. For example, using a ventilation fan which has a high ventilation capability, prepare inspiratory ports. Ensure that there is an air current throughout the experimental laboratory.
6. Check the working environment and working conditions regularly.
7. Use proper protective safety equipments, and work with solvents for the shortest period of time possible. The spattering of solvents on the face or hands often causes burning.
8. Health check is useful to the early detection of disorders. Make sure that there are proper instructions and guidance, and the laboratory is appropriately staffed.
9. Confirm the dangerous and hazardous information of organic solvents in the Material Safety Data Sheet (MSDS).

Don't you pollute the air?

When a symptom due to an organic solvent appears!

(1) Contact a faculty staff (professor or associate professor).

(2) Contact the Health Administration Center and follow the instructions.
Tel: 795-7829/795-7824

(3) In case of emergency, visit the University Hospital for consultation.
When open Tel: 93-7000 (extension) / 717-7000 (public line)
When closed Tel: 93-7024 (extension) / 717-7024 (public line)

Chapter 7 High Pressure Gas

7.1 Introduction

These days, gases are commonly used in all kinds of places, including vehicles, in hospitals in the form of anesthesia, in our hot water supply, in cooking stoves in homes and in fire extinguishers.
These gases are controlled under the Law Concerning High Pressure Gas Safety. In the School of Engineering, many laboratories have high pressure gas cylinders. Some of them contain liquefied gases, such as nitrogen and helium, for use in research and education. Some gases are highly explosive or poisonous. There is, however, the possibility that even inert gases like nitrogen, which are deemed to be safe, can induce oxygen deficiency or asphyxiation. This chapter describes the correct ways to handle high pressure gases and their containers.

7.1.1 High pressure gas

"High pressure gas" is a term which refers to pressurized gas with a pressure of 1 MPa or above, and the term "liquefied gas" is used to talk about gases with a pressure of 0.2 MPa or above at ambient temperature. "Pressurized gas" can be defined as gas which has a pressure of 1 Mpa or above and liquefied gas which has a pressure of 0.2 MPa or above at 35°C. In the case of ethylene, the term "high pressure gas" refers to ethylene ~~whose~~ which has a pressure of 0.2 MPa or above at ambient temperature, and ethylene which has a pressure of 0.2 MPa or above at 15°C.
*When fully charged, pressurized gas in the container is 14.7 Mpa (about 1,500 tons).

7.1.2 Classification of high pressure gases

(1) Classification by the state of the gas in the container
Pressurized gas: oxygen, hydrogen, nitrogen, argon, etc.
Liquefied gas: Carbon dioxide, propane, ammonia, chlorine, etc.
Low temperature liquefied gas: liquefied nitrogen, liquefied helium, liquefied argon, dry ice, etc.
(2) Classification by the nature of the gas
Combustible gas: hydrogen, ammonia, hydrogen sulfide, methane, city gas (13 A), etc.

Combustion-aid gas: oxygen, air, chlorine, bromine, fluorine, etc.

Explosive gas: gas mixture that consists of combustible gas and combustion-aid gas, silanes, alkylamines, metallic hydrogenised compounds and organic metal gases.

Inert gas: Nitrogen, carbon dioxide, helium, argon, etc.

Toxic gas: chlorine, hydrogen chloride, ammonia, hydrogen sulfide, hydrogen cyanide, etc.

7.1.3 Basic notes on handling high pressure gas (common to all chemicals)

(1) Routinely check high pressure gas equipment and control it to conform to the criteria.

(2) Master the correct ways to handle high pressure gas equipment, gas containers, etc.

(3) Understand the properties of high pressure gases listed in the MSDS.

(4) Have drills and understand emergency measures in case of an accident.

7.1.4 When high pressure gas is leaking

(1) Combustible gas (this also applies to combustion-aid gases)

i) Do not go near the leak if there is a significant amount which has leaked.

ii) Confirm the exact place from which the gas is leaking.

iii) Open windows and doors for ventilation.

iv) The use of fire is strictly prohibited. Do not switch on ventilating fans or lights.

v) Take the leaking container outside.

(2) Inert gas

i) Ventilate the room where the gas is leaking to prevent oxygen deficiency.

ii) Do not go near the leak without an oxygen mask if the leak is large.

iii) Evacuate any place where the oxygen concentration is below 18%.

7.1.5. In the case of fire

(1) If the gas is alight

i) Close the main valve to cut off the supply of combustible gas.

ii) If you cannot get close to the container, spray water over it to cool it.

iii) If there is a fear that the gas may stay in the room, spray water over the container.

iv) Remove all other containers from the area as soon as possible.

v) Wear safety gear, such as a gas mask and protective gloves, if the gas is poisonous.

(2) If fire has broken out around the container

i) Let the firefighters know the type and the amount of gas.

ii) Take the container outside to a safe place if possible.

iii) If it is impossible to take the container outside, spray water over it to cool it.

iv) If there is a possibility of an explosion, evacuate the area.

7.2 Handling High Pressure Gas According to Classification

7.2.1 Handling combustible and explosive gases

Combustible gases are those which have a lower explosion limit of 10% or less, or those with an explosion where the upper explosion limit is 20% or above in the air. Explosive gas is a mixture of combustible gas and combustible-aid gas with a certain mix ratio. One of the most common is a mix with air. Explosion limits in air are shown in Table 7-1. When handling combustible gas, take the following precautions:

(1) Make sure the mix ratio of the combustible gas is not within the explosion range.

i) Do not allow gas leak from the high pressure gas equipment (the joints, the cylinder valves, etc.) into the room.

ii) Install a combustible gas detecting alarm to warn against gas leaks. When a leak occurs, ventilate the room to get the gas out immediately in a safe manner.

(2) Pay attention to overheating, static electric sparks, impact, friction, and fine powdered metal, etc. since they contribute to explosions in gas mixtures.

i) "Fire prohibited" signs must be strictly adhered to. Gas ignites when it is heated above the ignition point or firing point. There is a potential danger of gas igniting or exploding due to radiation heat from ~~a~~ high temperature furnaces, electric furnaces, etc.

Table 7-1 Explosion limit of main gases in the air (1 atm, Ambient Temperature)

(Digits represent the volume fraction in percentage of combustible gases)

Gases	Lower Limit	Upper Limit	Gases	Lower Limit	Upper Limit

Acetone	2.1	13.0	Hydrogen	4.0	75.0
Benzene	1.4	7.1	Carbon monoxide	12.5	74.0
Toluene	1.1	7.1	Hydrogen sulfide	4.0	44.0
Pentane	1.5	7.8	Methane	5.0	15.0
Normal hexane	1.1	7.5	Ethane	3.0	12.5
Cyclohexane	1.3	8.0	Propane	2.1	9.5
Methyl alcohol	6.0	36.0	n-Butane	1.6	8.5
Ethyl alcohol	3.3	19.0	Ethylene	2.7	30.0
Isopropylalcohol	2.0	12.7	Propylene	2.0	11.1
Acetaldehyde	4.0	60.0	Acetylene	2.5	100.0
Diethyl ether	1.9	36.0	1- Butene	1.6	10.0
Diethylamine	1.8	10.1	Isobutylene	1.8	9.6
Trimethylamine	2.0	11.6	1,3-Butadiene	2.0	12.0
Ethylbenzene	1.0	6.7	Ethylene oxide	3.6	100.0
Ethyl acetate	2.0	11.5	Propylene oxide	2.8	37.0
Ammonia	15.0	28.0	Vinyl oxide	3.6	23.0
Carbon Disulfide	1.3	50.0	Ethylene tetrafluoride	11.0	60.0

7.2.2. Handling combustion-aid gases

Combustion-aid gases can involve other substances to combustion. When handling combustion-aid gases, take cautions as follows:

(1) Oxygen and air

i) Compared to air, there is a range of explosion limits (especially the upper limit) for oxygen.

ii) There is potential danger of ignition occurring when oxygen comes into contact with oil, fat, organic insulating material, or other substances that may lead to ignition.

iii) When handling liquefied oxygen, wear safety glasses and leather gloves to prevent frostbite.

iv) When liquefied oxygen comes into contact with clothing, it is absorbed and this can ignite when fire, like a cigarette, is close by.

v) When liquid oxygen adheres to clothing, remove it as soon as possible and wash the oxygen away using tap water to protect from frostbite.

(2) Halogen gases

i) Halogen gases, such as chlorine, bromine, fluorine, etc. support combustion. An explosive gas mixture of chlorine and hydrogen often causes an active reaction that results in an explosion. Explosions occur even with radiation from the sun, so the presence of a spark or a flame, or a strong heat source, is obviously very dangerous.

7.2.3 Handling inert gases

Inert gases are classified as gases that do not easily cause active chemical reactions such as ignition and explosions. There is, however, a potential danger of oxygen deficiency or asphyxiation and it is necessary to take the following precautions:

(1) When handling a large amount of gas or handling it in places with poor ventilation, avoid oxygen deficiency. Table 7-2 shows the symptoms of oxygen deficiency.

※What to do in the event of oxygen deficiency

In the event of discovering a laboratory member with oxygen deficiency, make judgments carefully to ensure that a secondary accident does not occur. The first step is to call the person loudly by name. If the person does not respond, assess the situation, and decide the best course of action. If you consider it safe enough, hold your breath and drag the person outside the room, and if it is not safe enough, use an oxygen mask. In facilities where there is an inherent risk of oxygen deficiency, ~~an~~ oxygen masks and oxygen meters must be put in convenient places.

Table 7.2 Human responses to oxygen-deficient atmospheres

Atmospheric oxygen level	Symptom
21%	Natural oxygen level
18%	Safety limit; continuous ventilation is needed.
16-12%	Increase in breathing and pulse rate, loss of concentration, headache, buzzing, retching
14-9%	Stupor, headache, retching, facial pallor, whole-body weakness
10-6%	Coma, loss of consciousness, whole-body spasms
6% or below	Unconsciousness, coma, cessation of respiration, cardiac arrest, death in 6 minutes

(2) Since carbon dioxide is heavier than air, beware when it is stored in a basement where a gas leak can easily lead to asphyxiation.

7.2.4 Handling liquid gases and low temperature liquefied gases

Liquefied gas is a liquid-state gas that is produced by artificially compressing and/or cooling a gas in a gaseous-state under ambient temperature and pressure. Liquefied nitrogen and helium are often used in laboratories. When handling low temperature, liquefied gases, take the following precautions:

(1) During vaporization, liquefied gases are characterized by remarkable volume expansion and heat absorption, both of which need to be taken into consideration. Caution against asphyxiation.
(2) Cold injuries can be avoided by not touching liquefied gas. Wear safety glasses and leather gloves to prevent direct contact with the gas. If it adheres to your clothes or gloves, remove them if possible, and wash it out with a large amount of water.
(3) Take cautions against spitting or boiling when you pour liquefied gas into a container, or put something into it.
(4) Since dry ice and liquefied gases are heavier than air, they tend to stay low. You must always be aware of this and be careful.
(5) When moving a Dewar vessel containing liquefied gas, ensure that the cap is tightly closed before moving it. When moving a large Dewar vessel, get help from other people and use a dedicated two-wheel cylinder cart, etc.

7.2.5 Handling toxic gas

Toxic gases are those with concentrations of 200 ppm or lower, allowing for long-term labor of 8 hours a day without any adverse health effect (permissible concentration). Some toxic gases induce an anesthetic reaction, leading to anesthetic death (chloromethyl, nitrogen oxide, etc.). Some cause the contraction of respiratory organs leading to death (chloride, sulfur dioxide, ammonia, etc.). Some result in damage to the brain or blood circulation leading to death (hydrogen cyanide, hydrogen sulfide, carbon monoxide, etc.). Even gases with no direct toxicity to the human body can deplete the oxygen below concentrations necessary for respiration or result in oxygen deficiency leading to asphyxiation. Table 7-3 shows toxic gases and their permissible concentrations. When handling toxic gases, take the following precautions:

(1) Investigate the toxicity and hazardous nature of the gas in advance using MSDS.
(2) It is critical that there are no gas leaks, but you must always be prepared for the unexpected.
(3) When there is a potential danger of a gas leak, install a gas leak detecting alarm and routinely measure the gas concentration.
(4) Routinely have ventilation ready, and assume there is always a small gas leak.
(5) Assuming a gas leak, prepare hazard-removing agents (absorbent, neutralizer, etc.) and safety gear such as a gas mask and protective gloves.

Table 7.3 Threshold limit values (TLV) of toxic gases (unit: ppm)

Gas	TLV	Gas	TLV
Ammonia	25	Acetone	500
Carbon monoxide	25	Benzene	0.5
Carbon dioxide	5,000	Methanol	200
Chlorine	0.5	Ethanol	1,000
Fluorine	1	Diethylamine	5
Bromine	0.1	Acetic acid	10
Ethylene oxide	1	Ethyl acetate	400
1,3-Butadiene	2	Butyl acetate	150
Nitrogen monoxide	25	Vinyl chloride	5
Hydrogen sulfide	10	Toluene	50
Hydrogen cyanide	10	Normal hexane	50
Hydrogen chloride	2	Acrylonitrile	2
Phosgene	0.1	Methyl bromide	1
Sulfur dioxide	2		

7.2.6 Handling city gas

City gas is mixed with a strong odorous substance to make it easily perceived by human senses with a gas leak of only 0.1% (in the case of Sendai city, butanethiol is used). However, since city gas (which has a specific gravity of 0.66) is lighter than air, there are occasional delays in perceiving the gas leak. Pay attention when handling the city gas in the following ways:

(1) Check visually when lighting or extinguishing the gas. Check all the gas cocks, including the main cock, when you leave the room.

(2) Use safe gas-devices. Check all the gas hoses. Replace old gas devices with new ones.

(3) Use a fastener to the connector of the gas pipes. Put a rubber cap on gas plugs not being used.

(4) Use a reinforced gas hose, or a consent hose that will not crush when stepped on.

(5) Do not use octopus piping or temporary piping, etc.

(6) Use ~~a~~ burner safety device. Set the alarm for gas leaks.

(7) Clean up the gas burner and its surroundings.

(8) Do not put combustibles around the gas equipment.

(9) Do not put gas burners on workbenches made of wood, etc. Use workbenches made of metal or inorganic material.

(10) When a gas leak is detected, immediately ventilate by opening doors and windows and then close all the gas cocks. Never switch ventilation fans and electric lights on/off, etc. Leave them as is. If possible, ventilate the air on an hourly basis when using gas.

(11) The main component of city gas is methane. When imperfect combustion occurs, carbon monoxide is generated. Since carbon monoxide is colorless and odorless, there are occasional delays perceiving it. Careful attention must be paid to the risk of imperfect combustion.

The components (volume fraction) and properties of city gas 13A (measured by the Sendai Gas Office)

Nitrogen: 0.15 Methane: 88.95 Ethane: 4.88 Propane: 2.82

Isobutane: 1.24 n-Butane: 1.94 Isopentane: 0.02

Gross calorific value of gas: 11,000 kcal/m^3

Specific gravity (air =1): 0.66

Combustion range: 5-13%

7.3 Handling Special Material Gases (Special High Pressure Gases)

7.3.1 Overview of special material gases (special high pressure gases)

The School of Engineering is actively engaged in semiconductor research and uses special gases, such as monosilane, in the semiconductor manufacturing process. Table 7-4 shows the 37 types of gases that are referred to as “special material gases” since they all require special safety precautions to be taken. Among these special gases are arsine (5 ppb), disilane (5 ppm), diborane (0.1 ppm), hydrogen selenide (0.05 ppm), phosphine (0.3 ppm), monogermane (0.2 ppm) and monosilane (5 ppm). They are designated as special high pressure gases because they can spontaneously combust in air, explosively decompose or have very high toxicity.

Before handling special high pressure gases, consult the Health and Safety Management Office since handling these gases require installing hazard removal equipment and a gas leak detection alarm as well as the control authority to be notified. Table 7-4 shows the general natures of special material gases.

※Descriptions for * (1), (2) and (3) are their threshold limit values.

Table 7.4 General natures of special material gases

Class	Name	Chemical formula	Toxicity	Combustible	Spontaneous combustibility * (1)	Explosive Decomposition * (2)	Corrosive * (3)
Silicon compounds	Monosilane	SiH_4	○	○	○		
	Disilane	Si_2H_6	○	○	○		
	Dichlorosilane	SiH_2Cl_2	○	○			○
	Silane trichloride	$SiHCl_3$	○	○			○
	Silicon tetrachloride	$SiCl_4$	○				○
	Silicon tetrafluoride	SiF_4	○				○
Arsenic compounds	Arsine	AsH_3	○	○			
	Arsenic trifluoride	AsF_3	○				○
	Arsenic pentafluoride	AsF_5	○				○
	Arsenic trichloride	$AsCl_3$	○				○
	Arsenic pentachloride	$AsCl_5$	○				○
Metal alkyl compounds	Trialkyl gallium	GaR_3	○	○	○		
	Trialkyl indium	InR_3	○	○	○		

Boron compounds	Diborane	B_2H_6	○	○			
	Boron trifluoride	BF_3	○				○
	Boron trichloride	BCl_3	○				○
	Boron tribromide	BBr_3	○				○
Phosphorus compounds	Phosohine	PH_3	○	○	○		
	Phosphorus trifluoride	PF_3	○				○
	Phosphorus pentafluoride	PF_5	○				○
	Phosphorus trichloride	PCl_3	○				○
	Phosphorus pentachloride	PCl_5	○				○
	Phosphorus oxychloride	$POCl_3$	○				○
Metal hydrides	Hydrogen selenide	H_2Se	○	○			
	Monogermane	GeH_4	○	○		○	
	Hydrogen telluride	H_2Te	○	○		○	
	Stibine	SbH_3	○	○		○	
	Tin hydride	SnH_4	○	○			
Halides	Hydrogen trifluoride	NF_3	○				
	Sulfur tetrafluoride	SF_4	○				
	Tungsten hexafluoride	WF_6	○				○
	Molybdenum hexafluoride	MoF_6	○				○
	Germanium tetrachloride	$GeCl_4$	○				○
	Tin tetrachloride	$SnCl_4$	○				○
	Antimony pentachloride	$SbCl_5$	○				○
	Tungsten hexafluoride	WCl_6	○				○
	Molybdenum pentachloride	$MoCl_5$	○				○

* (1) Spontaneous combustion gases

If these gases leak into air below the ambient temperature, oxidation starts once the ambient temperature is reached. As the exoergic reaction progresses, the temperature of the gas increases and this leads to spontaneous combustion.

* (2) Explosive decomposition gases

When there is an ignition source (ignition temperature), these gases cause a fire without being mixed with a combustion-aid gas. The fire rapidly propagates and leads to an explosion.

* (3) Corrosive gases

These gases produce halides (hydrochloric acid, hydrofluoric acid, etc.) when they react with moisture and this leads to the corrosion of metal materials.

7.3.2 Handling special material gases (special high pressure gases)

When handling special material gases (special high pressure gases), take the following precautions:

(1) Investigate the toxicity and hazardous nature of the gas in advance using MSDS.

(2) Safety education given by an advisory teacher is critical. Without permission from the teacher, no one is allowed to conduct experiments.

(3) Experiments must be carried out with one or more partners. Carrying out experiments alone late at night is strictly prohibited.

(4) From experience, most accidents occur when starting up the experimental equipment. Thoroughly check for leaks under a vacuum before letting the gas flow for the first time. A special check of pressurized parts is necessary.

(5) Experimental equipment that uses special material gases involves many valve operations. Be sure to prepare a manual (experimental procedure, handbook, etc.) available for valve operations. Even if you are familiar with the experiment, do not neglect to check the manual.

(6) Conduct periodic safety checks. Have work records for experimental equipment that require periodic safety checks and maintenance to prevent the history from being forgotten.

(7) Prepare for emergencies. Conduct periodic safety drills and have fire extinguishers and gas masks ready for use. It is also important to routinely discuss emergency measures in case of earthquakes, fire, gas leaks, etc.

7.4 Handling of High Pressure Containers

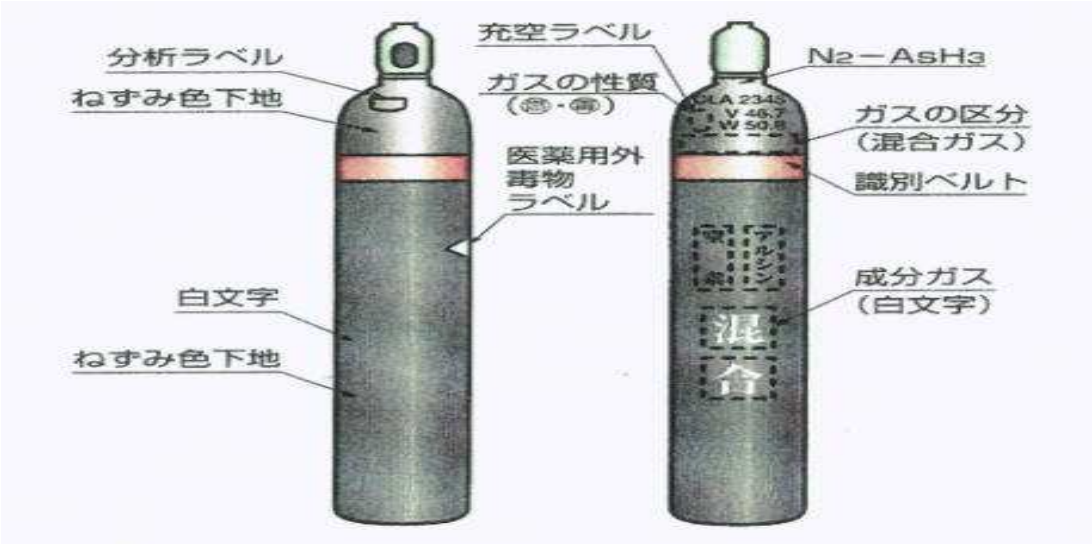
7.4.1 Overview of high pressure gas cylinders

High pressure gas cylinders are classified as “seamless containers” for pressurized or liquefied gases and “welded containers” for low pressure liquefied gases such as LP gas. Cylinders are colored according to the kind of gas, as shown in Fig. 7-1. The names of the parts of the cylinders are shown in Fig. 7-2. The gases are clearly marked “Combustible” or “Toxic”. The volumes of the cylinders most used in the School of Engineering are 7 m^3 and 1.5 m^3.

Fig. 7.1 Colors of high pressure gas cylinders

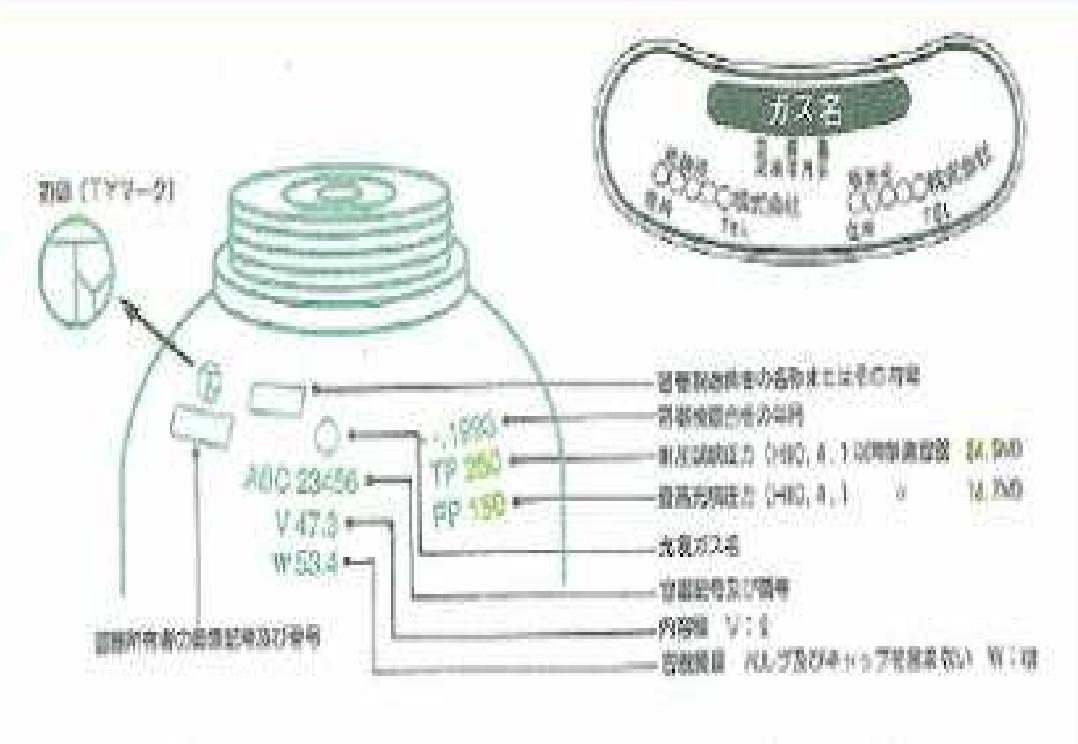
Oxygen gas: black
Chlorine gas: yellow
Carbon dioxide gas: green
Hydrogen gas: red
Ammonia gas: white
Acetylene gas: brown
Others: grey
LP gas: grey

Fig. 7.2 Names of high pressure container part



The shoulder of the container is stamped with letters indicating the name of the contained gas, the container code and number, the internal volume (symbol: V, unit: litter), the container weight (excluding the valve and cap, symbol: W, unit: kg), the date of pressure proof test, the tolerance pressure from the pressure proof test (symbol: TP, unit: MPa) and the maximum charge pressure (symbol: FP, unit: MPa). Fig. 7-3 shows the details.

Fig. 7.3 Shoulder of high pressure container



7.4.2 Handling the cylinder valve and pressure regulator When handling the cylinder valve and pressure regulator, take the precautions ~~as~~ shown in Figs. 7-4 and 7-5.

(1) Before attaching the pressure regulator to the cylinder, loosen the regulating handle of the regulator.

* To loosen the handle, turn counter-clockwise. Then, the gas is “closed”.

(2) Do not put your face against the pressure gauge of the regulator.

(3) Slowly and carefully open/close the cylinder valve.

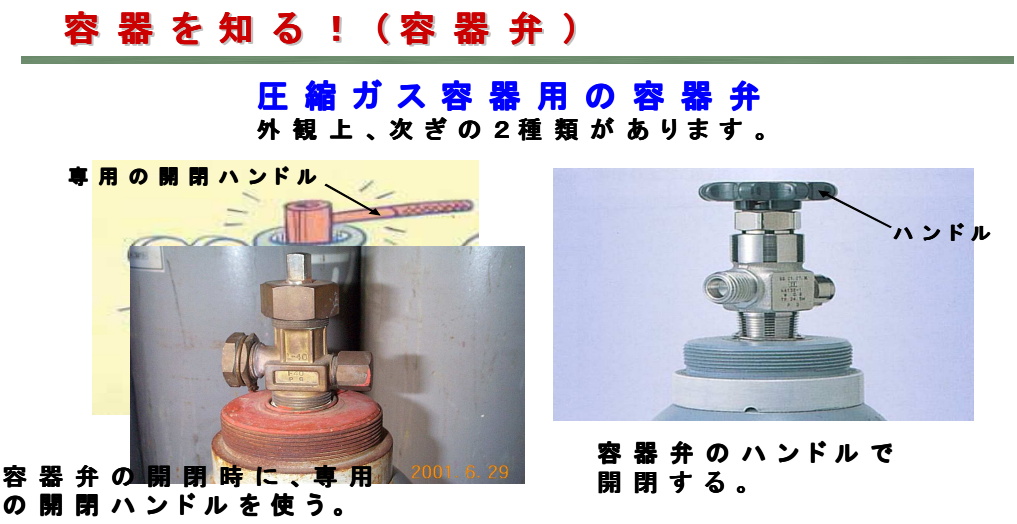
(4) Check for gas tightness at the attachment by checking for liquid bubbling ~~in liquid~~.

(5) Set the outlet pressure of the regulator to the predetermined value by turning the regulator handle clockwise while constantly paying attention to the low pressure gauge.

Fig. 7.4 Cylinder valve

Understanding the gas cylinder (Cylinder valve)

Pressurized gas cylinder valves
Two types of cylinder valves in appearance

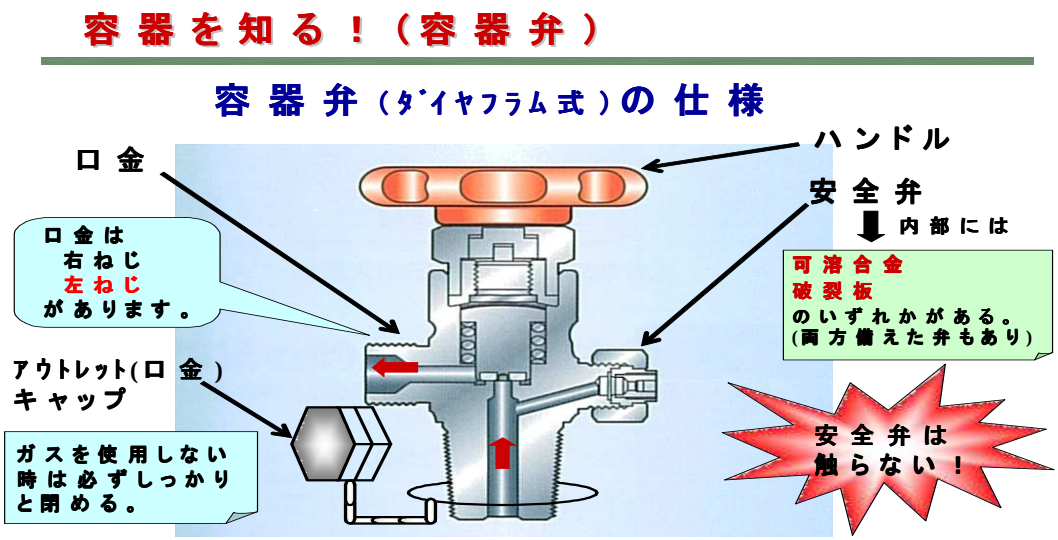


Dedicated open/close handle
When opening/closing, use the dedicated handle

Handle
When opening/closing, turn the valve handle

Understanding the gas cylinder (Cylinder valve)

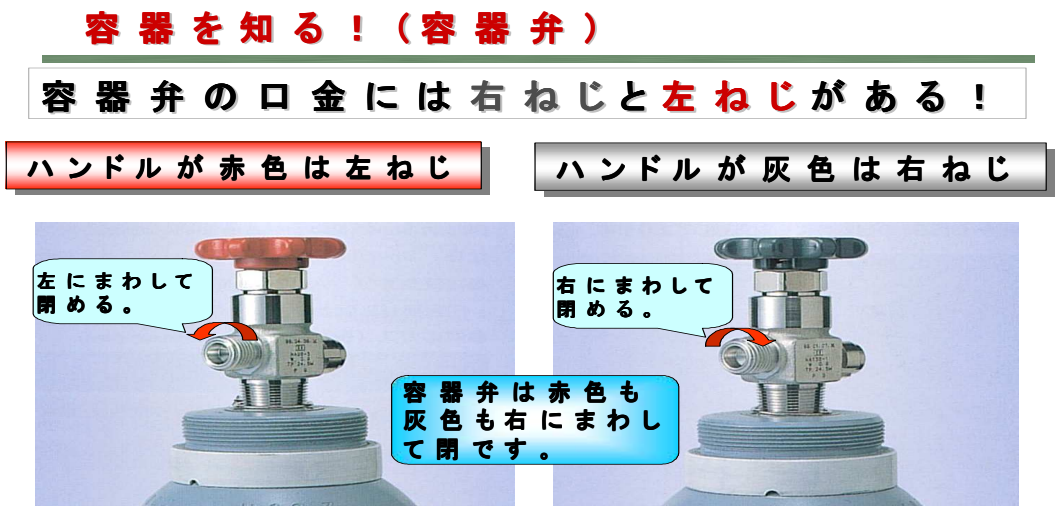
Diaphragm mechanism



Safety valve inside: Do not touch the safety valve
(Either a fusible alloy, burst plate or both are used)
Outlet cap: Be sure to tighten the outlet cap when not in use

Understanding the gas cylinder (Cylinder valve)

There are clockwise and counter-clockwise outlets



Red Handle

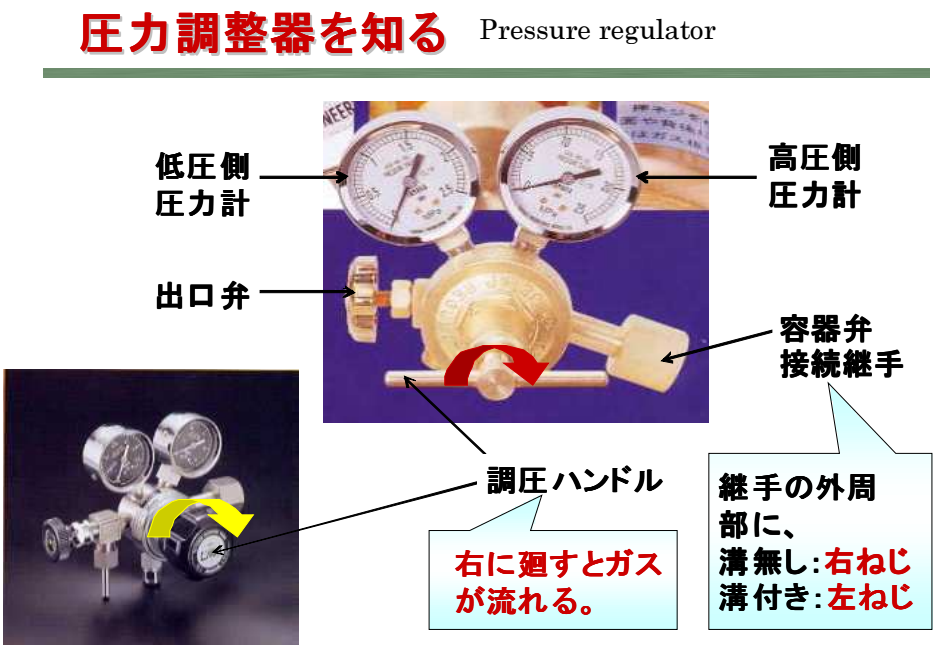
Turn the outlet counter-clockwise to close it

Grey Handle

Turn the outlet clockwise to close it

Turning the outlet clockwise to close it is common between the red handle and grey handle.

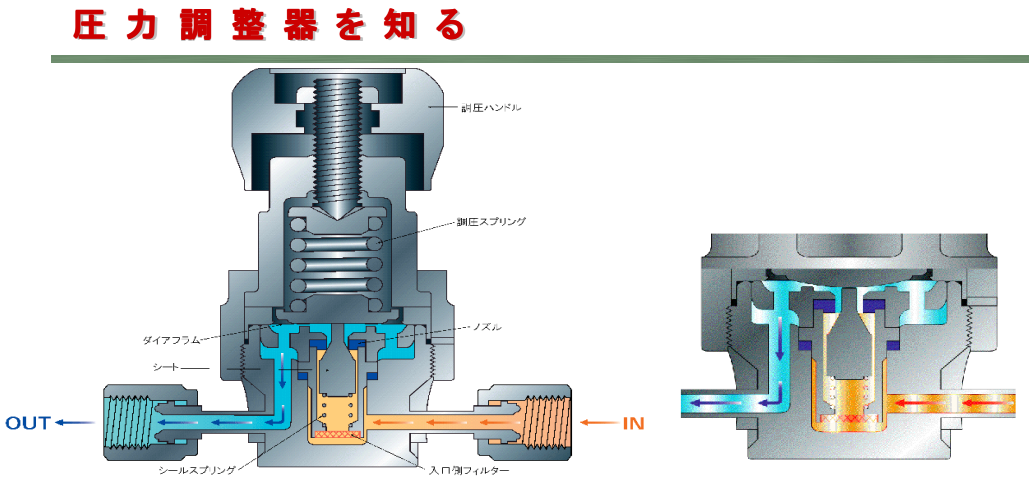
Understanding the pressure regulator



Low pressure gauge, high pressure gauge, outlet valve, cylinder valve, pressure gauge, connection

Turn clockwise to allow the gas to flow

For fittings without grooves, turn clockwise; for those with grooves, turn counter-clockwise



7.4.3 Cautions when moving high pressure gas cylinders

(1) Do not handle roughly or bump the cylinder by dragging them, laying them down or rolling them sideways. The pressure gauge and the connection between the regulator and the cylinder are weak, and are particularly so in the case of impact.

(2) When moving the cylinder over a short distance, use a dedicated two-wheel cylinder cart. When using another type of cart, do not support the cap and valve against the frame.

(3) When moving an acetylene cylinder or liquefied gas cylinder, use a dedicated two-wheel cylinder cart. Stand the cylinder in the cart.

(4) When moving the cylinder manually, check that the cap is tight and carefully move the cylinder by sliding and turning it.

(5) If gas leaks when moving the container, check the leak immediately and take appropriate measures. If the leak is serious and danger is foreseen, move the container to a place where there are no people and the ventilation is good. Make an emergency call.

7.4.4 Keeping high pressure gas cylinders in the facility

The following guidelines for keeping high pressure gas cylinders in the facility were decided at the Safety and Health Committee held in June 2005.

June 28, 2005
Safety and Health Committee
School of Engineering

Keeping high pressure gas cylinders in the facility

1. When bringing in new cylinders or replacing rental cylinders, fill in the “High pressure gas inventory form (Attachment 1)” in each department or laboratory and file it.
2. Store combustible or toxic gas cylinders in a well ventilated location. Keep the temperature where they are stored below 40°C.
3. Sort the cylinders into three types and store them in their respective places in the cylinder corner.
   * Sort with three kinds of labels: “Fill up”, “Empty” and “In use”.
4. When using a stand for the cylinders, take safety measures against overturning in the event of an earthquake. Fix the stand to the floor or wall by chaining at upper and lower positions of the stand. When a stand is not used, chain the cylinder to the wall at the upper and lower positions (refer to Attachment 2).
   * Fasten the cylinder tightly. Do not handle it in a way that permits bumping. Instead of a chain, thick rope or belts that can bear the weight of the cylinder can be used.
5. Keep the area around the cylinder (within 2 m) clear and well organized and do not obstruct walkways. Have only the instruments and the like that are necessary to measure the gas content. Do not use fire and keep combustible materials away.
6. Do not keep combustible gases, oxygen and toxic gases in the same place (or close proximity) to prevent fires, explosions and other disasters.
7. Have appropriate fire extinguishers based on the Fire Service Law.
8. Do not use cylinders that are corroded or have signs of damage on the surface. Return the cylinders to the supplier when they are no longer needed.

9. If the cylinder was purchased, do not use it when it is out of its service life. If it is a purchased cylinder, do a pressure tolerance test before use. Purchased cylinders must undergo testing according to the High Pressure Gas Safety Law and be under strict management. Because of the responsibility in managing the cylinders, it is a requirement to gradually change from purchased to rental.

Attachment 1

High Pressure Inventory Management Log (Example of the form)

Department: Laboratory: Written by:

No.	Date of entry	Type of the container					When moving outside			Used by or place of use	Returned date	Supplier
		Name of gas	Management symbol	Management number	Charge pressure (MPa)	Date of tolerant pressure test (mass/kg)	Date	Moved to	Date of entry			
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												

Attachment 1

High Pressure Inventory Management Log (Example of writing)

Department: Laboratory: Written by:

No.	Date of entry	Type of the container					When moving outside			Used by or place of use	Returned date	Supplier
		Name of gas	Management symbol	Management number	Charge pressure (MPa)	Date of tolerant pressure test (mass/kg)	Date	Moved to	Date of entry			
1	2004/ 4/ 1	Hydrogen	B-12	JKL55555	0.1	2003.4.1(7m3)				Mass spectro.		YY, Ltd.
2	2004/ 4/ 15	Oxygen	B-20	ASD33333	0.1	2003.10.1(1.5m3)				1st lab room	2004/4/30	GG Corp.
3	2004/ 5/ 6	Argon	A-5	QWE22222	0.5	2004.1.4(7m3)	2004/5/10		2004/5/20	Prof. xxx		YY, Ltd.
4	2004/ 5/ 7	Carbon dioxide	A-10	AZXC11111	0.5	20032.1(30 kg)				1st lab room		GG Corp.
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												

Attachment 2

How to prevent high pressure gas cylinders from overturning

(Case 1) One-cylinder stand: chain the cylinder at the upper and lower points

(Case 2) Three-cylinder stand: chain each cylinder at the upper and lower points

(Case 3) Three-cylinder stand: chain each cylinder at the upper part and chain all the cylinders together at the lower point.

How to prevent high pressure gas cylinders from overturning

(1) Fasten the cylinders tightly at two (upper and lower) points. Use one chain for each cylinder to fasten the upper point. Refer to cases 1-3. A belt or a piece of rope can be used instead of chain to secure the cylinders.

(2) If a cylinder stand is used, fasten it to the floor or the wall. If a cylinder stand is not used, fasten each cylinder to the wall.

(3) If a multiple cylinder stand does not have a cradle for each cylinder, or one cradle is empty, chain each cylinder at the upper and lower points to the angle iron to prevent overturning.

(4) If a cylinder rack is made of angle iron, fasten each cylinder at the upper and lower points to the angle iron using a belt, or something similar.

Chapter 8　Biohazards

All students, staff and faculty who carry out experiments using bacteria, laboratory animals or blood and tissues of the human body, do experiments on DNA reformation, or carry out other biological tests have to recognize the risks involved with being exposed to disease germs and toxins. In addition, there is a risk of creating a new organism or allergen. If these samples are mishandled, the handler may suffer infection and then transmit the infection to other human beings or animals. Such risks are referred to as biohazards. To prevent biohazards, it is vital to adhere to sterilization and disinfection guidelines and prevent recombinant DNAs spreading into the environment.

In addition, strict management of bacteria and pathogenic microorganisms and preventing their loss and theft are critical in avoiding infections.

8.1 Handling Bacteria and Pathogenic Microorganism

8.1.1 General cautions when handling microorganisms, etc.

It is essential to be constantly aware that you are handling invisible and toxic bacteriaand be extra cautious when carrying out experimental procedures. The latest information on the risks posed by each bacterium is provided by the National Institute of Infectious Disease and the Japanese Society for Bacteriology through their websites. It is important to fully understand all the risks involved and to carry out disinfection and sterilization according to the latest information.

National Institute of Infectious Disease website (http://www.nih.go.jp/niid/index.html)

Japanese Society for Bacteriology website (http://wwwsoc.nii.ac.jp/jsb/biosafe.htm)

8.1.2 Sterilization

It is important that you understand the various methods of sterilization and have mastered them. There are several methods of sterilization; by heat, gas, percolation, ultraviolet rays, and radiation. The most appropriate method should be chosen for each situation, and must be carried out thoroughly.

8.1.3 Disinfection

Disinfection is a method used to destroy the infectious nature of a bacterium, virus, or germs. Though boiling is an effective method of disinfection, sterilization by disinfectant is more common. However, since many disinfectants are toxic, the amount of the disinfectant used and the amount of time you are exposed to the disinfectant should be minimized, while ensuring that the disinfecting procedure is carried out thoroughly.

8.2 Handling Animals for Biological Experiments

Animals used for biological experiments should be selected from those produced under strict quality management considering inheritance. In situations when these animals cannot be used, there is a risk of contamination while they are being kept. It must be remembered that animals such as rats, mice, guinea pigs, rabbits, cats and dogs harbor bacteria, germs viruses, fungi, protozoa and parasites that can infect human beings. The most common routes of infection are by oral contagion and transmission through scratches and cuts. Therefore, it is crucial to wear safety gear such as, at least, a lab-coat, mask, hat and gloves, and, before and after the experiment, disinfect the hands and instruments used. If bitten, the wound should be immediately and thoroughly washed with running water and then professional medical assistance should be sought.

8.3 Handling Human Blood and Tissues

There are infectious bacteria and viruses in human blood and tissues. Therefore, all experiments and inspections should be carried out with the utmost care. Adhere to the above disinfection procedure and wear safety gear similar to animal experiments. Vaccinations may be necessary in some cases.

8.4 Gene Recombination

There are countermeasures to be taken when carrying out genetic recombinat experiments. They are based on general knowledge on biohazards posed by pathogens. The latest law and notification are the “Law Concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (2003)” and the “Ministerial Ordinance Concerning the Preventive Measures for the Genetic Recombinant Experiment of Type 2 Use of Living Modified Organisms for Research and Development (2004).” The university has established the “Tohoku University Safety Management Manual for the Genetic Recombinant Experiment of Living Modified Organisms.” In addition, the university has notified each faculty and research institute to comply with the “Law Concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms” on July 28, 2005. It is crucial that those who carry the experiments adhere to these regulations and manual strictly and ensure complete safety. The basis of the regulations is to prevent the spread of recombinant genes into the environment. Of primary importance in biohazard prevention is thoroughly

understanding and mastering the knowledge and techniques about handling pathogenic microorganisms. The head of the organization and the people responsible in the laboratory must take full responsibility to ensure safety when conducting recombinant DNA experiments. This includes preparing physical and biological containment devices as well as providing necessary education and training.

The latest information on life sciences including the related laws and regulations and research information is provided by the website of the Ministry of Education, Culture, Sports, Science & Technology, Japan, titled as "Safety Approaches in Life Sciences".

(http://www.lifescience-mext.jp/bioethics/anzen.html#kumikae).

When you plan to conduct gene recombinant experiments or transfer living modified organisms, please contact the Research Cooperation Section of the School of Engineering.

8.5 References (in Japanese)

1) Guideline for biochemical experiments No.3 and 4, Kagaku-Dojin, (1996).
2) "Biological test," New Biochemical Course, Vol.19, Tokyo-Kagaku-Dojin, (1991).

Chapter 9　Radiation (Radioisotopes) and X-rays

9.1 Exposure to Radiation (Radioisotopes) and X-rays

The effects of radiation can be categorized into somatic and hereditary, acute and late onset, or stochastic and deterministic effects. If the radiation damage is in the form of mutation and chromosome aberration and occurs in germ cells, it can be transferred, manifesting itself as a hereditary disorder in the offspring of the exposed individual. This effect is known as the hereditary effect. In other cases, damage to somatic cells has a propensity to become a disorder in the exposed individual. This kind of disorder is known as a somatic or deterministic effect. Since there are thresholds that have to be met in order for a deterministic effect to occur, deterministic effects can be avoided by restricting the radiation dose. The framework of radiation protection is intended to prevent the occurrence of deterministic effects by keeping doses below the relevant threshold, and ensuring that all reasonable steps are taken to reduce the incidence of stochastic effects. The exposure limit (effective dose limit) under Japanese regulations is shown in Table 9.1. At facilities handling radiation or radioisotopes, all areas where there is a possibility of radiation levels exceeding 1.3 mSv in three months are designated controlled areas, and access to those areas is restricted.

Table 9.1 Exposure limit (effective dose limit)

Exposed subject	Exposure limit (not permitted to be exceeded)
Male radiation worker	・ (Effective dose) 100 mSv per five years (50 mSv per year) ・ (Equivalent dose) Eye lens　150 mSv per year Skin　500 mSv per year
Female radiation worker (Excluding pregnant women)	・ (Effective dose) 5 mSv per three months

※Equivalent dose is the dose corrected by a radiation weighing factor based on the effectiveness of the incident radiation since radiation effects on human tissue and organs differ depending on the radiation type and energy.

9.2 Handling of radiation (radioisotopes) and X-rays

Radiation and radioactive materials are causes of hazardous effects. The use of radiation and radioactive materials must be, therefore, strictly controlled. Laws and ordinances apply uniformly regardless of the nature of the establishment. In Japan, the Atomic Energy Basic Law and the Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, Etc., were enacted in 1955 and 1957, respectively. Both have been revised on a regular basis to incorporate the latest scientific and technological knowledge into law.

Because the Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, Etc., was drafted and modified in line with publications of the ICRP, its provisions regarding control do not differ significantly from the international standards. The purpose of the Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, Etc., is to prevent radiation hazards and protect the environment during the use of radiation and radioisotopes. In order to achieve this purpose, the law is separated into two sets of regulations: standards for facilities and regulation standards for actions, which prescribe the appropriate way to handle radiation and radioactive materials.

The Atomic Energy Basic Law deals with the development and use of atomic power and also provides for the separate enactment of the Law for the Regulation of Nuclear Source

Materials, Nuclear Fuel Materials and Reactors to regulate safety control with regard to nuclear materials and reactor operations.

9.3 Radiation Protection Rules at the School of Engineering of Tohoku University

The basic concepts of radiation protection at the School of Engineering of Tohoku University, the safety-control structure, and specific practices that radiation workers must adhere to, are all very clear. Radiation workers at the School of Engineering of Tohoku University must thoroughly understand the rules and observe them at all times. The Radiation Protection Rules detail all aspects of radiation control for the radiation facilities at the School of Engineering of Tohoku University. The responsibilities of the School of Engineering, the radiation protection supervisor, and radiation workers are prescribed.

Because the rules at each establishment are based on the Law Concerning the Prevention of Radiation Hazards, radiation workers are not required to know all details of the law itself. However, they must fully understand all items in the Radiation Protection Rules relating to what they themselves must do. For this reason, lectures on the rules are included within the education and training provided prior to anyone handling radiation or radioisotopes for the first time.

Major Items Covered in Radiation Protection Rules

1) The responsibilities of those working with radiation ("Radiation Workers")
2) The responsibilities of the radiation protection supervisor and other personnel engaged in safety control
3) The selection of an acting radiation protection supervisor
4) The maintenance and management of radiation facilities
5) The inspection of radiation facilities (controlled areas)
6) The uses of radioisotopes and radiation generating equipment
7) Refills, storage, transportation and disposal
8) Measuring, recording and recording of radiation doses, etc.
9) Education and training
10) Medical examinations
11) Record entries and the custody of records
12) Emergency measures
13) Other items necessary for the prevention of radiation hazards

9.4 Radiation Workers

Those who handle radiation generating equipment or radioisotopes mainly in controlled areas are legally referred to as "radiation workers" under the Law Concerning the Prevention of Radiation Hazards. Radiation and radioisotopes are considered harmful, and must not be handled by just anybody. Only those who have completed specific prerequisite steps to work in controlled areas are allowed to use radiation or radioisotopes, i.e. to serve as radiation workers. Radiation workers, in the course of their handling of radiation and radioisotopes, are concurrently subject to necessary personnel control (education and training, exposure control and health control).

Only those who have had both the required education and training and a medical examination are permitted to enter controlled areas as radiation workers. Education and training are given to radiation workers to ensure that they have the minimum knowledge and skills required of radiation workers. Three kinds of training courses are organized by Cyclotron and Radioisotope Center at Tohoku University for new applicants: i) a Radioisotope Training Course for the handling of radioisotopes and/or radiation from accelerators, ii) an X-ray Training Course for the handling of X-rays and/or electron microscopes, and iii) a

Synchrotron Orbital Radiation Training Course. The applicants must take the appropriate course corresponding to the type of radiation they will use. A medical examination is required to determine if the individual is medically suitable for assignments involving the handling of radiation and radioisotopes. New applicants must also attend the instructive course held at the School of Engineering of Tohoku University in which the safe handling of radiation and the radiation protection rules of the department are explained. If the radiation worker claims to have had, or clearly has had experience handling radiation at another establishment, the past records of his or her exposure must be carefully checked.

After finishing all the application procedures, it is possible to be designated as a radiation worker in the radiation facilities at the School of Engineering of Tohoku University, and a personal dosimeter will be issued to you. Radiation workers should be informed of the results of their personnel monitoring on a monthly bases, and they themselves should make a habit of confirming such results. In each laboratory, radiation workers must learn from the supervisor and/or colleagues about the procedures, rules and the handling manual of radioisotopes and/or radiation generating equipment in that particular facility.

9.5 School of Engineering Radiation Safety Management Office

In order to carry out appropriate and thorough radiation control and the measured management of nuclear fuel materials, a Radiation Safety Management Office was established for the radiation facilities at the School of Engineering of Tohoku University.

Radiation Protection Supervisor: Keizo Ishii
Sub-radiation Protection Supervisor: Ryo Nakayama
Sub-radiation Protection Supervisor: Hiromichi Yamazaki
Sub-radiation Protection Supervisor: Yoshinori Takahashi
Radiation Protection Officer: Mitsuyoshi Satoh
Office Tel.: 795-7939

Detailed rules on radiation safety control in accordance with the conditions and circumstances of radiation facilities must be provided in each facility's manual for radiation protection. Radiation workers must fully understand the basic concepts of radiation protection at each facility.

Chapter 10　Laboratory Waste Treatment

10.1 Basic Principles for Laboratory Waste

10.1.1 Basic attitude toward laboratory waste treatment

(1) Waste harmful to the environment must not be discharged from the university.

(2) The responsibility for treating and disposing of laboratory waste lies with the individual who generated it.

10.1.2 General rules

(1) Waste water that does not meet the Effluent Standards set forth by Sewage Law (see the attached table) must not be discharged into the laboratory sink.

(2) Do not throw laboratory waste into normal trash cans.
The normal trash should not contain hazardous materials. Empty reagent bottles must be disposed according to the resource recycling guidelines.

(3) Do not burn laboratory waste in incinerators.

10.2 Guideline for Laboratory Waste Treatment

10.2.1 Solid waste

(1) Each laboratory must keep solid waste including solid waste reagents and the precipitation sludge from experiments, paying attention to not causing loss or leakage. Clearly indicate the content on each waste container. Waste treatment is outsourced to an external waste treatment company on a faculty/research institute basis. Outsourcing is once a year.

(2) Each laboratory must carefully keep the waste (PCBs, beryllium, thallium, osmium etc.) that does not have a suitable waste treatment method.

(3) For the treatment of radioactive isotopes and any related hazardous waste, follow the instructions of the Radiation Safety Management Office.

(4) For the disposal of empty reagent bottles, wash the bottles twice, making sure to recover all the wastewater if the bottle content was poisonous or deleterious substance, since there is some residue of the reagent left even inside “empty” bottles.

10.2.2 Liquid waste

(1) The Environment Conservation Research Institute (ECRI) requires each discharger

of liquid wastes to put them into the designated plastic containers, as a primary treatment, according to the Liquid Waste Classification Table.

*The Liquid Waste Classification Table has been made for the safe and efficient operation at ECRI, Confirm this table carefully and classify and store the liquid wastes appropriately according to the Quick-reference Guide for Sorted Collection. If you have further questions, please inquire to ECRI.

(2) Do not discharge explosive substances, carcinogenic substances or pathogenic microorganisms to the ECRI without appropriate pre-treatment (ECRI may accept them after detoxification).

10.3 Waste Liquid Treatment at the Environment Conservation Research Institute (ECRI)

10.3.1 Introduction

Most of the wastes that are generated from the education, research and medical activities at the university may have an adverse effect on human health and the environment. They must be treated properly with regard to environmental conservation and public health concerns.

The basic principle of waste treatment is an "on-site treatment", meaning that waste treatment must be carried out at the laboratory that produces it. The general rule at Tohoku University is "Treating your waste is your responsibility". Handling waste should be included in the education, research and medical activities at the university. The on-site treatment means that no activity has been completed until the waste has been properly treated.

All wastes are finally discharged into the natural environment. When you treat waste, always keep in mind that it must be detoxificated and made harmless, and that the waste volume must be minimized. From this point of view, it is essential to understand the on-site treatment concept, that is, the discharger collects, sorts and treats the waste on their own.

The ECRI was established on April 1st, 1979 as a service organization for the whole university. The ECRI treats waste common to laboratories to allow for efficient collective waste treatment. In order that the collective treatment at the ECRI is carried out effectively, each discharger must classify and store the waste liquids appropriately (on-site treatment). This is because each respective discharger knows the history, the content, and the risks of the waste better than anyone else. This process not only ensures the waste liquid is treated properly, but also encourages an awareness of the

need to protect the university environment.

The PRTR law, which regulates chemical substances management and environmental protection, was established in July, 1999 and was enacted in 2001. Since the School of Engineering, where a large amount of chemical substances are handled on a daily basis, is subject to this law, every department and laboratory must control the purchase, use, discharge, disposal and inventory management of specified substances.

10.3.2 Collective treatment and on-site treatment

A wide variety of experimental waste from research, education and medical treatment is generated in the university. Waste is treated collectively at the ECRI to make it harmless. In addition, it is necessary that the relevant students, staff and faculty take the responsibility for treating the waste in their respective laboratories (on-site treatment). The combination of the treatments at each laboratory and ECRI enables Tohoku University to fulfil its responsibility to protect the environment. On-site treatment processing means that waste must be stabilized at each laboratory that generates it prior to collective treatment. The reason is that each researcher who generates waste knows the history, content and inherent risks of the waste better than anyone else. Research and education activities at the university must include the on-site treatment of waste. Researchers fulfil their minimum social responsibility through this process of on-site treatment. Collective waste treatment is carried out at a great cost, a cost that the university considers justified considering the value of the research, education and medical treatment carried out at Tohoku University. All laboratory waste must be disposed of properly in order that the activities essential to our university run smoothly.

10.3.3 The PRTR Law regarding waste treatment

The PRTR (The Pollutant Release and Transfer Register) provides strict guidelines for reporting to the government agency on the amounts of chemicals released to the environment and those transferred off-site in the form of the waste, then, tallying the reported data and finally publishing them. In Japan, PRTR was regulated in the “Law Concerning Reporting Releases of Specific Chemical Substances to the Environment and Promoting the Improvement in Their Management”, which was enacted in 1999.

Organizations handling Class 1 designated chemical substances (354 kinds) listed under this law, are required to estimate the quantities of chemical substances both released to the environment and transferred in the form of waste. It is their duty to report the data to the government agency if they handle 1 ton or more of the designated

chemical substances and/or 0.5 tons or more of the specific Class 1 designated chemical substances (11substances including asbestos). The government tallies the reported data from various organizations. The amount of each designated chemical thus tallied is added to the data estimated for the discharges from households, farmlands and automobiles. The agency annually publishes both actual and estimated data. According to the PRTR system, we know every year what kinds of chemicals are discharged, from where they are discharged, and the quantities that are discharged.

Institutions of higher education (including affiliated facilities, and excepting humanity sciences) are subject to the PRTR Law. The Aobayama campus in Tohoku University is considered an independent establishment. The procedures to report the related government agency are as follows:

(1) When each laboratory of the School of Engineering purchases or uses the designated chemicals, register the purchased and used amounts into the Management System for Lab Chemicals.
(2) The Health and Safety Management Office tallies the data registered by each laboratory at the end of the year and reports the calculated results to ECRI.
(3) ECRI tallies the data collected from each campus (Aobayama, Kawauchi, Katahira, Amemiya, and Seiryo), and if the total amount for any of the designated substances is exceeded the specified level, the ECRI reports it to the related government agency.

The amount of the designated chemical substances handled in the School of Engineering is added to those from the School of Science and the School of Pharmacy.

Since the ECRI collects waste liquid from the whole campus, it is considered to be an independent establishment. Therefore, even if the annual amount of one particular designated chemical substance used in a certain laboratory is small, the annual amount handled at the ECRI could be very large. Thus, each laboratory is asked to register its liquid waste in the Management System for Laboratory Waste.

Please inquire to the Safety and Health Committee of each department and the Health and Safety Management Office. You can access the list of Class 1 designated chemical substances on the Internet.

(http://law.e-gov.go.jp/htmldata/H12/H12SE138.html)

10.3.4 Waste liquid treatment procedure

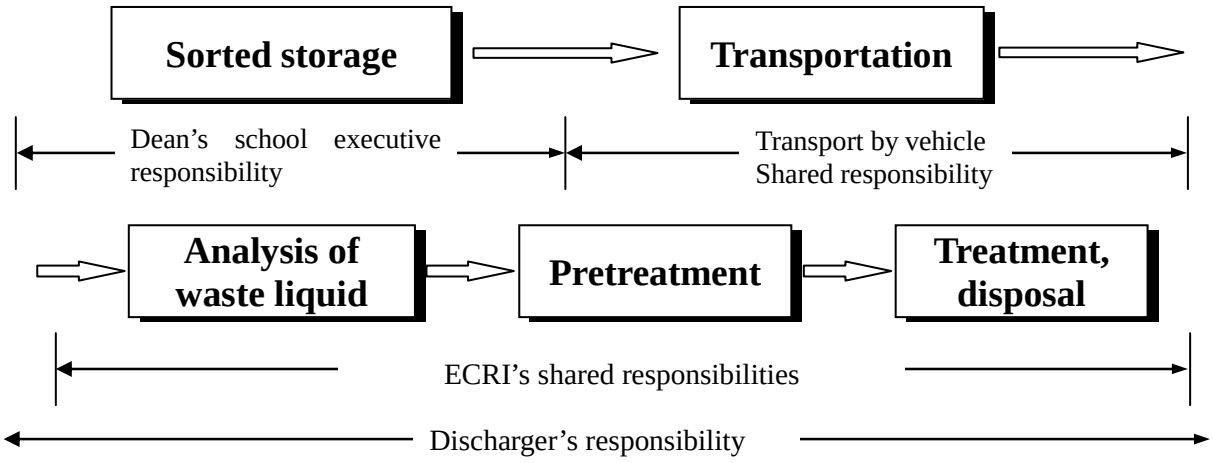
1. Laboratory waste liquid must be kept in a plastic container (Use a designated colored container. Color changes depending on the substance.) in a sorting manner at each

discharging laboratory (on-site waste treatment) according to the Classification Table of Waste Liquid. Register the Management System fot Laboratory Waste and apply to the ECRI for waste liquid treatment.

2. Laboratory waste liquid from each laboratory is collected by the ECRI on the designated date at the designated place.
3. The ECRI analyzes the waste liquid and checks if the primary treatment (classified storage) has been done correctly according to the classification table. If the waste liquid cannot be treated at the ECRI or primary treatment has not been carried out properly, it will be returned to the discharger.
4. The ECRI treats the waste by separating the treated wastewater and solid waste (hazardous sludge). After the water quality analysis, the treated wastewater will be discharged to the public sewage drain if it meets the effluent standards of the Sewage Law of Sendai City.
5. The final treatment of the solid sludge is carried out by a disposal company licensed by the Japanese government.

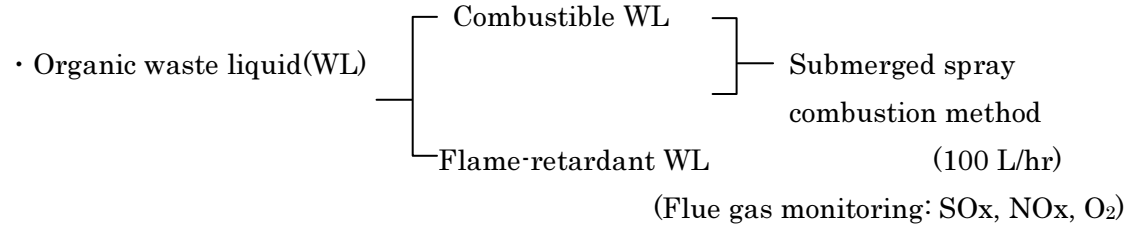
*The discharger is responsible for any accidents which occur during procedures 1 through 4.

* The following chart shows the actual flow of waste and responsibility for it with regard to the collective treatment.



*The discharger of each laboratory waste liquid must keep in mind that he or she is responsible for the entire process and should follow the guidelines for the collective waste treatment.

10.4 The Treatment System at the ECRI



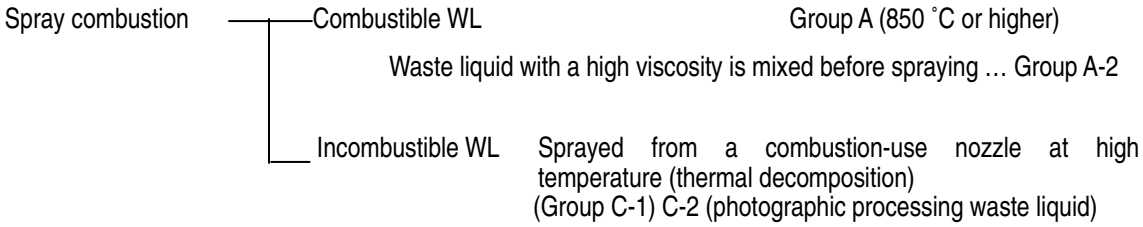
・Inorganic WL ——— Air oxidation ferrite method
(1,500 ppm 6m³/batch)

・Pretreatment
- ·Mercury compounds (Dowa iron powder method, Chelate resin method)
- ·Fluoride compounds（Calcium salt precipitation method）
- ·Cyanide compounds (Thermal decomposition)

10.4.1 Classification table and treatment system

In order to ensure the treatment system procedures are carried out efficiently at the ECRI, a classification table has been prepared based on the treatment methods and their limits. The discharger must follow this table when sorting and keeping laboratory waste liquid.

10.4.2 Treatment of organic waste liquid



Cautions

1. Explosive substances must not be included.
2. The waste must not contain any PCBs.
3. The waste must not contain any pathogenic microorganisms.
4. The waste must not contain any carcinogenic experiment waste liquid.
5. Group B waste must be treated at an external waste treatment company.

10.4.3 Treatment of inorganic waste liquid

Heavy metals are treated collectively according to the air oxidation ferrite method.

The following are ferrite reactions:

$$nM^{2+} + (3-n)Fe^{2+} + 6OH^- \rightarrow M_nFe_{(3-n)}(OH)_6$$

$$M_nFe_{(3-n)}(OH)_6 + 1/2O_2 \rightarrow M_nFe_{(3-n)}O_4 + 3H_2O$$

(ferrite solid solution)

Here "M" refers to metal ions. The following ions can be treated.

Mg, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, Sb, Pb, Ag, Zr, Sr, Ba, Sn, Bi, Y and Lanthanides (Be, Se and Os cannot be treated).

Disadvantages of the ferrite method (The necessity of pre-treatment)

1. The efficiency for the Hg ion is relatively low. (Group D)
   (The discharger must treat organic mercury into organic mercury.)
2. Cyanide ion cannot be decomposed. (Group E)
3. Fluoride and phosphate ions cannot be removed. (Group F-2)
4. Organic substances and sulfur interfere with the ferrite reaction. (Group C-1 and C-2)
5. Organometallic complexes cannot be treated. (Group C-1)

10.5 General Cautions for Sorting and Keeping

In order to operate the treatment system at the ECRI safely and efficiently, the dischargers are required to keep the waste liquid after strict sorting according to the classification table for collection.

The discharger must pay special attention to the following:

Read the classification table carefully to ensure that the ECRI's waste treatment system operates safely and efficiently. The discharger has responsibility for correct classification and keeping (on-site waste treatment).

Take cautions as follows:

1. Do not hesitate to clarify your understanding or make queries to the ECRI if you have any questions. Do not include matters of which you are not sure of the content, since this may cause an accident or cause a system breakdown at the ECRI facility.
2. Keep a record of the content when you put waste liquid into a plastic container.
3. Any precipitates including suspended solid that may have been generated when

kept in the laboratory must be filtered out beforehand.

4. If the waste liquid has the potential to generate gas, ensure that gas generation has stopped before discharging it.
5. Polymeric compounds must be solidified with a suitable solvent and filtered.
6. The concentration of heavy metals must be no higher than 5,000 ppm (5 g/l) or lower. In the case of mercury, the limit is 1,000 ppm (1 g/l).
7. Inform the ECRI if there is any possibility of spontaneous ignition when mixed with other substances.
8. Explosive materials, radioactive materials and liquids containing pathogenic microorganisms are prohibited.
9. Keep in mind that there are workers at the treatment site.

Questions and Consultations

1. Please contact the ECRI when you need detailed information on using the ECRI's waste treatment system.
2. For details about waste liquid treatment, please send fax or email to ask questions and avoid any inconvenience of missing contact with the relevant staff because of his/her temporary absence.
3. Detailed information on waste liquid treatment is available from the ECRI website. (http://www.env.tohoku.ac.jp/index-j.html)

ECRI contact number

For detailed liquid waste treatment

FAX: 795-7530

Emergency TEL: 795-5937, 3782

For administrative matter (10:30-17:00):

TEL: 795-4321

Organic waste liquid classifications

	Container color	Materials	Substances which cannot be treated at the ECRI	Cautions for handling	Treatment
Solid Wastes		Organic solid specimens and products	Consult with the ECRI	Remove the liquid sufficiently.	Commission out to a private company.
Combustible organic waste liquids	A-1 (Red)	Flammable organic solvents (hexane, alcohols, acetone, ethyl acetate, acetonitrile, toluene, benzene, xylene, etc.)	1. PCBs and those containing PCBs 2. Nitric ester, nitromethane, diazo compounds, etc. (explosive substances)	The emulsion is classified as C-1. Halogenides are classified as B. Organic waste liquids with a high flash point such as glycerin and ethylene glycol are classified as C-1.	Spray combustion
		Explosive organic solvents (aniline, nitrobenzene, pyridine, etc.)			Same as above
		Highly flammable organic solvents (diethyl ether, petroleum ether, carbon disulfide, etc.)	Those classified as special inflammable materials under the Fire Service Law.	Ensure the concentration below ca.5% in the 18 liters of waste liquid. Do not store in the laboratory in large quantities. Ask for collection frequently.	Same as above
	A-2 (Red)	High viscosity oils (heavy oil, machine oil, animal and vegetable oil, and other high viscosity oils)	Consult with the ECRI for silicone oil.	Dilute viscosity liquids.	Same as above
Halogen	B (Brown)	Halogenated organic solvents(with water). (Chloroform, methyl chloride, methyl dichloride, carbon tetrachloride, methyl bromide, dichloromethane, chlorobenzene, benzyl chloride, etc.) Halogenides containing water (hydrochloric acid, perchloric acid, iodic acid, etc. mixed with an organic solvent such as alcohol or acetone)	1. PCBs and those containing PCBs 2. Explosive substances	Specify the name of each halogen element with its concentration.	Spray thermal decomposition
Non-combustible organic waste liquids	C-1 (Green)	Organic solvents containing water(aqueous solutions containing water-soluble organic compounds such as alcohol, organic acid and amines, or those containing a large quantity of water) Those forming an emulsion			Same as above
		Waste liquids from the circulating aspirator Water containing a slight amount of organic solvent			Same as above
		Non-decomposable waste liquids (chelate compounds, organometallic compounds, etc.)			Same as above
		Acids such as sulfuric acid and nitric acid containing organic compounds (excluding the acids containing hydrochloric acid, perchloric acid, etc.)		Take measures to classify the waste liquids containing hydrochloric acid as F-1. Adjust pH to 3-4.	Same as above
	C-2 (Green)	Developers and stop solutions		Do not mix with a fixing solution.	Same as above
Biohazardous wastes	G (Orange)	Biohazardous wastes			Consult with the ECRI $4 \leqq pH < 9$

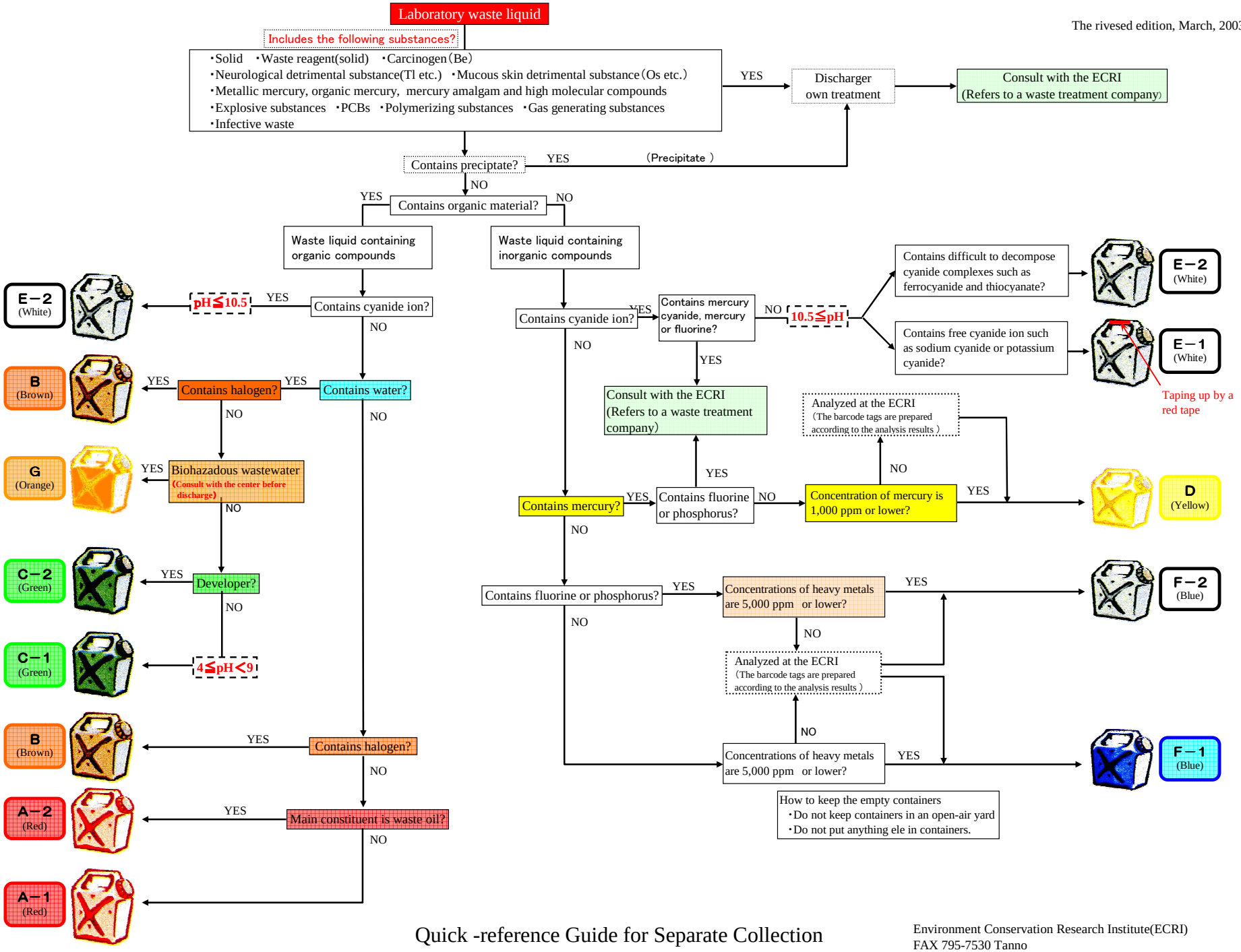
Refer to the separate collection table for details.

Inorganic waste liquid classifications

	Container color	Materials	Substances which cannot be treated at the ECRI	Cautions for handling	Treatment
Solid waste		Solid generated during laboratory activities. Precipitate Silica gel Other solids	Consult with the ECRI.	Drain the moisture before storage. Keep mercury and mercury compounds in a plastic bag.	Consult with the ECRI.
Inorganic waste liquid	D (Yellow)	Waste liquid containing inorganic mercury compounds	Solid of metal mercury, amalgam mercury and inorganic mercury, and liquids containing (including) organic mercury	Specify the mercury concentration.	Dowa's iron powder method
	E-1 (White)	Waste liquid containing cyanide ion.	1. Waste liquid containing cyanide complexes difficult to decompose is classified as E-2. 2. Solids of cyanide complexes cannot be treated. .Make sure there is no strong acid in the waste.	Keep the waste liquid alkaline(pH of 10.5 or higher)	Dilute and submit to thermal decomposition under an atmosphere of 1,100℃
	E-2 (White)	Waste liquid containing cyanide complexes difficult to decompose			
	F-1 (Blue)	Acids and alkalis Aqueous solutions containing metals (cadmium, lead, chromium, arsenic, manganese, iron, nickel, magnesium, tin, copper, zinc, selenium, etc.)	1. Waste liquid containing cyanide complexes is classified as E-2. 2.Waste liquid containing organic compounds or chelate compounds is classified as C-1. 3.Solid powder cannot be treated.	For liquids not containing hazardous materials, discharge is possible after neutralization to pH of 5-9. Solutions containing organic compounds (acetone, alcohols, etc.) are classified as C-1. Solutions containing aqueous ammonia or ammonium compounds are classified as C-1.	Neutralization Air-oxidized ferrite method
		Beryllium, osmium and thallium	Consult with the ECRI.	Be cafeful because these materials are virulent.	
	F-2 (Blue)	Waste liquid containing inorganic phosphorous compounds. Waste liquid containing inorganic fluorine compounds.	Waste liquid containing organic compounds or chelate compounds is classified as C-1.	Do not put undiluted hydrogen fluoride into the waste. Do not mix with strong acid.	React with slaked lime and precipitate (calcium fluoride).
					React with slaked lime and precipitate (calcium phosphate).
Photographic waste solutions		Fixing solution		Do not mix with other waste liquids. The color and size of the plastic container is not designated.	Commission out to a private company

Refer to the separate collection table for details.

The rivesed edition, March, 2003



Quick -reference Guide for Separate Collection

Environment Conservation Research Institute(ECRI)
FAX 795-7530 Tanno

Effluent standard according to the Sewage Law

Substances or items				Designated work sites		Non-designated work sites		Effluent standard (see Ministry of Environment Ordinance for detail)
				Amount of effluent(<50 m³/day)	Amount of effluent (≧ 50m³/day)	Amount of effluent (< 50m³/day)	Amount of effluent (≧ 50m³/day)	
Standard by local law		Temperature		<45℃	＜45℃	＜45℃	＜45℃	-
		Hydrogen ion concentration (pH)		5~12	5 ~ 9	5 ~ 11	5 ~ 9	Public water area except ocean 5.8~ 8.6 Ocean 5.0 ~9.0
		Biochemical oxygen demand (BOD)		<1200	<600	<1200	<600	160 ［120］
		Suspended solid (SS)		<1200	<600	<1200	<600	200 ［150］
		Iodine consumption		<220	<220	<220	<220	-
		Content of n-hexane extract	Mineral oils	5	5	5	5	5
			Animal and vegetable fats and oils	150	30	150	30	20
Standard by ordinance	Substances which pose a potential risk to the environme-nt	Phenols		5	5	5	5	5
		Copper and its compounds		3	3	3	3	3
		Zinc and its compounds		2	2	2	2	2
		Iron and its compounds (soluble)		10	10	10	10	10
		Manganese and its compounds (soluble)		10	10	10	10	10
		Chromium and its compounds		2	2	2	2	2
	Toxic substances	Cadmium and its compounds		0.1	0.1	0.1	0.1	0.1
		Cyanide		1	1	1	1	1
		Organic phosphorous and its compounds		1	1	1	1	1
		Lead and its compound		0.1	0.1	0.1	0.1	0.1
		Dichromate and its compounds		0.5	0.5	0.5	0.5	0.5
		Arsenic and its compounds		0.1	0.1	0,1	0.1	0.1
		Mercury, alkyl mercury and other mercury compounds		0.005	0.005	0.005	0.005	0.005
		Alkyl mercury compounds		Not detected	Not detected	Not detected	Not detected	Not detected
		Polychlorinated biphenyl		0.003	0.003	0.003	0.003	0.003
		Trichloroethylene		0.3	0.3	0.3	0.3	0.3
		Tetrachloroethylene		0.1	0.1	0.1	0.1	0.1
		Dichloromethane		0.2	0.2	0.2	0.2	0.2
		Tetrachloromethane		0.02	0.02	0.02	0.02	0.02
		1.2-dichloroethane		0.04	0.04	0.04	0.04	0.04
		1.1-dichloroethylene		0.2	0.2	0.2	0.2	0.2
		Cis-1.2- dichloroethylene		0.4	0.4	0.4	0.4	0.4
		1.1.1-trichloroethane		3	3	3	3	3
		1.1.2-trichloroethane		0.06	0.06	0.06	0.06	0.06
		1.3-dichloropropene		0.02	0.02	0.02	0.02	0.02
		Thiuram		0.06	0.06	0.06	0.06	0.06
		Simazine		0.03	0.03	0.03	0.03	0.03
		Thiobencarb		0.2	0.2	0.2	0.2	0.2
		Benzene		0.1	0.1	0.1	0.1	0.1
		Selenium and its compounds		0.1	0.1	0.1	0.1	0.1
		Boron and its compounds		12(230)	10(230)	10(230)	10(230)	10(230)
		Fluorine and its compound		8(15)	8(15)	8(15)	8(15)	8(15)
		Nitrogen in forms of ammonia , nitrite and nitrate		380	380	380	380	100
		Dioxins		10pg/L	10pg/L	10pg/L	10pg/L	10pg/L
	Effluent standard Water Pollution Control Law	Number of coliform group		-	-	-	-	3000/cm³
		Chemical oxygen demand (COD)		-	-	-	-	160 ［120］
		Phosphorus		-	-	-	-	16 ［8］
		Nitrogen		-	-	-	-	120 ［60］

(note)

1. All units are mg/L except dioxins, pH, temperature and coliform. [ ] shows daily average.
2. ▨ shows effluent standard which, if exceeded, result in direct penalties.
3. □ shows effluent standard necessitating the facility to be relocated.

Chapter 11　Electricity

11.1 Natural Properties of Electricity

11.1.1 Commonalities between nature and electricity

Depending on whether you are looking at the peak of Mt. Izumigatake from Sendai city or from half way up the mountain path, you will have a very different sense of its height. The difficulties you might encounter while trekking are largely due to the ups and downs of the trekking pathway, as well as the bumpiness and corrugation of the walkway. The mountain water originating in the western Izumigatake range flows into many waterfalls, weaves its way through hills and valleys, and finally flows into the Hirosegawa River. As shown by these examples, there are many commonalities between nature and electricity. Instead of nature's mountain paths, waterfalls and rivers, with electric phenomenon we have to contend with the voltage potentials, the electric field intensity, the current magnitude and the current density.

11.1.2 Types of electricity and the electrical nature of physical objects

Electricity can be generally classified into static electricity and dynamic electricity. Lightning is a good example of static electricity, but the most common type we encounter on a daily basis is the crackling sound you hear when taking off a sweater. Dynamic electricity can be further categorised into two types: a) direct current (DC) from a battery cell, and b) alternating current (AC), commercial power provided from a power utility company.

Some physical objects have high electric resistance and others have low resistance. "Insulators", in fact, only act as insulators for DC, but let electric charges pass through in the case of AC each time the potential alternates. To put it differently, insulators act as capacitors, letting the current flow through when alternating potential is applied. This quality becomes more apparent the higher the frequency, and the higher the dielectric constant. For this reason, insulators can also be called dielectric objects. A classic example is air: high voltage applied to air can generate spark discharges, resulting in a dielectric breakdown. Vinyl chlorides, rubber, and glass are known to have a dielectric strength about ten times higher than air.　However, surprisingly, when a vinyl chloride sheet is inserted with electrodes, the dielectric breakdown starts at a much lower voltage than you might expect. The reason for this is that the voltage split between the air and the vinyl chloride is proportional to the dielectric constants of each material. Thus, when electrodes are inserted into a vinyl sheet, it acts more like a

conductor than an insulator. It should be noted that organic compound materials like plastics can have very low dielectric strengths, especially if the object develops cracks in harsh environmental conditions.

11.2 Electrical Wiring and Earthing

11.2.1 Electrical wiring system

Electric power is supplied to the university buildings via power lines. The general voltage classification in Japan is:

(1) Low Voltage: DC – 750 Volts or lower
AC – 600 Volts or lower

(2) High Voltage: DC – from 750 Volts to 7,000 Volts
AC – from 600 Volts to 7,000 Volts

(3) Rated High Voltage: 7,000 Volts or higher

The School of Engineering buildings are provided with AC three-phase, 66,000 Volts from Tohoku Electric Power Company. The substation in the university lowers the voltage and dispatches electricity to each building. Mainly, 100 V is used for the single-phase, three-wire system, and 200 V is for the three-phase, three-wire system. Table 11-1 summarizes how each building receives electricity.

Table 11-1 Electricity supply systems for the School of Engineering buildings

Power Supply Plan		Lecture and administrative buildings (rooms)	Research buildings (rooms)	Experiment buildings (rooms)	Factories
Single-Phase	Two-wire, 100V	Mech. Eng. Elect. Eng. No.3		Elect. Eng.	
	Three-wire, 100/200V	Quantum Eng. Mech. Eng. Elect. Eng. Chem. Eng. Elect. Eng. No.3 Admin. Building, Lecture Hall	Elect. Eng. Materials Eng. Env. Eng. Human –Social Eng. Lab. Complex Building Admin. Building	Elect. Eng. Chem. Eng. Env. Eng. Human Eng. Quantum Energy Materials Eng. Lab. Complex Building Admin. Building	Mech. Eng. Materials Eng. Env. Eng.
Three-Phase	Three-wire, 100V, 110V	Admin. Building		Elect. Eng.	

	Three-wire, 200V	Mech. Eng. Chem. Eng. Human Eng. Quantum Eng. Elect. Eng. No.3 Admin. Building, Lecture Hall	Elect. Eng. Env. Eng. Materials Eng. Env. Eng. Lab. Complex Building Admin. Building	Elect. Eng. Chem. Eng. Metal. Eng. Env. Eng. Human Eng. Quantum Eng. Lab. Complex Building Admin. Building	Mech. Eng. Materials Eng. Env. Eng.
	Three-wire, 400V			Quantum Eng.	
	Three-wire, 3.3kV			Materials Eng.	

The wiring schemes for AC power are explained below.

a) Single-phase, three-wire system

Figure 11-1 shows the single-phase, three-wire connection. This wiring system, from the transformer room to the distribution panel at each floor at the university, is used to provide electricity for lighting and other purposes. This system is similar to that used for household wiring. After the distribution panels, two wires go to the wall outlets. The three-phase distribution panel and power switches usually use red, white (as neutral), and black wires. The voltage between the neutral (white) and either of the other wires is 100 V, and 200 V between black and red wires.

If you are unsure which wire is neutral, measure the voltage between a grounded portion of the distribution panel, such as its frame, and the wire in question. The neutral wire should give you a potential reading of around zero. The neutral circuit should not use power fuses anywhere within, and should have a copper bar as the base conductor. This is because if a fuse melts in an accident, the rest of the panel can experience a high voltage surge exceeding 100V, resulting in potential ignition damage of the instruments. The exception to this is when you use a molded case circuit breaker with a safety mechanism which can simultaneously trip all three lines, including the neutral.

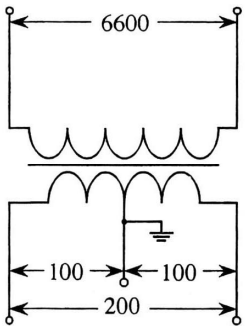


Fig. 11-1 Single phase, three-wire

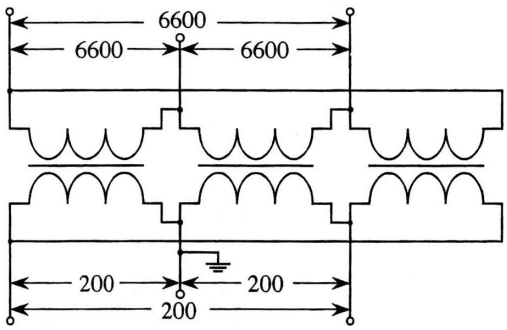


Fig 11-2 Three phase, three-wire

b) Three wire, three-phase system

Figure 11-2 shows the three-wire, three-phase connection. This wiring system is used for 200V appliances such as air conditioners. The voltage of any two wires of the three wires combines to 200V. Usually one wire is grounded and the other two provide 200V.

11.2.2 Wiring in laboratories

Usually in laboratories, there are electricity outlets on the wall and a distribution panel for experiment activities. The maximum rated output of wall outlets is usually 15 Amperes (A), so if you need outputs higher than this, you have to consider an additional wiring system to receive electricity supply directly from the distribution panel. Ask a professional electrician from a special manufacturer for wiring work (ex. Cable wiring, etc. with the introduction of experimental equipment) other than easy wiring to get rid of octopus wiring by removing the plug from the outlet.

There were two electrical fires in 2007 (July and October). One was caused by a short circuit due to an overload in the distribution panel cable that ignited papers around the panel. The other was also caused by a short circuit because a plug was not completely inserted into the outlet. Dust accumulated on the exposed electrodes and the short circuit ignited near-by papers. The common causes of these fires were the existence of flammable materials in humid places or around the electrical equipment. Electrical fires can happen in laboratories and homes where electrical appliances are used. To avoid a third fire, check electrical equipment, etc. using the checklist shown in Table 11.2.

Table 11-2

Electrical equipment inspection checklist

Dept., Org., Course, Lab. name		Date of inspection (yy/mm/dd)	
Building name		Inspected by	
Room name		Responsible person (Confirmed by)	

1. Inspection items for the entire room

No.	Inspection item	Inspection Result (○, ×)	Corrective action for (×)
(1)	Does the experimental equipment used have the specified capacity (A)?		
(2)	Is the experimental equipment made power-off except for overnight operation in unmanned operation?		
(3)	When introducing the experimental equipment, do you ask for cable wiring, etc. from an electrician from a special manufacturer? Is cable wiring installed by a student?		

2. Inspection items for the power distribution panel

No.	Inspection item	Inspection Result (○, ×)	Corrective action for (×)
(1)	Is there an abnormal noise?		
(2)	Is there an abnormal odor?		
(3)	Is the electric leakage circuit breaker in operation (switched off)?		
(4)	Is the earth leakage indication button of the electric leakage circuit breaker protruding?		
(5)	Is the breaker in operation (switched off)?		
(6)	Are any parts of the breaker, cable, etc. hot (check the temperature after switching off the breaker and looking around)?		
(7)	Is there color change in any parts of the breaker, cable, etc.?		
(8)	Have the breaker terminal screws loosened (check using a screw driver after switching off the breaker)?		
(9)	Are the earth wire and other wiring broken or removed?		
(10)	Is the surrounding of the distribution panel arranged and in order? Are there combustibles around it?		

3. Inspection items for cables and power strips

No.	Inspection item	Inspection Result (○, ×)	Corrective action for (×)
(1)	Are plugs, cables, power strips, terminals, etc. in use significantly deteriorated due to aging?		
(2)	Are cables are laid directly on the floor? ※When laying a cable on the floor, use a cabtire cable, cover it with the floor cable protector to prevent people from stumbling or falling.		
(3)	Is there an octopus wiring?		
(4)	Are power outlets free from dust? Are power bars used fixed to the wall, bench or the like?		
(5)	Is there loosening of screw plugs? Are cords sharply bent?		

4. Inspection items for electric machinery and apparatus

No.	Inspection item	Inspection Result (○, ×)	Corrective action for (×)
(1)	Before using, are the oil and dust adhering to the cable connection cleaned off?		
(2)	Are the electric machinery and apparatus perfectly grounded?		
(3)	In addition to grounding, is the electric leakage circuit breaker installed to any of the electric machinery and apparatus which are used in a wet or humid environment?		

※ Inspection should be made once half a year for each room using this checklist.

11.2.3 Choosing insulated wires, cords and cables

As you grow more accustomed to using electric appliances, you may become less careful when using insulated wires and cords. Beware that this sense of confidence can result in serious injuries and property damage.

Insulated wires have two types, i.e., single-wires insulated and strand-wires. For flexibility, strand-wires of soft steel are widely used. Figure 10-3 shows some examples of strand-wire cords and cables for a temporary or portable use.

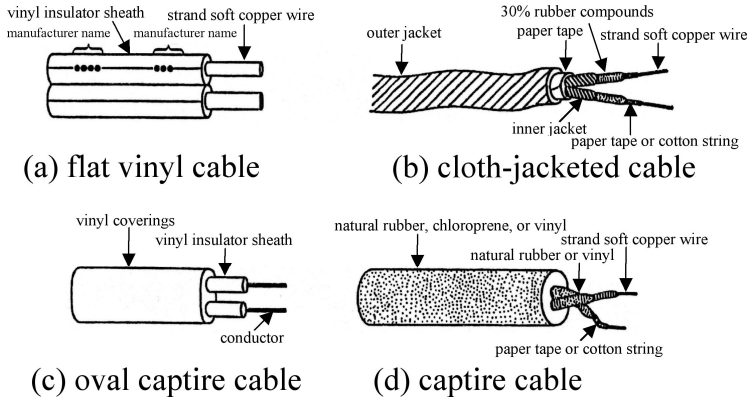


Fig. 11-3　Structures of power lines and cables

(1) Flat vinyl cord

A flat vinyl cord is a strand of copper wire sheathed with a vinyl insulator. It is widely used for general household appliances. However, it is vulnerable to heat, allowing for a permanent ambient temperature of under 60°C only. Therefore, this type of cord must not be used to feed electricity to heat appliances such as heaters, or incandescent lamps. Further, this cord is strictly for temporary use, which means it is definitely not suitable for permanent wiring structures.

(2) Cloth-jacketed cord

The cloth-jacketed cable is better able to withstand heat. The conductor strand is first wound with paper tape or cotton cloth, then covered with a rubber coat and jacketed with cotton cloth. It is widely used for heating appliances.

(3) Vinyl coated cord

In the vinyl coated cord, each copper strand is first coated with a chloride vinyl covering, then all strands are again coated with a thick chloride vinyl covering. There are round type (VVR) and flat type (VVF: F-cable) cords, all water, oil, and chemical proof. They tend to be fixed with staples and are good for indoor or permanent wirings. – When you attach them, use staples.

(4) Oval cab-tire cord

Because of its flexibility, the oval cab-tire cord is widely used for small appliances. The conductor strand is first coated with thin vinyl chloride and then coated with thick cab-tire rubber or a vinyl chloride sheath. They are highly water-proof and physically sturdy.

(5) Cab-tire cable

A flexible conductor strand is insulated with a rubber compound (or vinyl chloride), and then thickly coated with a heavy-duty, cab-tire rubber (or vinyl chloride). Because of its heavy-duty, waterproof nature, the cab-tire cable can be used in harsh conditions, or outdoors in a humid environment as a portable cable.

11.2.4 Earthing (System earthing and frame earthing)

If the premises of the School of Engineering are provided with 66,000 V power, why is it that we are not threatened with the possibility of being shocked with a voltage as high as 66,000V? The safest potential for us living in this environment is the earth potential. The principle of a lightning conductor is to keep its potential equal to that of the earth so lightning will be safely routed to it. By the same token, high voltage appliances are safe when a portion of it is kept at the earth-level potential. To realize this, one of the power distribution wires, by convention, must be earthed. This is called system earthing. If the system earthing is done properly, there is no threat that 66,000V will come though the appliances and appear at the 100V terminals. Note that in Figure 11.1, the neutral wire is system-earthed, and in Figure 11.2 one of the three-wirings is system-earthed.

It is important to earth the frame of electric appliances to prevent electrical shock to users. This is called frame earthing. If the frame or the case of the appliances is properly earthed, current leakage within the appliance will not be routed to flow through the users around it, making an electrical shock far less likely to occur. Typical household appliances, such as microwave ovens which have a high voltage power supply for the magnetron inside, and electric washing machines, used in heavy humidity, must have proper frame earthing for safety.

You may find some of the distribution panels have a relatively high earthing resistance, but they still serve as good frame earthing. Buildings built with reinforced concrete often provide good earthing resistance. Water pipes may also seem good, but if you suspect they are connected only to vinyl chloride pipes, be careful not to use them for earthing. Furthermore, earthing wires must not be connected to gas pipes since they can trigger an explosion or fire.

11.3 Electric Shock

What happens to a frog's legs when you administer an electric shock is a well-known example of what galvanizing electricity does to muscles. The heart and brain activities of human being are also based on the electro-stimulating property. An electrical shock is defined as the symptoms that appear when a person approaches or touches the voltage-applied portion of an electric circuit, and electric current flows though the body down to the ground, or to another power wire.

11.3.1 The physical effects of electric shock

The seriousness of the electricity shock will depend on the type of the power source, the route of the shock current, the magnitude of the current and the duration of the shock. The resistance of human skin on the palm of the hand is around 5 kΩ when dry, 2 kΩ when wet, and that of human body is around 300 Ω. If you touch a 100 V circuit, a shock current of about 22 mA can flow through your body when it is wet. With this current flowing through your body, it may be impossible to pull yourself away from the shock current by yourself. Table 11-3 shows how the human body reacts to various levels of shock current when touching a commercial AC power source. These reactions are based on the current flowing from one hand to the other hand, or from a hand to one of the feet. The body resistance at 200 V is a couple of magnitudes lower than at 100V. The typical reactions of a human body to various levels of voltage are shown in Table 10-4.

When the product value of shocking current (in mA) multiplied by the duration of the shock (in seconds) exceeds 30, the shock may result in a serious or even fatal injury. In cases where the shock results in serious damage to the heart, recovery is very unlikely. It is thus very important to understand the necessary precautions and prevention measures relevant to electric shocks.

Table 11.3 Typical symptoms for various levels of shocking current

Current (mA)	Symptoms
1	(Weakest current that can be sensed)
5	Pain felt (Pain Current)
10	Unbearable pain
20	Muscle convulsion, paralyzed nerves, cannot self-evacuate (Freezing Current)
50	Hard to breathe, high likelihood of death
100	Damage to heart, respiration to cease (Fatal Current)

Note: DC shocks are lower in sensed intensity by about one fifth. High frequency shocks also lower the shock intensity.

Table 11.4 Typical influences for various levels of shocking voltage

Voltage (V)	Typical influences
10	Dangerous when entire body is soaked in water (10 V/m: Safety limit)
20	Safety limit with wet hands
30	Safety limit with dry hands
50	Life-threatening limit
100～200	Life-threatening likelihood rapidly increases
200 or higher	Critical threat to life
～300	Attracted to voltage applied portion
10 kV or higher	Kicked away by voltage shock, minimal chance of survival

11.3.2 Rules for the prevention of electrical shock

Take cautions to prevent electrical shock:

(1) Never touch electric appliances with wet hands

(2) Replace damaged or worn-out plugs, table taps, terminals and cables.

(3) Confirm proper earthing of the appliances if they are used adjacent to water or steam. Also confirm proper earthing for appliances with metal cases or frames.

(4) In laboratories with a risk of spilled water, confirm frame earthing and use a current breaker to prevent current leakage. Do not put connectors and table taps directly on the floor.

(5) Clean the appliances and remove mud, dust and oil spillage before using to prevent current leakage.

(6) When touching the terminal of a capacitor device, make sure it is completely discharged. Note that the capacitor can retain the applied voltage for a considerable period of time after the power supply is removed.

11.3.3 Treating electric shock victims

If there are damaged power lines, keep your distance from them. Never touch power lines or appliances with wet hands. Promptly switch the appliance off, pull the victim away by his or her clothing with a dry bar, or with dry cloths wrapped around your hands. If the victim has fallen unconscious, artificial respiration is highly advised: his or her survival may depend on it. Therefore, all students, staff and faculty are advised to participate in artificial respiration drills.

11.4 High Voltage Appliances

Various high-voltage appliances are stationed in the university buildings, ranging from a proto-type kit with only hand-made level of safety/functionality considerations, to

fully-fledged and highly reliable commercial appliances. The degree of safety of these appliances varies considerably depending on whether there is a part exposed to the outside, or if they have safety precautionary equipment (mechanical and/or electrical interlocks). Table 11.5 shows typical high-voltage appliances found in the School of Engineering facilities.

1. Keep in mind when you handle high voltage appliances:

(1) In the case of voltages over 300 V, you can be shocked by electricity by dielectric breakdown even without directly touching the part where voltage is applied. Always make certain that you maintain a safe distance from the voltage; at least 300 mm away for at 2.5 kV, and at least 1 m away for 50 kV.

(2) Electric resonance and/or the abnormal voltage associated with it can bring about high voltage surges of several to teen times the nominal voltage.

(3) Interference noise can originate from high voltage appliances due to the high level of energy within, and influence the surrounding mechanisms. Therefore, always be prepared in case the circuit protection mechanism unexpectedly fails.

(4) Even with the wires cut, an electric arc may still bridge the disconnected portion, and delay the detection of damaged wires.

2. Adhere rigidly to the following when using high voltage appliances:

(1) Two or more people must be in charge of an experiment dealing with high voltage and/or current, with one solely supervising the other's activities for safety purposes.

(2) Wiring must be fixed with screws so it does not become loose and pose a threat to people.

(3) Do not expose the high voltage part to the outside or, to prevent human access, shield it using a metal cover equipped with a frame earthing conductor. Designate a high voltage area and keep people out with fences.

(4) Proper cables and/or high-voltage cords must be used for high-voltage wiring. Furthermore, treat the high voltage cords as if they were naked to be prepared for unexpected wire failures.

(5) Put up a cautionary sign reading "DANGER HIGH VOLTAGE" to draw attention to what you are working with and keep others at a distance. Warning lamps and a warning buzzer must be used while high voltage is in place. Switching on a high voltage power source must be done by a person in charge of controlling the facility.

(6) Capacitor terminals must be kept securely grounded (earthed) while at work, since high voltage remains in the capacitor even after the power source is switched off.

Never let the terminals come off the earth while at work. Seek an experts' guidance and drills for large-scale high voltage appliances, such as pulse power systems and laser power sources.

Table 11.5 Typical high voltage appliances

Appliance name	Specifications	Types of earthing, w/ or w/out safety mechanism
Air dielectric breakdown testing equipment	0～3 kV　100 mA	System earthing
Static deflection testing equipment	Beam deflection: 0～3 kV 1.7 mA Beam acceleration: 0～6 kV 830 mA	System earthing
Spattering equipment	1～2 kV　1 A	System earthing
Plasma accelerator power source	1.2 kV　20 A	System earthing
Ion source high voltage source	15 kV　180 mA	System earthing
Ion beam etching equipment	Ion beam part: 30 kV 20 nA e-beam part: 30 kV, Several 10 microamps	System earthing, w/ safety mechanism
Spattering equipment	1～1.2kV　1A	System earthing and Frame earthing
Spattering equipment RF600W	Frequency 13.56 MHz	System earthing, w/ safety mechanism
Spattering equipment RF450W	Frequency 13.56 MHz	System earthing, w/ safety mechanism
Plasma discharging equipment	Plasma generating source: 2 kV 4 A Discharging: 1.2 kV　1 A	System earthing
Electronic gun	5 kV　0.6 A	System earthing
Curve tracing equipment	2 kV　0.1 A	System earthing, w/ safety mechanism
Ion injecting equipment	200 kV	System earthing, w/ safety mechanism
High frequency heating equipment (Epitaxial grower furnace)	60 kHz　100 kW	System earthing, w/ safety mechanism

11.5 Static Electricity

Static electricity is generated by contact or friction between objects, which explains why it is also known as friction electricity. The accumulation of electric charges is called electrification, and objects with accumulated electric charges are called eletrificated objects. Insulators are objects with high resistance to current; in other words, a slow

relaxation property for static electricity. Static electricity generated to objects like this mostly gathers on the object's surface, to make it "electrified." Static electricity phenomena in general are classified as: physical phenomenon, such as attraction and repulsion, and discharging phenomena.

Of those, physical phenomena can sometimes disrupt production activities. Dust or mist suspended in the air in the production environment can easily become charged with static electricity, which can cause so-called contamination damage to the products, to the work-in-process or to the raw materials. Attention should be drawn to contamination in industry, particularly the semiconductor industry, the healthcare industry and the food and beverage industry. It can also pose a problem in biotechnology and in precision manufacturing.

Discharges can also cause damage like explosions and inflation of the flammables, electric shocks and/or similar biological disorders (arcing, exposure of photographic and X-ray films, and the destruction of semiconductor devices just to name a few). Furthermore, electromagnetic noise is emitted with frequency bands which can be as wide as 1000s of MHz, causing unexpected malfunctions and stoppages to computers and automated production systems in the vicinity, and potentially lead to secondary disasters in the form of injuries to production line workers, or even their deaths in the worst case scenario. Past examples of such injuries and disorders in production lines are summarized in Table 11-6 for your review.

Table 11.6 Past examples of production line fatalities or disorders due to static electricity

Where it happened	What happened	Supposed causes
Auto assembly line	Malfunction of computer that controlled conveyor belt due to spark electromagnetic noise, causing runaway of assembly machine, line worker trapped and injured	Discharging noise from a welding robot or electrically charged conveyor belt
Cleansing line of electronic devices	Partition panel within the cleansing solvent bench mistakenly opened by a false command from a control computer, resulting in an explosion and fire due to formation of mixed flammable gas from the solvent mist and air	Statically charged jet solvent mist from the cleansing nozzle to discharge
Resin coating line of insulating cloths	Air seeping into incompletely sealed vacuum chamber for	Charged glass wool cloth running at high speed

	de-bubbling circuit boards for void prevention. Situated nearby was the resin coating line on glasswool cloths.	
Automated carriage line of materials	Carriage robot runaway on epoxy resin coating line floor stopped at the wrong position, colliding with a rack, causing things on the rack to fall and spill.	Friction charge between the carriage robot and the floor
Sewing line of tent materials	Industrial sewing machine malfunctioned, needles broken and produced many off-standard products	Worker or cloth statically charged
Line supervision computer	Display flickering or a mistaken entry from keyboard when worker stood up from chair	Chair or the worker statically charged

The most serious accidents static electricity can cause are explosions and fire. A vaporized organic solvent catching fire because of static discharge is among the most common causes of such incidents. There are also frequent reports of flammable vapor or powdered substances catching fire while being transported, and during the filling and drying processes.

For instance, there was an explosion while a worker was pouring fuel oil from one container to another. The estimated cause of the accident was static discharge occurring around the metal funnel, sparking the vaporized fuel and resulting in a fire and explosion. The worker was wearing vinyl footwear, and the funnel was placed on an insulated plastic container, so both the worker and the funnel were securely insulated from the ground. The weather was fine and the humidity was low at the time of the accident. In this case, static charges are thought to have been generated while oil was poured from the can to the plastic container, producing sparks between the negatively charged funnel and the positively charged metal can. When pouring oil using a funnel, the contact between the oil and the filter can lead to generating twenty to thirty times as much as electric charge compared to not using a filter. The worker overlooked the risks involved in what he was doing.

In summary, the recommended precautions to be taken to prevent accidents because of static electricity are listed below:

(1) Earth to prevent charging

(2) Prevent workers from becoming charged

(3) Prevent insulators from becoming charged

(4) Eliminate the charge

(5) Use charge prevention material

(6) Humidify the working environment

When earthing is considered for static charge prevention, the earthing resistance should be below 1,000 Ω. In cases where there is an earthed terminal with an earthing resistance lower than 1,000 Ω, additional earthing terminals are not required.

Anti-charging measures for the human body include wearing anti-static workwear made from conductive fabrics, anti-static work shoes with conductive shoe-bed material, and the installation of anti-static flooring in the work place.

To prevent insulators from static charging, it is recommended to minimize the risk of the materials and the property coming into contact, by carrying out surface treatment by cleansing and smoothing the surface of the material in a humid environment, and applying anti-charging materials on the surface.

Static electricity is considered easy to handle since it is so commonplace. After all, it is encountered on a daily basis in the form of the annoying crackling sound or some other casual event of instant discharging. Its relative energy is much lower and, thus, tends to give the mistaken impression that it is much more manageable than commercial electric power, making us much less likely to be cautious to prevent the kind of serious accidents it can bring about. As a result, there are almost a constant number of accidents caused by a similar type of situation year after year. To prevent this, it is important that each of the students, staff and faculty members pay attention to detecting the potential risks in their routine work procedures and underestimate potential risks.

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2. *Prevention of industrial accidents and injuries caused by static electricity*, Ed. Y. Tahata, OHM separate book, Oct. 1995.

Chapter 12　General- and Special-purpose Machines and Laser Appliances

University laboratories and facilities dealing with natural science and engineering studies are equipped with many machines for education and research. Students, staff and faculty who use those machines are expected to know not only how to operate them, but also how to prevent potential accidents and injuries while using them. This chapter includes the minimum required knowledge for the safe usage and operation of general and special-purpose machines and laser appliances. In addition to the common safety guidelines, users are strongly advised to read through the attached operation manuals for each machine or piece of equipment and create an experimental procedure that allows a good understanding of the safety precautions before operating the machines or equipment. High power, high speed and large-scale machines in particular require a thorough assimilation of knowledge and techniques before use as well as preparing for proper operation and potential hazard prevention. People in charge of controlling these machines must ensure that, by communicating clearly with students, staff and faculty, nobody gets to use the machines without the proper preparation and training. Users are also advised to wear neat work clothing with a tight sleeve edge and not to wear a lab coat with the wide bottom hem to prevent it from being caught in the power transmission device, or reciprocating or rotating part of machines.

12.1 General-purpose Machines

12.1.1 Cutters

12.1.1.1 Electric cutters

Electric cutters are more commonplace in offices and libraries these days in place of the conventional hand-operated cutters. Considering the fact that even hand-operated cutters have resulted in occasional finger and hand injuries, it is advisable to introduce an electric cutter with a two-hand switching mechanism. Never ask someone else to switch it on. Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating part.

12.1.1.2 Shear cutters

(1) Shear cutters, which are used in machinery factories for cutting hard materials like metal plates, must only be used by qualified users with the proper training and experience.
(2) Shear cutters with foot pedal switches should be equipped with a hand protector so that the user's hand cannot inadvertently slip towards the blade.
(3) The power supply of shear cutters must be secured with locks. The lock should be solely under the supervision of the person (faculty or staff) in charge of the machine.
(4) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

12.1.1.3 Round saws and straight saws

These are the most commonly used cutting machines. Attention must be paid to the following:

(1) The blade cover must be in place and cover the saw, to prevent pieces of the cut specimen from flying about.

(2) Secure the machine on a stable and sturdy workbench or the like to avoid vibration.

(3) The machine must be located in a place with plenty of space around the work zone and with as few passersby as possible.

(4) The ON/OFF switch should be placed near the user's hand.

(5) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

12.1.1.4 High speed cutters and fine cutters

These are commonly used in the machine workroom and the common experimental room. Their high-speed rotating grindstones can break with cracks and the pieces can fly about. To ensure safe operation, observe the following precautions:

(1) Inspect the grindstone for cracks and flaws before you begin work.

(2) Sandwich the grindstone with thin pieces of paper when putting it back in place, mildly tighten the flange to secure it to the shaft (counterclockwise screw), and check that it is placed central to the shaft to ensure symmetric rotation and that it will not come loose while working.

(3) Rotate the stone once to check for sideward sways and deviations from the shaft center. Also check that the cooling water is flowing properly.

(4) Secure the specimen tightly, and use a safety cover.

(5) Move the grindstone slowly and carefully towards the specimen, and never apply an impulsive or excessive load to the cutter.

(6) Never apply an excessive load to the cutter to speed up the work process – overstressing it may lead to cracking the grindstone and its pieces may fly about. Use extreme care on fine cutters since they have thin stones and are vulnerable.

(7) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

12.1.2 Grinders

To ensure safe operation, observe the following precautions:

(1) Avoid placing grinders where vibration is not allowed since they vibrate during operation.

(2) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

(3) Do not leave flammable objects around the grinder.

(4) Secure the grindstone tightly at the flange without eccentricity from the shaft center.

(5) Never use worn-down grindstones.

(6) Keep the distance between the grindstone and the support structure to less than 3 mm.

(7) Never grind objects with too little a holding area.
(8) Have cooling water readily accessible at the worksite.
(9) Use special care when grinding flammable materials like magnesium, titanium and their alloys.

12.1.3 Lathes
(1) Secure the specimen tightly with a jig to prevent displacement.
(2) Before switching on the lathe, check the fixing handle and ensure that other tools are all taken away.
(3) For high speed lathes, pay attention that string-like chips that come off in curls do not hurt or burn your fingers.
(4) Do not place your tools, specimens or finished work on top of the lathe.
(5) Consider putting a safety fence or a protection cover in place when working on a long object.
(6) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

12.1.4 Electric discharge machining (EDM)
EDMs are used for the low-distortion, high-precision machining of metal materials that require complicated machining patterns. They utilize the electrical discharges between a wire and the specimen placed in a bath of water or kerosene. Kerosene bath machining, in particular, has a significant risk of catching fire, so users must be careful of the following;
(1) Fix the specimen deep enough so that the discharging portion is sufficiently under the surface of kerosene.
(2) Keep a fire extinguisher readily at hand at the work site.
(3) To prevent the risk of fire, do not let the machine operate unattended even if the processing time needs to be extended.
(4) Never leave flammables around EDMs.
(5) Do not place appliances sensitive to electromagnetic noise in the vicinity. EDMs emit electric noise while working.
(6) Use protective covers on the high voltage electrodes to prevent touching high voltage electrodes.
(7) Equip the EDM with a safety switch that automatically shuts it off in the event of an earthquake or fire.
(8) Wear a dust-protective mask and goggles. Do not wear gloves to prevent them from being caught in the rotating machine.

12.2 Special-purpose Machines

12.2.1 Impact testers
Impact testers are used to test for the mechanical strengths of materials.
(1) Only qualified operators should operate the impact tester. Ascertain that no one is inside the

safety fence when testing.

(2) Prior to testing, confirm that the impact tester operates properly. Make sure that there are no flaws in the braking mechanism, the hammer support or the supporting springs, in particular.

(3) Never stick your head or hands into the zone where the hammer falls.

(4) Prepare a protective shield to prevent cracked objects from flying about.

(5) Do not operate the hammer without using the operating handle.

(6) Make sure the hammer has come to a complete standstill before removing the testing object.

12.2.2 Tension / compression testers

Extra care needs to be taken when using large-scale testers. The general rules for use are as follows:

(1) Check that the pressing rod is in complete alignment with the center axis of the testing object.

(2) Use a chuck retainer to prevent the chuck from coming out due to impact if the testing material breaks.

(3) When testing brittle materials, watch for small pieces that may fly about and could injure others.

(4) Be careful that your head or hands do not become caught up between the testing object and the pressing rod or the cross rod.

(5) Never operate large-scale testers alone.

(6) If the tester is attached to an electric furnace, check in advance for electric leakage between the tester and the furnace.

12.2.3 Rolling mills

Rolling mills are considered hazardous. No one should operate a rolling mill alone. Students must use the mill in the presence of a well-experienced faculty or staff member.

(1) Only the well-experienced faculty or staff members are allowed to operate these machines.

(2) Confirm in advance that the safety shutdown mechanism is functioning properly.

(3) Never touch the rotating roller. The cleaning and maintenance of the roller should be carried out from behind the roller, with the roller completely at a standstill.

(4) Notify someone else when placing your specimen into the roller.

(5) Pay attention to the rolled end of the specimen since the specimen may come out bent upwards or downwards.

(6) The person at the receiving end of the specimen must not stand directly in front of the roller.

12.3 High-temperature Machines (Heat treatment furnaces and melting furnaces)

Take cautions when using heat treatment furnaces and melting furnaces that are used for high temperature processing and annealing of materials.

(1) Correctly control and measure the temperature of the heating furnace, and precisely measure

the material heating temperature.

(2) Use fire-proof gloves and pinchers when taking the material out of the furnace. Check in advance that there are no flammable objects in the vicinity of the furnace.

(3) Never touch the heated material or furnace with wet gloves on. The steam may burn your skin.

(4) Pay attention to preventing spillage and bursts of molten metal material. Wear safety gear such as a dust-protective mask and goggles.

(5) To prevent explosions from occurring, check the cooling water pipe system for leakage prior to use.

(6) Wear rubber boots to prevent electrical shocks when using a large-scale electric furnace or a high-frequency furnace.

(7) When heating specimens sealed inside a glass tube or a quartz tube, especially that have a high vapor pressure, pay attention to the allowable heating temperature and resisting pressure strength of the glass tube.

(8) Place fire extinguishers near the furnace.

12.4 Low-temperature Machines (helium and nitrogen liquefying equipment)

The liquefaction of helium and nitrogen for coolant use requires the repeated compression and inflation of the gas. Note that, though the temperature of liquefied helium is as low as 4.2 K and for liquefied nitrogen it is77 K, the pressure of those liquids is at normal values. Component materials of the coolant producing equipment may become brittle because they are exposed to very low temperatures. Care must be taken when handling these parts.

(1) Wear leather gloves when handling liquefied gas or cold materials. Cotton gloves are NOT to be used.

(2) To prevent frostbite, never touch liquefied gas.

(3) Ventilate your work site well to ensure an abundant supply of oxygen when using liquefied nitrogen, liquefied helium or other coolants in a closed room. Install an oxygen meter and check the oxygen concentration. Follow the instructions of the person (staff or faculty) in charge of oxygen deficiency and hydrogen sulfide related hazardous work.

(4) When pouring coolant into a container, make sure that it is not broken due to rapid quenching. To do this, after pouring first few drops, swirl them around inside the container to cool the entire container. Then continue pouring slowly.

(5) Use a protector shield in case the container should explode due to sudden inflation.

(6) When liquefied gas is kept in the pipe system with the valves closed, take cautions that the pipes exposed to heat may be pressurized by the evaporated gas from inside, and could result in an explosion.

12.5 Pressure Containers (1st Class, 2nd Class and Small)

Pressure containers are containers that hold gaseous or liquid substances above atmospheric pressure and are of the following types: i) a container that heats its contents by being fed vapor or other heat transfer media, or generates vapor by itself to heat the contents; ii) a container where a reaction occurs and vapor is generated; iii) a container whose contents are heated to generate vapor so that its liquid content can be separated; and iv) a container that holds liquid whose boiling point inside the container exceeds its boiling point under atmospheric pressure. These containers are classified into 1st class, 2nd class and small-type depending on the container volume and the pressure inside. A 1st class pressure container is subject to high temperature and high pressure and certain cautions are required. Most of the containers used in the School of Engineering are the following two types:

Autoclave – used for chemical reactions, extractions, sterilization, etc. under high temperature and high pressure.

Reactor – used for chemical reactions such as synthesis of methanol, ammonia, etc.

(1) Experimental equipment that uses a 1st class pressure container must be operated under the instructions of an authorized 1st class pressure container handling supervisor (faculty/staff).

(2) Be sure to wear safety gear such as helmets, cotton gloves, eye protection and lab coat. Take into account the type of experimental equipment and whether the container has gas or liquid.

(3) Check that the piping, safety valve, pressure gauge and thermometer are attached to the equipment correctly and operating properly before starting.

(4) Stop using equipment if a leak, corrosion or surface damage is detected since this may lead to an accident such as bursting.

(5) Do an emergency shut down if an abnormal temperature or pressure, etc. is detected during operation.

(6) Close the lid of the pressure container tightly to prevent the lid from popping off during operation.

(7) Prepare the experimental procedure for the equipment.

12.6 Laser appliances

12.6.1 General caution

The potential risks to the human body posed by laser beams must be carefully controlled and avoided. Laser damage to the eyes and the skin is particularly disastrous. Ultraviolet laser beam burns to the retina can cause irrecoverable damage to vision. Continued skin exposure to a laser may cause skin cancer. Laser beams, depending on their intensity and the risks they present with regard to eye damage, are classified into four categories from Class 1 (negligible risk) to Class 4 (extremely hazardous). It is important to know prior to use which class of laser you are about to

work with and to take all the necessary precautions. The procedures must be carried out properly at all times.

The following precautions for safety only refer to open-type laser beams which are emitted outside the equipment structure, but also it is important to be careful with closed-type equipment when the shields are uncovered during inspections and maintenance.

(1) Indicate "DANGER" when using a laser beam (generally Class 3 or higher) on the door of the room where it is being used. Make sure that no one inexperienced comes into the room while the laser beam is in use.

(2) Attention must be paid to handling the high voltage power supply, since laser equipment is typically powered by high-energy capacitors. When replacing the laser excitation lamp, make sure the power supply breaker is switched off. While working, never let others operate the power supply.

(3) When using an ultraviolet laser, be careful in case ozone and other toxic gases are being generated. In the case of the eximer laser in particular, ventilate the room well.

(4) Do not directly expose your body parts to high power laser beams (generally Class 3 or higher). As well as the risk of skin burns and disorders that may result in tissue degeneration and skin cancer, there is a risk that your clothing may catch fire. Users are advised to wear fire-resistant work wear.

(5) Only a qualified controller with sufficient knowledge and training, or an entrusted delegate of such a controller, are allowed to operate hazardous laser equipment (Class 3 or higher).

11.6.2 Precautions to protect eyesight

Laser beams can penetrate the eyeball, concentrating energy which burns the retina of the eye. The duration of emissions from a pulsed laser flash is very short and the laser light enters the eye directly. It must be noted that only visible light provokes a protection response in human beings by closing their eyelids. Extreme care must be taken at all times when using high powered lasers.

(1) To avoid laser beams from unexpectedly penetrating the eye, never mount the equipment at eye-level.

(2) To minimize the potential risk of eye damage, ensure that the workroom is well lit so that the pupils remain small.

(3) Never reflect the beam on high-reflection objects. Remove your wristwatch when calibrating the equipment.

(4) When using invisible-band lasers, like infrared-band or ultraviolet-band lasers, anticipate the paths of the beam, and confirm where the light is reflected or scattered using an infrared viewer, fluorescent plate, etc. in advance. Pay attention to what others in the vicinity are doing, and alert them to what is going on.

(5) Never look into any of the following: the laser source, scattered rays, or glass-reflected rays, even from a low-energy (low class) laser source. Stay alert and take care of your eye position while calibrating the axis since it is possible that the laser can suddenly resonate and start emitting.

(6) Wear eye protection glasses when using highly dangerous lasers (Class 3B or higher). The eye protection glasses must adequately correspond to the laser wavelength in use. Do not take off your protection glasses without being absolutely sure that it is completely safe to do so, and do not stand in the direct path of laser beams. Do not look directly into the laser beam since the protection glasses cannot completely kill the beam. Note that the protection glasses are for back-up purposes only, and are only to be considered added safety after complete safety training, and learning safety management and operating procedures.

(7) In the case of a pulsed YAG laser, there is subsidiary beam radiation that is emitted in directions with about a 1% variation from the main beam. It is killed using the absorbent. Be sure to place a protector shield behind the absorbent to prevent the subsidiary beam being directed at the user since the absorbent needs to be moved when measuring the intensity of the main beam.

(8) Wear eye protection glasses when changing the operating conditions of the laser equipment. When making a change to the laser path, confirm the beam direction and where and how the beam is scattered using an infrared viewer.

12.6.3 Handling laser appliances at facilities

There were several accidents involving laser appliances at the facility of the School of Engineering. Following these, the Safety and Health Committee created the guideline to handling laser appliances in January 2006. Details are in 12.6.1-12.6.2 and the following.

January 31, 2006

School of Engineering Safety and Health Committee

Handling laser appliances at facilities

I. Laser light

Laser light is generated when a particular substance is artificially excited by an energy source. Electromagnetic radiation occurring while returning to the ground state is amplified during the stimulated emission process. Wavelengths of laser light range from below 180 nm to 1 mm. The emitted laser beam consists of almost a single wavelength and is coherent with a strong directional property. Up to now, a few accidents occurred where faculty, staff and students using laser apparatus have suffered from eye or skin damage caused by laser light absorption. To prevent these accidents, laser control measures shall be followed based on this guideline. Table 1 shows the classification of main laser types.

Table 1 Classification of main laser types

Class	Wavelength (μm)	Output	
		Continuous	Pulse
Gas laser			

He-Ne	0.63	1-50	-
CO_2	10.6	10-5,000 W	-300 J
Ar	0.51	0.5-5 W	-
	0.48	5-20 mW	-
Excimer	0.2-0.4	-	-2 J
He-Cd	0.325/0.442	2-200 mW	-
N_2	0.337	-	-300 mJ
Solid-state laser			
YAG	1.06	10-500 W	-50 J
Ruby	0.69	-	-20 J
Glass	1.06	-	-100 kJ
LD excitation	-	-	-
Liquid laser			
Dye			
Rhodamine 6G	0.5-0.65	0.1-10 mW	-
Superconducting laser			
GaAs system	0.64-3.1	1-10 mW	-

*1. A fiber amplifier achieves high output power.

II. Laser apparatus classes

According to Japanese Industrial Standards (JIS), there are seven classes of laser apparatus (*2) depending on the output of the laser beam, the level of potential damage to the human body, accessible emission limits, etc. Table 2 shows the classifications. It is imperative that users (faculty, staff and students) sufficiently understand the class of the target apparatus. Confirm the class with experts from the manufacturing supplier, etc. since the structure of laser apparatus and laser characteristics are complex.

*2 The classification was revised in March 2005 from the conventional five (1, 2, 3A, 3B, 4) to seven. New classes do not always correspond to the old ones (e.g. Class 3A → Class 3R does not always occur).

Table 2 Laser classes

Class	Description
Class 1	A safe level under all conditions where any optics (lenses, telescopes, etc.) collecting light do not cause damage to the eye.
Class 1M	This laser is safe under conditions when observation by the naked eye is done at a distance of 100 mm or over from the laser source. There is a risk of damage to the eye if light is collected using the optics.
Class 2	Only applies to visible-light lasers (400-700 nm). Damage to the eye can be avoided by the blinking reflex or other aversion responses.
Class 2M	Only applies to visible-light lasers. Observation by the naked eye is done at a distance of 100 mm or over from a laser source. There is a risk of damage to the eye if light is collected using the optics.
Class 3R	This laser is hazardous if observation is done directly by the naked eye without wearing eye protection. It is hazardous if light is collected using the optics. Its hazard level is lower than that of Class 3B.
Class 3B	This laser is hazardous is observation is done directly by the naked eye without wearing eye protection. It is hazardous if light is collected using the

	optics. Observation of diffuse reflection light poses a low risk of injury to the eye.
Class 4	This laser is hazardous if observed directly with the naked eye without wearing eye protector. It is hazardous if light is collected using optics. Observation of diffuse reflection light also poses a hazard. Exposure of the skin to this laser can cause a burn, and irradiating the laser to materials can cause a fire.

III. Safety control when using a laser apparatus

Laser apparatus at the School of Engineering are subject to the following safety control measures.

1. The person in charge of controlling the laser apparatus and the users

(1) For dangerous laser apparatus higher than Class 3, appoint a person as a laser controller at each laboratory where the laser apparatus are located. The laser controller shall have sufficient knowledge and experience with laser apparatus. He/she is required to:

i) Establish and control the laser area.

ii) Control the keys and other controls that start the laser apparatus.

iii) Inspect and maintain the laser apparatus and keep records.

iv) Inspect and maintain safety gear and monitor how they are used.

v) Conduct health and safety education and keeps records.

vi) Necessary measures to prevent users (faculty, staff and students) from health damage caused by exposure to lasers.

vii) Take any other measures related to the use of lasers.

(2) Create a "Laser Apparatus Control Ledger" by department for Class 3R or higher apparatus and submit it to the Health and Safety Management Office. Report any changes to the ledger.

(3) Check the laser beam path before starting the apparatus.

(4) Use the apparatus under sufficient lighting. Users must wear safety gear (laser safety goggles or glasses) appropriate to the class of laser. Do not continue viewing a laser beam directly with the naked eye even if it is Class 2 or below.

(5) Wear non-skimpy clothes made of flame retardant material when using the apparatus.

(6) When adjusting the optics with a laser beam, use the lowest laser beam output for the adjustment.

(7) The laser controller and the person responsible in the laboratory must require the user of laser apparatus to interrupt its use and consult a doctor or undergo a medical procedure if the user is suspected of being damaged by laser light.

2. Health and safety education

(1) When a new laser apparatus is put into use, or its experimental practices and specifications are changed, users must receive health and safety education from the laser controller or faculty/staff who have sufficient knowledge and experience as follows:

i) The nature of the laser beam.

ii) Principles and structure of the laser apparatus.

iii) Handling the laser apparatus.

iv) Performances of the safety device and safety gear and how to use them.

v) Emergency measures and evacuation procedures.

(2) Create a experimental procedure as described in Chapter 21 of this Safety Manual and keep it near the apparatus.

3. Laser control area, etc.

(1) The laser control area must be blocked off with a fence or the like, and be clearly indicated with a signboard, tape, etc.

(2) The laser control area is a no-go zone except for the personnel involved and this must be clearly indicated at the entrance.

(3) When a person other than the personnel involved has to enter the control area, he/she must behave under the directions of the laser controller or the person responsible in the laboratory.

(4) Post an indication at the entrance or other visually noticeable location of the control area as follows:

i) Name of the laser controller.

ii) Dangers and hazards of laser light with cautions about handling laser apparatus.

iii) A location sign that indicates that a laser apparatus is in place.

(5) Do not bring explosives or flammable materials into the room where the laser apparatus is located. Keep a fire extinguisher with its location sign in the area.

(6) Do not put anything not needed on the optical bench.

(7) Take measures to prevent adverse health effects such as by employing a draft chamber if hazardous gas or dust is generated when using the laser apparatus.

4. Laser apparatus

(1) Never mount the laser apparatus with the laser paths at the level of the eye.

(2) Take precautionary measures so that no one other than the laser operator looks at the laser beam directly.

(3) Take precautionary measures so that the laser beam is not directed at a mirror surface.

(4) Make the laser path as short as possible with the smallest possible number of turns, and do not have the laser path intersect a passageway.

(5) Be sure to terminate the laser path with a diffusion reflector or absorber with an appropriate reflection rate or heat tolerance. Never make the laser light diverge beyond the control area, and be sure to terminate it within the area.

(6) Use laser apparatus that have following specifications:

i) Operation can be started with a key.

ii) Emergency shutdown switches are positioned at the operating location and some other necessary locations that allow immediate shutdown of the laser light.

iii) Alarm devices such as an automatic pilot lamp that allows people to easily recognize that the apparatus is emitting laser light or is ready to emit laser light.

iv) The laser emission outlet of the apparatus has a shutter that prevents unexpected emissions of laser light.

v) The control area is fenced, or has an interlock system that does not allow laser emissions when the laser path shield is off.

(7) Post the laser emission outlet with an indication.

(8) Post the high voltage part of the apparatus with "CAUTION HIGH VOLTAGE" to prevent electric shock accidents.

(9) When high voltage gas is used as laser oscillation material, safety measures shall include preventing high pressure gas cylinders from overturning.

(10) When cryogens such as liquid nitrogen or liquid helium are use to detect laser light, safety measures shall include preventing asphyxiation.

5. Inspection and maintenance of laser apparatus

(1) The laser controller or faculty/staff in charge shall inspect the laser path, interlock function and safety gear before using the apparatus.

(2) Ask an expert to inspect the apparatus for the following items, and do the necessary adjustments if there is a problem:

i) Output power of laser light, mode, beam diameter, divergence angle, oscillation wavelength, etc.

ii) Input power, excitation voltage, excitation current, insulation, grounding, etc.

iii) Safety devices, automatic pilot lamp, shutter, interlock function, etc.

iv) Power meter, power monitor, etc.

v) Fan, shutter and other movable parts.

IV. Safety control criteria by class

Application of the safety control criteria described in III shall be according to Attachment 2 "List of Safety Control Criteria".

Attachment (Form 1)

Laser Apparatus Control Ledger

Department/organization _____

No.	Name of the building where located	Name of the room where located	Name of the laboratory where located	Manufacturer, equipment name and model	Name of the laser supervisor	Class
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

Attachment (Form 1)

Laser Apparatus Control Ledger (Example of writing)

Department/organization *Department of XXXX*

No.	Name of the building where located	Name of the room where located	Name of the laboratory where located	Manufacturer, equipment name and model	Name of the laser supervisor	Class
1	*Building No. 1*	*Room No. 101*	*XX laboratory*	*Manufactured by XX, Argon laser, 000-000*	*XXX assistant prof.*	
2	*North experimental facility*	*Students' experimental room*	*Shared use by the dept.*	*Manufactured by XX, He-Ne laser, 000-000*	*YYY associate prof.*	
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

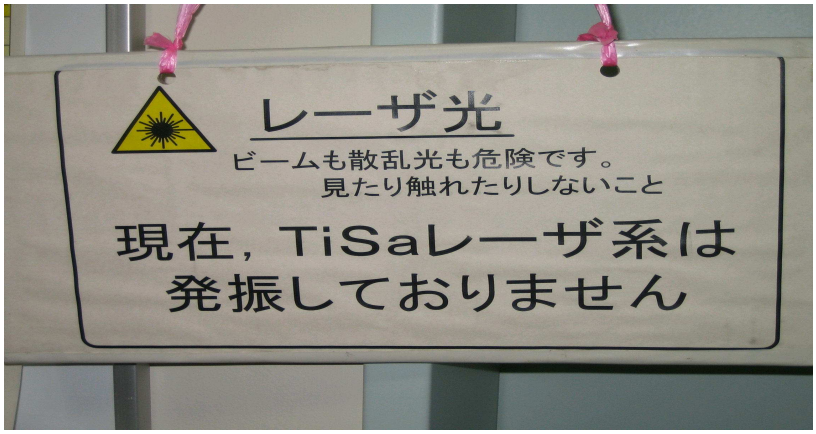
(Reference)

3 (2) Access restricted to the controlled area

3 (4) iii) Location sign of the laser apparatus

3.4 Entry and exit of the controlled area

4 (6) Laser is in operation



4 (7) Laser emission outlet

Attachment 2

List of safety control standards by class

Item	Class						
	1	1M	2	2M	3R	3B	4
1. Laser apparatus controller and user							
(1) Appointment of the laser apparatus controller					○	○	○
(2) Creation of the laser apparatus control ledger and reporting					○	○	○
(3) Position to operate the laser apparatus	○	○	○	○	○	○	○
(4) Wearing safety gear	○	○	○	○	○	○	○
(5) Clothing when using the laser apparatus					○	○	○
(6) Adjustment of the optical system	○	○	○	○	○	○	○
(7) Responses to laser hazard	○	○	○	○	○	○	○
2. Safety and health education							
(1) Safety and health education to users	○	○	○	○	○	○	○
(2) Creation of the experimental procedure	○	○	○	○	○	○	○
3. Laser controlled area, etc.							
(1) Clear indication of the laser controlled area					○	○	○
(2) Access restricted to the controlled area					○	○	○
(3) When people who are not involved enter the controlled area					○	○	○
(4) Entrance and exit sign					○	○	○
(5) Installation of fire extinguishers	○	○	○	○	○	○	○
(6) Organizing the optical bench	○	○	○	○	○	○	○
(7) Health damage prevention measures against the generation of toxic gas and dust	○	○	○	○	○	○	○
4. Laser apparatus							
(1) Height of the laser path	○	○	○	○	○	○	○
(2) Safety measures relating to those other than the laser operator	○	○	○	○	○	○	○
(3) Measures against the mirror	○	○	○	○	○	○	○
(4) Distance of the laser path	○	○	○	○	○	○	○
(5) End of the laser path	○	○	○	○	○	○	○
(6) Performance and structure of the laser apparatus	○	○	○	○	○	○	○
(7) Indication of the laser emission outlet					○	○	○
(8) Preventive measures for electrical shock	○	○	○	○	○	○	○
(9) Safety measures for high-pressure gases	○	○	○	○	○	○	○
5. Inspection and maintenance of the laser apparatus							
(1) Inspection before using the laser apparatus	○	○	○	○	○	○	○
(2) Voluntary periodic inspection	○	○	○	○	○	○	○

Chapter 13　Safety in Moving Materials

On a day to day basis, materials of various sizes are moved from one place to another. While handling materials and moving them, a small mistake could easily lead to injury. Even during a procedure we are well-accustomed with, there is a risk of minor or major injuries occurring due to carelessness which comes from the false sense of security that comes with habit.

Appliances and equipment are also often moved in the laboratory. Some of them are heavy, such as gas cylinders, occasionally causing a serious injury. When moving heavy loads, we normally use carrier carts or cranes, but there are times when it has to be done manually. Whatever the case may be, to prevent injuries when moving heavy loads, it is important not to overexert yourself, and, if necessary, get the help of professionals. Still, depending on the experiment, appliances and equipment are often moved by individuals. The list below includes the important points which should be kept in mind when moving materials.

13.1 Preparations to Move Materials

Basically, to move materials safely, make all the necessary arrangements in advance.

(1) Secure sufficient space for moving materials by removing any obstacles that may be in the way.
(2) Verify the places that could obstruct a smooth material moving effort, such as steps, and decide how you are going to overcome all the potential difficulties that may arise.
(3) Prepare the necessary equipment and have it inspected to ensure safety.
(4) Dress appropriately. Wear gloves, a safety helmet and safe footwear.
(5) If it is a group effort, appoint a leader and make sure everyone involved knows the details of how the procedure is to be carried out in advance.

13.2 Moving

To ensure safety, it is imperative that the load is handled with the utmost care.

13.2.1 Moving materials manually

Be sure to assume good posture to avoid　suffering from lower-back pain caused by lifting heavy loads.

(1) Make sure your hands are placed low on the load, your knees are bent deeply, and

your back remains straight. Make sure your body is close to the center of gravity of the load.

(2) Use your leg and shoulder muscles, stretch your elbows and slowly move up the load while maintaining your balance.

(3) If moving material is a group effort, communicate clearly throughout the procedure so that everyone is aware of what is going on at all times.

13.2.2 Moving materials by a carrier cart

(1) Select the cart according to the weight and dimensions of the load and inspect it before you start.

(2) Do not throw or pull down the load from a height.

(3) Take measures to prevent the load from slipping or collapsing.

(4) For long objects, put something eye-catching at the leading end to make it clearly visible to everyone.

(5) While moving the cart, pay attention to people walking in front of you and in the immediate vicinity.

(6) While moving gas cylinders, use a dedicated, two-wheel cylinder cart.

13.2.3 Moving materials using an automobile

(1) In principle, do not use private vehicles. There should be more than one person in the vehicle. Mount loads at a low position with their weight evenly distributed. Place a watcher, if necessary.

(2) For hazardous or long loads, adhere to the safety regulations by displaying a danger sign, the capacity of load, and the speed of the vehicle.

13.3 Moving Materials using Cranes

Anyone can operate a crane (equipment that can hoist and move loads horizontally) to lift loads of less than half a ton. However, for loads of over half a ton, only those who have received special education or have a license are authorized to operate the crane. (Contact information: Japan Crane Association (Co.), Tohoku Branch, tel: 022-263-3307)

The following should be kept in mind when operating a crane:

(1) Do not lift loads which exceed the stipulated weight.

(2) Only those who have received special education or faculty and staff members who have a license can operate the crane and hang the load. Attention should be paid to

ensure good communication by signaling between two persons, one who hoists a load and the other who slings a load onto a crane hook.

(3) Make sure that you check the lifting mechanism, that the load is properly secured and that the crane itself, the hook, the wire, and the wire fixture are in good condition for safe operation. In the case of a motor-driven crane, check the ON/OFF switch.

(4) Do not lift the load using a single wire, and use pads on the sharp edges of the load.

(5) Lift the load slowly and confirm that the wire is securely hooking the load and that the hook is directly above the center of gravity of the load.

(6) When moving the crane, move it slowly, paying attention that the hoisted load does not swing transversely.

(7) Do not leave the load being hoisted.

(8) While lowering the load, stop and check that everything is going smoothly when the load is about 10 cm above the ground and then complete the lowering operation. Once completed, confirm that the wire and the hook are completely removed.

(9) Do not stand under the hoisted load while the crane is in operation or it is being moved. Keep a safe distance at all times.

Chapter 14 Natural Disasters

14.1 Earthquakes

14.1.1 Preparations for an earthquake

(1) Preparation of emergency supplies

Prepare emergency supplies, such as a fire extinguisher, medicine, a radio and flashlights as described in Chapter 7 "Storing and Rationing Emergency Supplies" of the Emergency Management Manual for Disasters.

(2) Anchoring shelves

Anchor furniture that can topple, such as bookshelves, by fixing them to walls or columns.

(3) Check and secure an evacuation route

Be aware of your evacuation route in case of a disaster. Ensure there are no obstacles or dangerous objects blocking your path.

(4) Reduction and disposal of hazardous materials

Dispose of unnecessary solvents and reagents, unused equipment and unnecessary documents. Also, ensure that amounts of hazardous materials (inflammable or combustible solvents, and highly reactive reagents) and toxic substances, and the number of high-pressure cylinders are kept to a minimum.

(5) Posting a list of earthquake response activities

Enter the earthquake response activities to be performed into the Emergency Management Manual for Disasters. According to the necessity, post a list of earthquake response activities at conspicuous places near exits and experimental equipment in a simple style easy to understand.

(6) Explosion protection for experiments automatically being run

Accident prevention and explosion protection measures must be taken when carrying out automatically controlled, unmanned experiments, such as overnight operations.

14.1.2 What to do when an earthquake happens

"Calm yourself, don't lose your presence of mind, don't rush and don't panic!"

(1) When in a lecture room or a laboratory

At first, protect your head with a helmet. Reinforced concrete structures, which are common at the Aobayama campus, are generally earthquake-proof. Therefore, do not go outside the building, but hide in a safe place such as under a table. Be careful of broken glass if you are near a window. Protect your head with clothing or belongings from overturning bookshelves or things falling from the ceiling. Earthquakes can deform steel doors, making it impossible to open them, so be sure to open doors and windows to secure an escape route and prevent you from becoming trapped. Routinely bear the emergency route in mind (Two exits are necessary in one room. Windows on the ground floor can be used as an emergency exit).

(2) When in a large lecture room, a gymnasium, or a hall

In addition to the risk of overturning and falling of objects, there is a risk of group panic. It is necessary to shout loudly "Be calm" or "This building is safe" to keep others calm. All the buildings at the Aobayama campus are earthquake-proof structures, so there is very little chance that they will collapse, but it is possible that the ceiling lights may fall and the window panes might break. Therefore, it is advisable that you protect your head with clothing or your belongings first, then take shelter in a safe place, such as near the columns, walls or on the stair landings.

Then, follow the announcements or the instructions. Do not rush to the exits or stairs to avoid a crush of people. Use the flashlights kept at the laboratory or follow

the guidance lights or emergency lights in the event of an electric power failure. Under no circumstances should elevators be used.

(3) When you are in an elevator

When an earthquake is detected, the elevator is supposed to stop at the next floor automatically. In case it does not, stop the elevator manually at the nearest floor and get out immediately. Note that the elevator cable is secure and that there is almost no chance of it rupturing. If you feel an earthquake in the elevator, stop it manually at the nearest floor and get out immediately.

(4) When you are in a car

If you are driving a car when a major earthquake occurs, make sure that your car does not become an obstacle for evacuation or emergency vehicles. Also be sure that you do not park it where it might catch fire and exacerbate the disaster. In the event of an earthquake, the car may experience a problem, as if you got a flat tire, leading to the risk of rolling, collision or overturning. If you are driving, grip the steering wheel firmly, reduce speed, and stop the car on the left side of the road or in a parking space, and keep the road clear. Listen to the public information announcements on the radio. If you leave the car, do not lock the door and be sure to leave the key inside.

14.1.3 What to do in the aftermath of an earthquake disaster

(1) Disaster response head office and its branch offices

When a disaster occurs, the disaster response head office and its branch offices are alerted. Details are indicated in Chapter 20 “Disaster Response in the Event of a Major Earthquake.”

(2) Prevention of fires and initial response to extinguish fires

In order to prevent and mitigate the damage after the earthquake, your immediate response should be to extinguish any fire which may have started. If the fire is too big to be extinguished with the initial response, evacuate the area. When you feel the ground shaking, be calm and protect yourself first, and then take care of fires in your immediate vicinity. Generally, strong ground movement will stop within minutes. Once it stops, take care of any fire that you were not able to manage during your first response. It is estimated to take 3-5 minutes for fire to accelerate to the point where it reaches the ceiling. It is important that fire extinguishers are well maintained. Do not try to manage fires alone. Shout loudly “Fire.” A cooperative effort is needed to extinguish fires.

(3) Be aware of broken glass and falling objects

When an earthquake occurs, be careful of broken objects regardless of what they are made of, but be especially careful of broke glass. Wear something that covers your entire body. Also, gloves and good footwear are strongly recommended even if you are inside the house or in a building.

(4) Cooperate with others

In the event of an earthquake disaster, many injuries will be incurred, and also significant traffic hindrances will make effective search and rescue activities almost impossible. Do whatever you can to prevent yourself from being injured, and make sure you have basic knowledge of first aid procedures. Prepare a first aid kit and learn how to take care of minor injuries. Render medical aid to yourself and others around you. First-aid stations of the disaster response offices are assumed not to be able to cater to those with minor injuries. It is also important to be concerned with sanitary issues.

First-aid kits have been supplied to each department. The personnel in charge of emergency aid from the disaster response offices will mainly use them. An emergency

response drill is held several times a year with a lecturer from the Sendai City Fire Department. Please participate in the drill.

(5) Get access to reliable information

The state of confusion in the aftermath of a disaster allows rumors and false information to spread easily. Follow the instructions given by the disaster response head office or its branch offices and keep your presence of mind. To avoid confusion, listen to the radio or watch television for reliable and official public announcements. You can use a radio set and flashlight that have been supplied to each department. In case of a great earthquake disaster, do not panic and do what you can to protect yourself and help others. An earthquake includes a main quake and numerous afterquakes. Do not be afraid of afterquakes since they are small. Actively cooperate in preventing fires and other damages, and extinguish a fire, if it occurs. Scrambling to escape the fire may lead to loss of life.

14.2 Heavy Rains and Floods

A flood may occur after an extremely heavy rainfall. In case of heavy rain, be aware of flooding, slope failures and landslides. Check that the drainage system is working properly. Also, be especially cautious of areas that have experienced induced slope failures in the past.

Chapter 15　Fire Extinguishing and Evacuation

15.1 Fire

15.1.1 General Cautions

1. Do not store substances in excess of the amounts stipulated under the "Fire Service Law" in the laboratory. There should be a list indicating the stipulated amounts posted in the laboratory (See Chapter 4 "Dangerous Materials").

2. When using flammable/combustible solvents, keep the smallest necessary amount in the bottle for your use. If an accident occurs, and there is an excess amount of flammable solvent, the situation will be much worse, and evacuation may be difficult.

3. Do not place flammable/combustible substances near heat sources.

4. Be aware that in the presence of flammable/combustible substances, a fire may be ignited due to static electricity.

5. Place all equipment that uses a naked flame on a noncombustible bench.

6. Use standard switches, fuses and electric cords. Do not leave cords loose on the floor and do not use octopus wiring.

7. Check that all the rubber and polyvinyl chloride tubes are in good condition. Do not use any that crack when you bend them. Ensure that they do not come off from the connection easily and are not in contact with the electric cord.

8. The laboratory must be organized and cleaned on a daily basis. Avoid carrying out experiments in a messy environment.

9. Do not carry out experiments at night or alone that involve potential danger and whose procedures you are not familiar with.

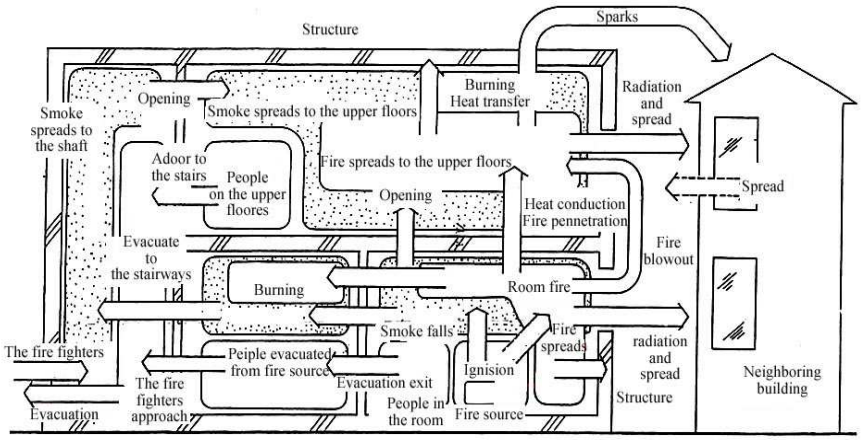
10. Do not smoke except in designated areas.

11. Ensure that laboratory equipment arrangements are adequate so that it does not hamper evacuation. No matter where an accident occurs, everyone should have easy access to an exit.

12. Do not place obstacles around fire doors, fire hydrants, or in the hall ways or fire escapes (See Fig. 15-1).

13. Confirm the escape route and evacuation area by yourselves.

14. Actively participate in a fire extinguishing drill at the time of the comprehensive disaster-prevention evacuation drill.



Concept of safety measures for a building on fire

15.1.2 What to do in the event of fire

In case of fire, be sure to do the following:

1. Shout "FIRE" in a loud voice to bring it to the attention of others. Depending on the size of the fire, sensors will work and the fire alarm will be turned on. The fire alarm receiver installed at each department will show where the fire is and alert the School of Engineering's administration building.

2. In the event of fires, use a fire extinguisher. If you operate a fire extinguisher properly and discharge adequate fire extinguishing agent, fires can be easily put out at an early stage. It is important to stay calm and take action without panic (See Figures 15-2 and 15-3). If the fire is too big to be extinguished at the early stage, evacuate the area.

3. Depending on the situation, one of the people on the site must push the button of the alarm (a bell will sound and a fire hydrant pump will start). In order to avoid confusion, use only the alarm on the same floor of the building where the fire started (See Figure 15-1).

4. Turn off the power supply of experimental equipment and close the gas cocks. Remove all flammable/combustible materials as quickly as possible.

5. If your clothing catches fire, stamp it out with your hands or whatever you may have at hand. If that doesn't extinguish the flame, you are advised to douse yourself with water or roll on the floor.

6. In the event of a fire breaking out in the draft chamber, switch off ventilation to prevent it from spreading upward and effectively extinguish it. However, depending on the situation, keep ventilating, especially if the fire generates smoke and toxic gas. It is important to make a judgment based on what is burning and the particulars of the situation.

7. If combustible gas gushing out of a cylinder catches fire, first remove all combustibles from the vicinity rather than extinguishing the fire. Then, discharge water on the cylinder and cool it down.

8. If combustible gas gushes out of a cylinder without catching fire, eliminate ignition by turning off power supplies and gas cocks remotely, then open the window to ventilate the area. If possible, close the main valve of the cylinder, and shut off the gas supply.

9. When extinguishing a fire that may generate toxic gas, put on a gas mask or, at least, try extinguishing the fire from the windward side.

10. When fire breaks out at night, you need to take into account that there will be fewer people around to help with extinguishing it. The fire extinguishing procedure is the same between the daytime and nighttime fires.

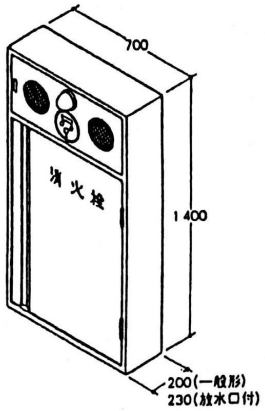
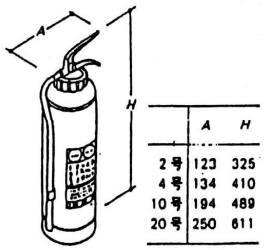


Fig 15-1 Fire hydrant



	A	H
2号	123	325
4号	134	410
10号	194	489
20号	250	611

Fig 15-2 Fire extinguisher

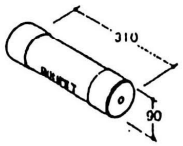


Fig 15-3 Automatic extinguishing cylinder

15.2 Extinguishing Fires and Evacuation

15.2.1 Extinguishing fires

Fig. 15-4 shows the extinguishing procedure and general action to be taken in the event of a fire. The flow includes detecting a fire, taking action and bringing it under control.

(1) Detect a fire and confirm it.
(2) Dial 119 to contact the fire department.
(3) Alert and report to the people in the facilities of the School of Engineering.

Following the above procedures, carry out initial fire extinguishing, escape guidance, safety protection, rescue and emergency aid activities.

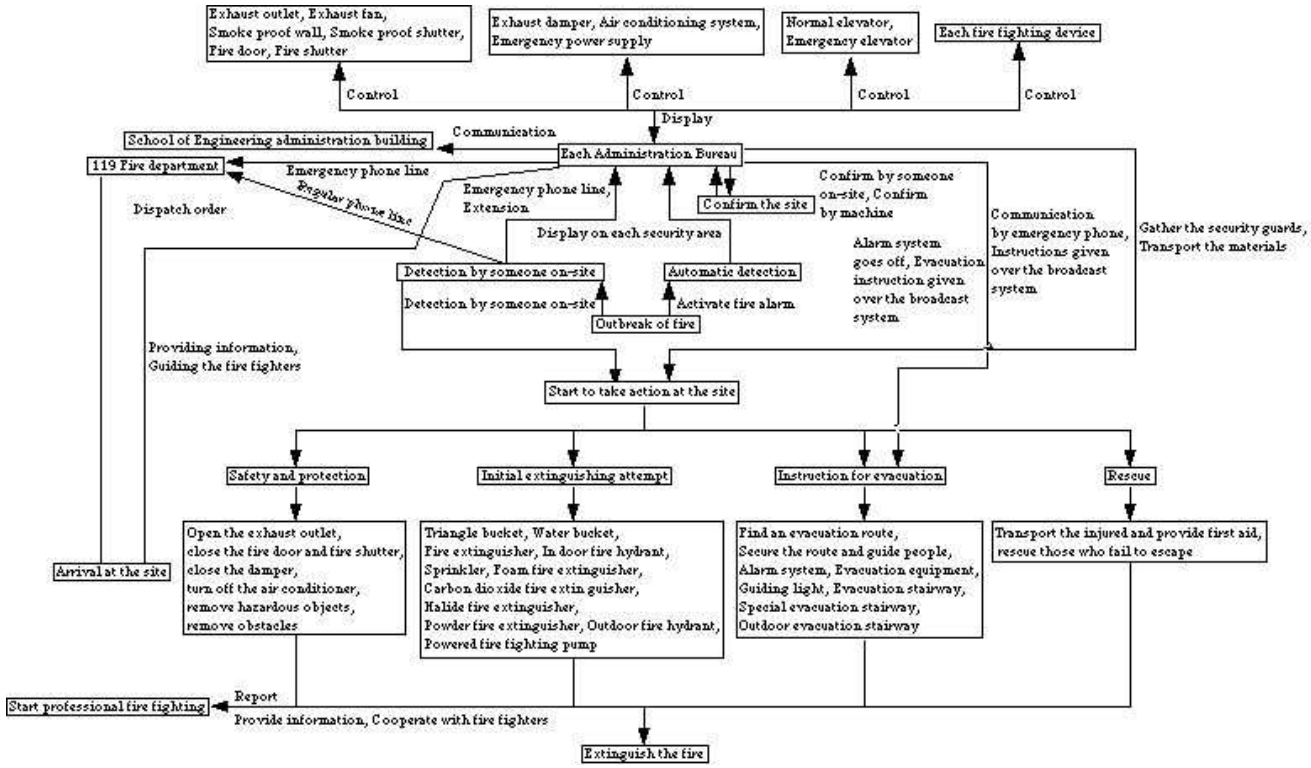


Fig. 15.4 Fire extinguishing procedure

15.2.2 Evacuation

The following are the general points to keep in mind with regard to evacuation in the event of fire.

1. When you judge that you are unable to put out a fire or stop a gas leak in its early stage, you must evacuate to a safe area as soon as possible.

2. The extent to which you can rely on a fire extinguisher to put out a fire depends on the situation. Even if the walls are on fire, it is still possible to extinguish the fire with the fire extinguisher. However, it is difficult to extinguish a fire once it reaches the ceiling.

3. When evacuating, take measures to prevent second disaster by turning off all gas supplies and electricity switches, and treating hazardous objects for safety if possible and make sure no one is left in the room before closing all the doors.

4. If there are no instructions about where to exit after evacuating to a hallway, pay attention to the smoke movement and go so that you remain upwind. Interior smoke moves at a speed of 3 to 4m/s in a vertical direction and 0.5 to 0.8m/s in a horizontal direction.

5. Refrain using an elevator. They will stop in the case of an emergency.

6. The stairway is dangerous because it is also a pathway for smoke. To be prepared, check the building structure and emergency exit locations to know the best evacuation route in the event of an emergency.

7. If smoke is filling the room, cover your mouth with a towel or handkerchief and keep your head as low as possible. It will take a while for the smoke to reach floor level.

8. If it is a situation where you are unable to use a fire escape, a ladder or other emergency equipment, evacuate from a window to the balcony. To be well-prepared, it is important to confirm your evacuation route before the event of an emergency.

9. Although the rooftop is a relatively safe area for evacuation, be aware that some buildings have numerous draft chamber exhaust outlets. If that is the case, do not evacuate to the rooftop unless there is no other option in an emergency.

10. When you close the fire doors, you must make sure that nobody is left inside. However, you can reopen the door by pushing or pulling it hard. You are supposed to leave the fire shutter ajar. When you need to reopen the shutter, use the manual handlebar inside the fire hydrant.
Look for the emergency exit signs when you evacuate.

15.2.3 Fire escape apparatus

In the event that you do not realize when a fire breaks out and you are unable to get out of the room because there is only one exit, a fire escape apparatus routinely installed in the room allows evacuation directly from the window to the ground. Post an indication showing the location of the fire escape apparatus so that it is easily recognized.

Fig. 15-5 shows a typical fire escape apparatus and Table 15-1 shows the time needed to deploy the apparatus and evacuate.

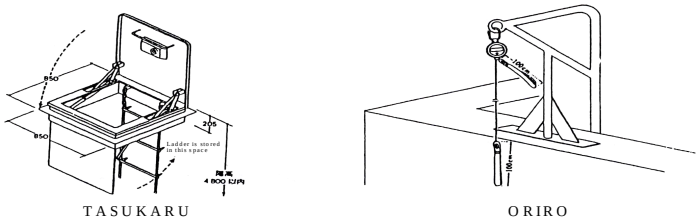


Fig.14-5 Fire escape apparatus

Table 15-1 Time required for deploying fire escape apparatus and evacuating

Fire escape apparatus	Duration for deploying the apparatus (sec)		Duration for evacuation		
	Experienced Person	Novice	Preparation (sec.)	Falling speed (m/s)	Escape (sec.)
Escape chute (slider type)	89	206	8	1.3	—
Escape chute (vertical type)	58	180	9	0.52	10
Slow descending machine	31	113	29	0.91	12
Hanging ladder (attached to the window frame)	85	160	11	0.27	—
Hanging ladder (attached to the balcony floor)	15	—	5	0.25	—
Fixed ladder	—	—	—	0.30	—

Table 15-2 Variety of fire escape apparatus and adaptability

Object	First floor	Second floor	Third floor	Fourth or fifth floor	Six floor and above
Hospital, clinic, midwifery home, each facility (retirement, child welfare, rehabilitation, facility for mentally challenged people), kindergarten, each school (blind, deaf and handicapped)	Escape ladder Gangway ladder	Slide Slow descending machine Escape bridge Gangway ladder Escape ladder	Slide Escape chute Slow descending machine Escape bridge	Slide Escape chute Slow descending machine Escape bridge	Escape chute Escape bridge
Theater, public hall, cabaret, dance hall, waiting room, restaurant, department store, hotel, dormitory, each school (elementary, middle, high), library, public bath, bus stop, others	Escape ladder Gangway ladder	Slide Slide-bar Escape rope Escape ladder Slow descending machine Escape bridge Gangway ladder	Slide Escape ladder Escape chute Slow descending machine Escape bridge Gangway ladder	Slide Escape chute Slow descending machine Escape bridge Escape ladder	Escape ladder Escape chute Escape bridge Slow descending machine
Factory, workshop, movie studio, TV studio, government facility, bank, office	Escape ladder Gangway ladder		Slide Escape ladder Slow descending machine Escape bridge Gangway ladder	Slide Escape chute Slow descending machine Escape bridge Escape ladder	Escape ladder Escape chute Slow descending machine Escape bridge

Three story (two story for restaurants and game centers) building that does not have two or more direct stairways to the escape doors or ground and it's capacity is ten or more people.		Same as above	Same as above	Same as above	Same as above

15.2.4 Keeping fire extinguishers in the laboratory

The School of Engineering Safety and Health Committee decided to keep fire extinguishers in the laboratories at the School of Engineering. The relevant laboratories are required to keep fire extinguishers (fire extinguishing equipment).

December 20, 2005
School of Engineering
Safety and Health Committee

Keeping Fire Extinguishers in the Laboratory

1. The general criterion for keeping fire extinguishers in the facilities is "Keep at least one fire extinguisher with its location sign in laboratories, etc. where chemicals, high pressure gas cylinders, experimental equipment with a high risk of causing a fire or explosion are used/stored".

2. Where to keep fire extinguishers

(1) Facilities where hazardous, toxic and deleterious substances, specific chemical substances and acid and alkali substances are used/stored or waste liquids containing them or their mixtures are stored.
(2) Facilities where high pressure gas (including liquefied gas) fed from a high pressure cylinder (including the common piping) is used/stored.
(3) Rooms and halls that are designated as radiation control areas where radioactive isotopes, internationally controlled substances and nuclear fuels are used/stored.
(4) Rooms where experiments using biohazardous materials (microorganisms, animals and recombinant DNAs) are carried out.
(5) Rooms where electromagnetic and high frequencies are generated.
(6) Rooms where metallic powder is used/stored.
(7) Clean rooms.
(8) Rooms for experiments by students.
(9) Rooms that have the following equipment:
   i) Draft chamber, clean bench.
   ii) Furnace.
   iii) Radiation generator and X-ray equipment.
   iv) Equipment that generates high voltage, such as a sputtering system (high voltage system).
   v) Laser apparatus (regardless of class).
   vi) Test machines.
   vii) Machine tools such as lathes and drilling machines.
   viii) Boiler and pressure vessel.
   ix) Equipment that uses city gas.
   x) Other equipment that may cause a fire/explosion or create a high temperature and high relative humidity in the laboratory rooms.

3. Types of fire extinguishers

Fire extinguishers shall be ABC designated (capable of extinguishing ordinary combustion materials, flammable liquids and electrical fires). When there is a threat of a potential fire/explosion that the ABC type cannot extinguish and thus increase damage, install appropriate fire extinguishing equipment in corresponding laboratory rooms.

4. Fire extinguisher location sign (example)

15.3 Common Everyday Accidents and Sanitation Concerns

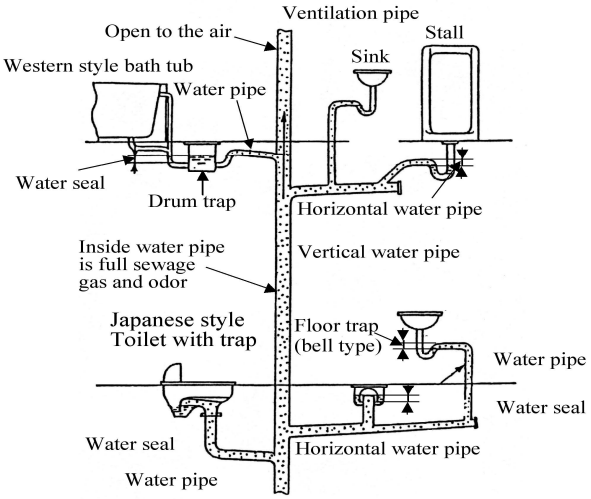
15.3.1 Everyday accidents

The most common day to day accidents tend to occur in stairways, especially when descending the stairs. Ideally, you are advised to always hold the handrail.
Cuts and burns are also common everyday accidents. The Health Management Center Clinic (extension 7829) for minor injuries is at the Kawauchi campus. Emergency response drills are held several times a year with a lecturer from the Sendai City Fire Department. Please participate in the drill. Each and every person in the School of Engineering is expected to have self-awareness at all times.

15.3.2 Sanitation

1. Restrooms
   Since the campus is over thirty years old, it is possible that restroom floor traps (Fig. 15-6) may generate an odor. If you sense that this is the case, please report it to the Administration Bureau.

2. Cleaning ventilation filters (figure 15-7)
   In many laboratories, the filters for the heaters and air conditioners are not clean. This not only reduces their efficiency, but also spreads dust throughout the room. Monthly cleaning is recommended.



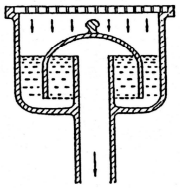


Fig.14-6 Trap

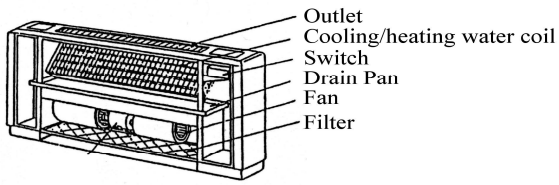


Fig.14-7 Floor fan coil unit

Chapter 16　VDT Work

Computers are playing an increasingly important role in the IT society. The VDT (visual or video display terminal) is integral part of the computer in addition to cellular phones, video game systems, etc. As VDT use has become commonplace, adverse health problems on VDT operators caused by eyestrain, etc. have become a social concern. The Ministry of Health, Labour and Welfare published guidelines for occupational health for VDT operators, and, to meet this, the university has been carrying out special medical examinations for corresponding students at the Health Administration Center since 1988.

Health Problems Associated with VDT Work – VDT Syndrome

Working with video display terminals (VDTs) requires visual attention and concentration as well as continuous keyboard operation. VDT work can result in physical problems including eyestrain and stress on muscles in the back, neck, arms, and wrists, and psychological stress from the long hours of monotonous work involved. Students are subject to extra physical and mental stress because of the intellectual strain involved with their performances and results and the need to carry out given tasks within a definite time frame. The health problems associated with VDT work are termed VDT syndrome (i.e. techno-stress syndrome). More than sixty percent of those working with VDT complain of health problems to some extent.

Symptoms

1. Eye symptoms: dry eyes, itching eyes, ocular hyperemia, blurring, sense of decreased vision, eyestrain, contraction of accommodation, conjunctivitis, keratitis, lacrimal hyposecretion
2. Physical symptoms: stiffness of the neck and shoulders, feeling of heaviness in the back, legs and lumber, pain in the neck, shoulders, arms and back, numbness in the fingers
3. Indefinite complaints: headaches, vertigo, feeling of heaviness of the body, loss of appetite, excessive eating, frustration, menstrual disorders, constipation
4. Mental symptoms: depression

Causes of adverse health effect

1. Staring at screens continuously causes a reduction in blinking and results in dry eyes.

2. The glare generated directly or indirectly by the light source, illumination and the reflection of lighting cause eyestrain.
3. Incorrect posture or maintaining the same posture over extended periods results in stiffness of shoulders and lumbar pain.
4. Switching attention back and forth between paper documents and the screen when typing results in eyestrain.
5. Aging, stress and lack of sleep reduce lacrimal fluid and facilitate eyestrain.

Dealing with VDT

In order to reduce the incidence of VDT syndrome, an improved work environment, better work management, regular health examinations and health & safety training are recommended. In the case of university laboratories, not to mention that each organization of the university takes an active part in improving safety and health management, the primal importance is that everyone who does VDT work understand good health management and put it into practice. The following is a summary of the important points from the Guidelines on Occupational Health for VDT Work (Ministry of Labor, 1985).

1. Improving the Work Environment

(1) Adjusting the light

Adjust the light to reduce the strong contrast between the monitor and the surrounding visual field such as the surface of documents and the keyboard. Avoid glare:

e.g.: The optimal brightness level when using the CRT:

For the monitor, 500 lux or below is recommended.

For the paper documents and keyboard, 300 to 1,000 lux is recommended.

For fine visual tasks (e.g. designing, drawing, typing and calculating), 700 to 1500 lux is recommended. Use blinds and curtains to adjust the directly incoming light from the sun.

(2) Eliminating glare

You should position the monitor so that high-bright illuminations, windows, wall surfaces and blinking light sources do not come into the view field of an operator nor they are reflected on the monitor.

The reflection of the light source can be reduced in several ways, including:

i) Tilting the monitor to change the angle toward the light

ii) Dimming the illumination level of lighting apparatus

iii) Attaching anti-glare filters or hoods to the monitor.

iv) Using anti-glare type monitors

(3) Prevention of noise and other irritations.

You should adopt proper countermeasures to reduce objectionable noise from the printer or the air conditioning and ventilating system. Whenever possible, improve your indoor environment (e.g. manage air-conditioning and ventilation, and eliminate static electricity).

2. Managing Workplace

(1) Working hours

You should not work using a VDT for more than one consecutive hour, and you should take one or two breaks during this period. When you start your next period of consecutive work on VDT, you should take regular rests of 10 to 15 minutes in duration.

(2) Use anti-glare type monitors and clear fonts and figures on the screen.

(3) Use the keyboard you find most comfortable, preferably one which is position-adjustable.

(4) Arrange your desk so that it has the space necessary for VDT work. Ensure there is sufficient leg room. For a person of average height, the desk should be 65 to 70cm from the floor. If the height can be adjusted, make sure it is in the 65 to 70 cm range, depending on your height.

(5) A stable chair with casters which can be moved easily and is height-adjustable is recommended. Also, a back rest and an armrest are considered desirable. Considering that it is difficult to adjust the height of the work desk and the keyboard, a height adjustable chair is recommended so that you can find the most comfortable position to work in.

3. Working Posture

VDT work results in both mental and physical fatigue. Maintaining the same sitting posture for lengthy periods of time can result in lumbago, stiff shoulders and mental fatigue due to stress. It is important to assume good working posture to minimize this fatigue.

(1) It is important to adjust the height of the chair and to position the keyboard and display so that you are not working in a cramped posture.

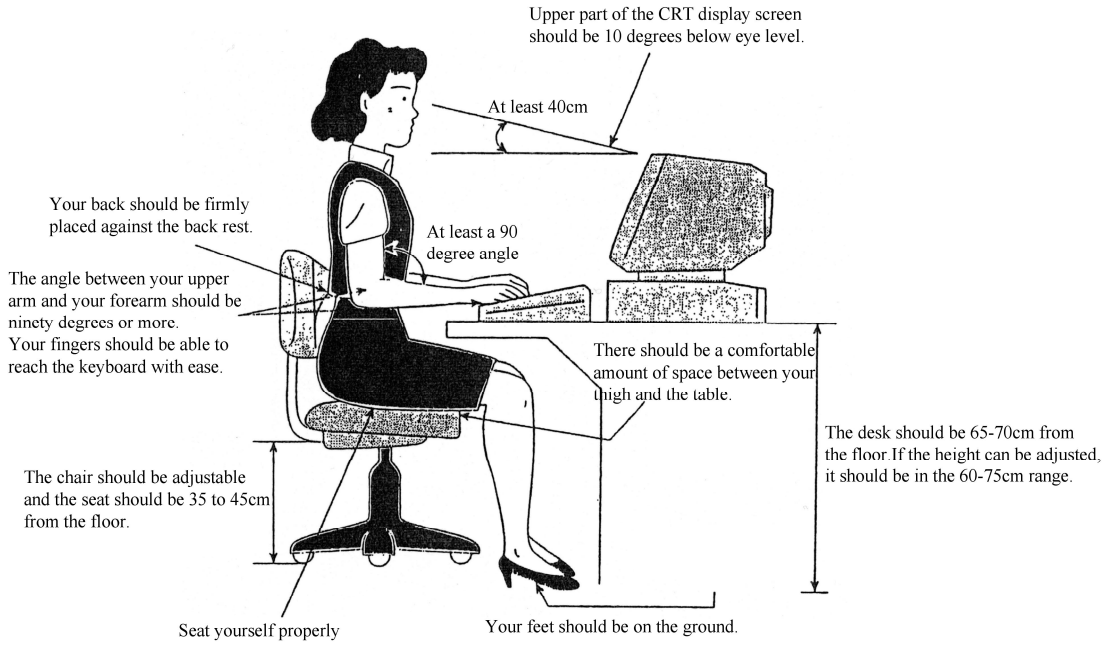
(2) Good sitting posture is when your feet are on the ground, and your back is firmly placed against the back rest. If necessary, use a footstool.

(3) There should be a comfortable amount of space between your thigh and the table when seated for work in the chair.

(4) Your fingers should be able to reach the keyboard with ease and your upper arm should hang vertically from your shoulders. The angle between your upper arm and your forearm should be a comfortable ninety degrees or more.

(5) Adjust your height so that the upper part of the display screen is at eye level and ensure there is 40 cm or more between your eyes and the screen.

(6) Arrange the display, the key board, the document and whatever else you may be using so that they are in easy view.



4. Health Management

(1) When continuing VDT work for long periods of time, keep your mind and body relaxed by taking regular rests from concentration. Do this by focussing on a distant point and stretching.

(2) If you wear glasses or contact lenses, make regular visits to the optometrist to ensure the right adjustments to your glasses and contact lenses are made.

(3) There are special physical examinations made available at the Health Administration Center for VDT operators every October. You are advised to take these examinations if you would categorize yourself as someone who does a lot of VDT work.

Chapter 17　First Aid

17.1 Introduction

An accident happens unexpectedly. It is essential to be prepared for accidents in order to prevent the worst result. In an emergency it is not easy for anyone to make cool-headed decisions and actions; however, it is necessary for people who encounter an emergency to have a minimum understanding of the status, make required communications promptly, and take first-aid actions until an emergency team arrives. Drills make people prepared for an emergency so that they can make the right actions.

17.2 Basic Life Support: BLS

17.2.1 Ensuring safety of rescuers and victims

Make sure that the surroundings are safe (i.e., no danger or contamination).

➔ Are the victims conscious? Are they breathing? Do they have a pulse?

17.2.2 Checking of consciousness

Pat a victim on the shoulder, speaking to him or her. If the victim reacts and needs medical treatment, you may go away to make a 119 call (i.e., call an ambulance). You should, however, come back as soon as possible to see that the victim's condition has not changed. Check his or her condition frequently.

➔ In case of a victim with possible cardio pulmonary arrest (CPA) (The survival rate four minutes after the CPA is 50%) (Fig. 1)

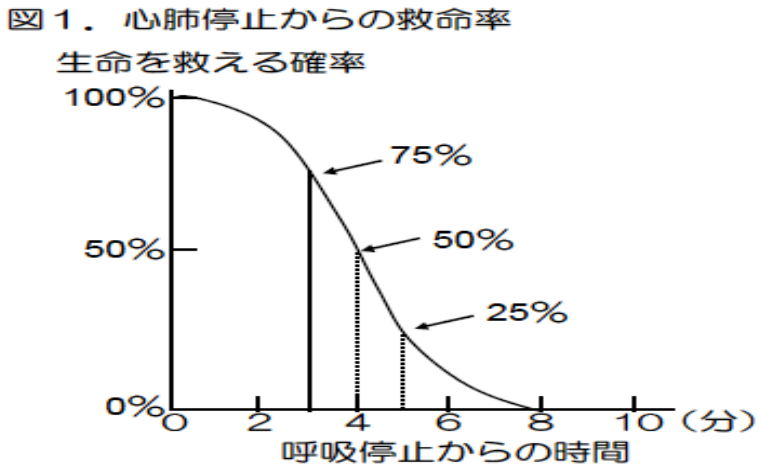


Fig. 1 Survival rate after cardio pulmonary arrest

Time after the respiratory arrest (minute) versus likelihood of saving the life

Pat both of a victim's shoulders softly, asking "Are you all right?" If the victim does not react,

(1) Call out "Help, somebody!", and make a 119 call (i.e., call an ambulance).

(2) Ask somebody coming for help to bring an AED (Automated External Defibrillator). AEDs are in place in the buildings. (*2)

＊1：ABC of resuscitation

A: Airway (airway management)

B: Breathing (artificial respiration)

C: Circulation (cardiac massage)

＊2：AED locations (total of 18 AEDs as of April, 2008)

Mechanical Systems and Design

Mechanical Systems No. 1 Building 1st Floor Lobby: 1 unit

Mechanical Systems No. 2 Building 1st Floor Lobby: 1 unit

Joint Building No. 1 Lobby: 1 unit

Quantum Science and Energy Research Lab 1st Floor: 1 unit

Electric Engineering and Information Engineering and Physics

Electric Engineering and Information Engineering and Physics No. 1 Building 1st Floor Lobby: 1 unit

Electric Engineering and Information Engineering and Physics No. 2 Building 1st Floor Lobby: 1 unit

Electric Engineering and Information Engineering and Physics No. 3 Building 1st Floor Lobby: 1 unit

Chemical Engineering and Biomolecular Engineering

Chemical Eng. and Biomolecular Eng. Lab. Complex Building 1st Floor Lobby: 1 unit

Metallurgy, Materials Science

Metallurgy, Materials Science A Building 1st Floor Staff Lounge: 1 unit

Civil Engineering and Architecture

Civil Engineering and Architecture A Building 1st Floor Lobby: 1 unit

Laboratory Complex Building

2nd Floor Hall: 1 unit

Environmental Studies

Main Building 1st Floor Lobby: 1 unit

New Industry Creation Hatchery Center

Main Building 1st Floor Lobby: 1 unit

FFF for New Information Industry 1st Floor Lobby: 1 unit

Environment Conservation Research Institute

Faculty Building 2nd Floor Hall: 1 unit

Administration Office

1st Floor Guard's Room: 1 unit

2nd Floor Sickbay: 1 unit

Branch Library

1st Floor Reading Room: 1 unit

17.2.3 Call 119

When you make a 119 call (i.e., call an ambulance), you should tell the dispatcher the number of victims, and their condition. In such a case, however, you tend to be in a panic. You should prepare yourself for such situation by reading "In Case of an Accident" contained in Chapter 18 of this manual so that you can be calm to speak to the dispatcher. The following shows how to behave in an emergency.

- When you are the only rescuer:

  If you find an unconscious victim (i.e., no body movement or no response to simulation), first call 119, and bring an AED where possible. As soon as you come back after making a 119 call, apply artificial respiration and cardiac massage (i.e., CardioPulmonary Resuscitation - CPR) on the victim, and use the AED for defibrillation, if necessary.
- When there are two or more rescuers:

  Do CPR, while one of the rescuers goes to make a 119 call and/or bring an AED.
- When an unconscious victim is an adult:

  There is a possibility that the victim has fibrillation (in that case, the only aid is defibrillation). Thus, it is then very important to bring an AED before applying artificial respiration or any other resuscitation means.
- In case of drowning or suffocation, without doubt:

  Try CPR for about two minutes before calling 119. Then go to make a 119 call.
- When a victim is a child:

  Try CPR for two minutes before calling 119, because a child often goes into cardiac arrest due to respiratory disorders.

17.2.4 Airway: Tilt the head back down, and lift the chin (Fig. 2).

(1) To begin CPR (Cardio Pulmonary Resuscitation), lay the victim with their back on a hard floor.

If a victim is lying on the face, roll the body over so that the victim will be on their back.

(2) Open the airway by holding the head back down and raise the lower jaw up with your hand (regardless of whether a victim is injured or troubled in some other way) Put the palm of one hand on the forehead of the victim, and put the fingers of the other hand on the edge of the lower jaw, and then pull the jaw up.

(3) After clearing the airway, check that the victim is breathing.

See, hear and feel whether the victim is breathing.

(i) Can you see the chest move? Can you hear the sound of breaths? Can you feel breath on your cheek?

(ii) Check whether breathing within ten seconds.

If you are not sure that the victim is taking normal breaths, blow air into the mouth (rescue breathing) twice. If you do not like doing this, just begin to do chest compressions.

図2. 頭部後屈・顎先挙上法

Fig. 2 Tilt the head back down and lift the chin

17.2.5 Rescue Breaths (ventilation)

(1) If a victim is not spontaneously breathing, blow air into the victim's mouth for one second, while pinching the nose with your thumb and index finger.

(i) If the rescue breaths are sufficient, you will see the victim's chest rising up.

(ii) If you do not see the chest rising up when you blow air once, tilt the head further back down and try the breaths again.

(iii) If a face shield or a pocket mask is available to you, use it to protect yourself from infection.

(2) Do not check for signs of circulation (i.e., breath, cough, body movement).

As soon as you have blown your exhaled air in twice, begin to do chest compressions by making 30 chest compressions.

17.2.6. Chest Compressions (circulation) (Fig. 3)

(1) Perform a series of 30 chest compressions and 2 rescue breaths. (This applies to all ages.)

Hand Position:

The center of the chest on the line connecting the nipples

Method:

Put both hands one over the other on that point. Compress the chest repeatedly at a rate of 100 per minute so that the chest wall can be compressed four or five centimeters downward each time. Ensure that the chest is not only compressed but also recoils each time. Each time, after you compress the chest, take the force away from the chest enough to relax the thorax completely. The time when the chest is compressed should be the same as the time when it is free from compression.

図3．心マッサージ

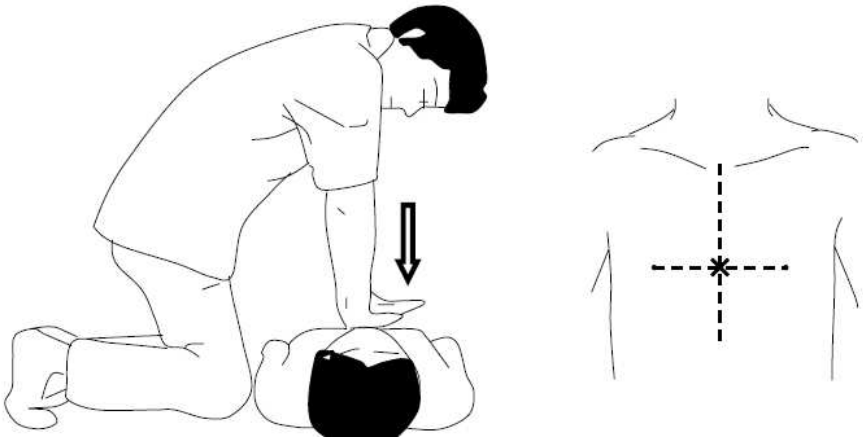


Fig. 3 Chest compressions

- When two people apply Cardio Pulmonary Resuscitation (CPR):

  One person should perform chest compressions while the other should perform rescue breaths. At every five cycles of CPR, they should exchange their CPR roles within five seconds and should continue CPR.

- When the rescuers cannot do rescue breaths:

  Do chest compressions only.

(2) Continue to do chest compressions until an AED arrives, until the body of the victim is seen moving, or until you turn the victim over to a rescue team. Regularly check the pulse.

- If the victim shows signs of circulation but no signs of respiration:

  Continue to do rescue breaths at a rate of once per five seconds.
- If the victim shows signs of both circulation and respiration, but is unconscious:

  Place the victim in a recovey position (i.e., put the victim on the side). (Fig. 4)

図4. 回復体位

Fig. 4 Recovery position

17.2.7 AED (Automated External Defibrillator)

The timing of attaching an AED to the victim is “just on its arrival” for every age group.

(1) Way of use

(i) First, switch on the power supply of the AED. When you turn it on, it begins to give you voice instructions. You must follow them without stopping CPR operations until it begins cardiac rhythm analysis.

(ii) Attach the electrode pads on the right upper part of the chest and the position of the apex of the heart, respectively. (Fig. 5)

Right side to the breast bone and lower side to the clavicle

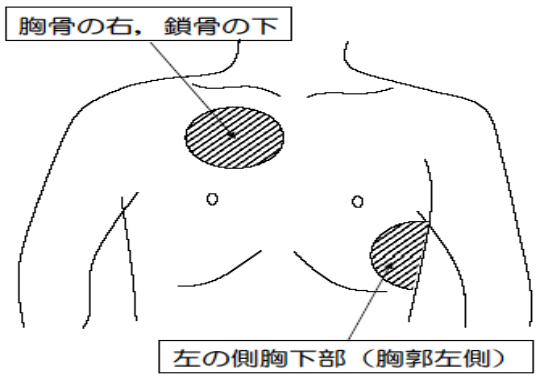


図5．AED パッド貼付位置

Lower left side of the chest (the left side of the thorax)

Fig. 5 Positions of AED pads

(iii) If the victim has a pacemaker embedded in the body, the pads must be more than 2.5 cm away from it. If there are plasters of percutaneous medicine on the positions of the chest, take them away, and, if the chest is wet, wipe it with a towel or a handkerchief, before you apply the AED pads.

(iv) Before the AED analyzes the victim's cardiac rhythm and discharge electricity, tell everyone near to stay clear away from the victim, and make sure of safety by speaking loudly:

"I'm away." "You're away." "All are away."

(v) After giving one AED shock, begin CPR operations (first, cardiac massage) again immediately.

(vi) Usually the AED starts analyzing the cardiac rhythm after two minutes of CPR operation.

(2) The possible results after giving one electric shock are as follows:

(i) The victim may recover normal heart rhythms.

The AED then gives a message "No further shock is necessary."

(ii) The victim may remain in the same abnormal condition (i.e., with fibrillation).

Defibrillate a maximum of three consecutive times until the victim recovers a normal cardiac rhythm.

(iii) The victim's cardiac rhythms may change to another abnormal rhythm that cannot be treated with an AED.

If the victim shows no sign of circulation, apply CPR operations for two minutes, and follow the instructions given by the AED again.

(3) Leave the AED pads on the victim's chest until the professional rescuers arrive.

If the victim recovers circulation and respiration, but has arrhythmia again, and the rescue team has not yet come, follow the following: (Fig. 6)

- <u>If the AED gives the message "No further shock is necessary,":</u>

(i) Check that the victim has an open airway and is breathing, and then that the victim shows signs of circulation.

(ii) If the victim is not breathing, or if there are no signs of circulation, apply CPR operations for two minutes, and follow instructions of the AED again. (The AED resumes analysis in two minutes automatically.)

- <u>If the victim is unconscious, but breathing with signs of circulation, do the following:</u>

(i) Leave the AED pads on the victim.

(ii) In case of no injury, place the victim in the recvery position and keep watching until the professional rescuers arrive.

- <u>If the victim is not breathing normally in spite of signs of circulation being shown:</u>

-

(i) Give rescue breaths at a rate of once per five seconds, without doing chest compressions.

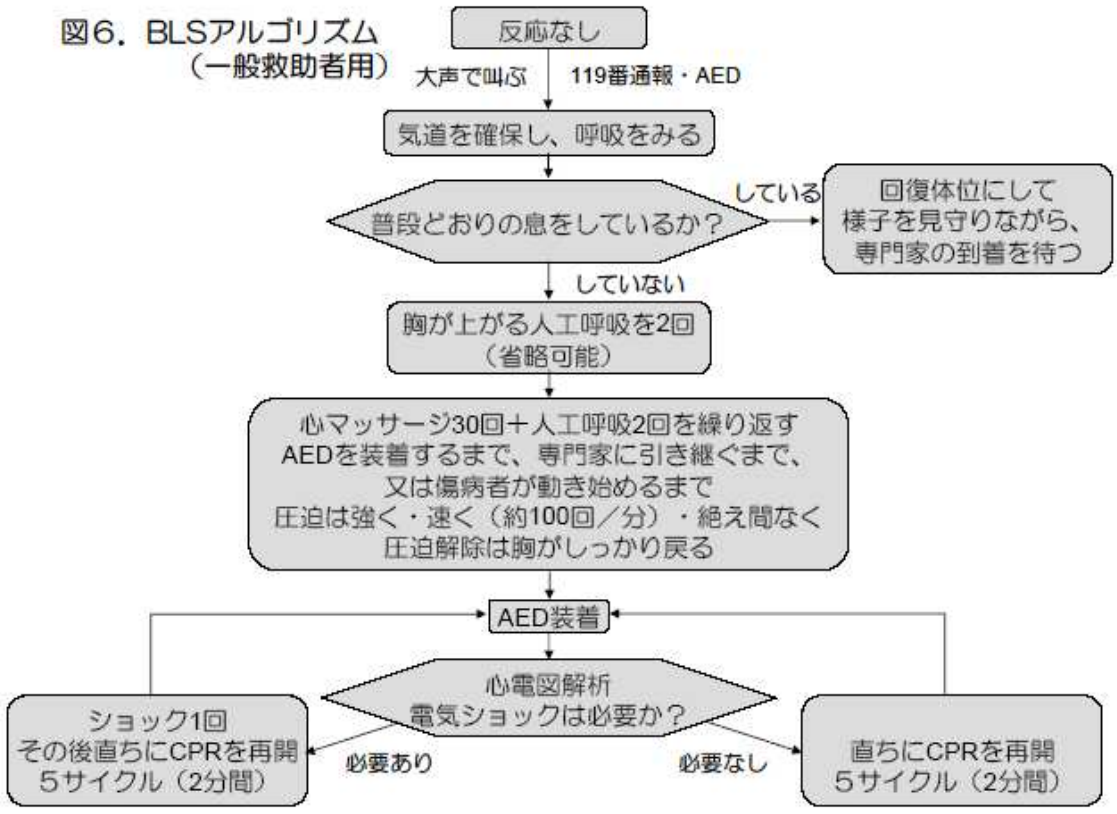


Fig. 6 BLS flowchart (for non-expert rescuers)

****

No response from the victim

Speak loud to the victim　　119 call and AED

Open airway, and check breathing

Is the victim breathing normally?　Yes　Place the victim in the recovery position, keep watching the victim, and wait for expert rescuers.

No

Give 2 rescue breaths.

(This may be omitted.)

Give cycles of 30 chest compressions and 2 rescue breaths until an AED is attached, until you turn the victim over to professional rescuers, or until he or she begins moving voluntarily.

Continue chest compressions strongly, rapidly (at a rate of about 100 times per minute) and allow for the chest to completely return to its normal position following each compression.

Attach the AED

AED analyzes the cardiac rhythm, to determine whether an electric shock is necessary (yes/no)?

Yes

Give one shock, and then do five cycles of CPR operations (for two minutes).

No

Just resume and do five cycles of CPR operations (for two minutes)

****

17.3 Injury Care: Hemostasis and Disinfection

17.3.1 Hemostasis **(Stop Bleeding)**

The basic of hemostasis is to compress the bleeding part directly.

(1) Direct compression

Apply a piece of clean gauze, a clean handkerchief, or other clean cloth, directly over the injured part, and press it by hand.

(2) Indirect compression

Compress a point of the body that is nearer to the heart than the bleeding part by hand or fingers, or other means.

(i) If using a rubber ring or string, do not tie it too tight.

Tissues distal to the point tied may die.

(ii) Tying a point proximal to the bleeding point is not usual for first aid because it may cause congestion and worsen the conditions except for arterial hemorrhages, large hemorrhages, etc.

17.3.2 Disinfection

When the victim is bleeding, first stop the bleeding, and then, clean and disinfect the wound.

(1) If the wound is dirty, wash it to remove the dirt with tap water.

(2) Disinfect it with Oxydol (hydrogen peroxide), etc.

(3) Cover the wound with a clean piece of gauze, and apply a bandage or adhesive tape.

<u>If a knife or a piece of wood is stuck into the chest or the abdomen:</u>

Do not pull it out, but leave it as it is.

Severed finger:

If a finger is severed, dress the wound with a piece of gauze and apply hemostasis pressure. At the same time, wrap the severed finger part with a piece gauze or clean cloth, put it in a plastic bag, put the bag in another bag with pieces of ice, and take it to a hospital.

17.4 Care of Burns and Scalds

17.4.1 Cooling

For burns and scalds, it is critical to cool them as soon as possible. Cool them by immersion in running tap water. After cooling for 20 minutes, go to a hospital (preferably keep cooling them with a cool wet towel or ice).

If the victim's clothing is stuck to the burn:

Never peal stuck clothing from the burn, but flush the burn area with large amounts of cooling water.

17.4.2 Calling an ambulance

If the victim's burn is large, or the victim has inhaled hot air, call an ambulance. Especially, pay attention to the following.

(1) When burns extend over 30% or more of the body surface, it is a serious condition.

(2) It occasionally happens that even though it does not look like a problem initially, the victim may fall gradually into shock or kidney dysfunction.

(3) A burn of the airway is a serious condition.

Pay attention to eyebrow burns, redness and/or pain of the pharynx, hoarse voice, dyspnea, soot in the sputum, etc.

17.4.3 Injury by electric shock

For injury by an electric shock, see if injury inside the body is serious even with small burns at the points of entrance and exit of electricity. It is necessary to hospitalize the victim for medical examinations and follow-ups.

17.5 Sprain, Bruise, and Fracture

17.5.1 Fractures are suspected in the following cases:

(1) The victim feels a sharp pain when the injured part is moved or touched.

(2) The injured part is swelling.

(3) There is a deformation in the injured part.

(4) Due to pain, it is difficult to move the victim.
(5) The victim has a wound and/or bleeding, and the bone sticks out from the wound.

17.5.2 Care of bone fractures

The basics of care of bone fractures are to cool them and not move the injured part.

(1) Set the injured part in a rest condition.
(2) If the victim has wound and/or bleeding, first take care of them.
(3) Cool the injured part with ice.
(4) Raise the injured part a little.
(5) The victim should see an orthopedist soon.

* If the victim feels very bad or is in unbearable pain, call an ambulance.

17.5.3 Fixing the fractured part

(1) Prepare a splint long enough to fix the distal and proximal articulations of the fractured part, i.e., a long splint over the two articulations with the fractured part in between.
(2) The order of fixing is first the part higher than the fracture, then the part lower than it, then another part higher, then another part lower.
(3) In each fixing action, ask the victim if there is pain. If you can have another person to help, have the person support the fractured part while you are fixing.

<u>If the victim suffers stronger pain by fixing, and takes an unnatural posture:</u>

Keep the victim in a rest posture without fixing.

<u>Be careful about possible shock</u>.

Call an ambulance if the victim feels strong pain, breaks into a cold sweat, becomes pale, or has a weak pulse.

17.6 Hyperthermia

People suffer hyperthermia when they play sports or work in an environment with high temperatures and/or high humidity.

17.6.1 According to the level of symptoms, hyperthermia is classified into:

(1) Heat cramps: muscle pain, cramp, nausea, dizziness, and headache
(2) Heat exhaustion: lowered blood pressure, frequent pulses and body temperature rises (up to 41 degrees centigrade)
(3) Heat stroke or sun stroke: dried skin with no sweating, body temperature rises to 41-43 degrees centigrade, and unconsciousness

17.6.2 Points of care

Move the victim to a cool place. Give the victim a sports drink, and cool the body.

(1) The victim is unconscious or faint: Call an ambulance.

(i) After loosening the clothing, make the victim lie or rest in breezy shade.

(ii) Apply pieces of ice or ice packs to the neck, armpits, ankles, etc., to cool the victim.

(iii) Fan the victim with a fan or the like.

(iv) If the victim can swallow water on their own, have the victim take a sports drink or the like to supply water and salt.

(2) If the victim is conscious, but cannot swallow water on their own, or is staggering, call an ambulance to turn the victim over to a hospital.

(i) After loosening the clothing, make the victim lie or rest in breezy shade.

(ii) If the victim is pale and has a weak pulse, make the victim lie with the feet raised.

(iii) If the body of the victim is hot, apply pieces of ice or ice packs to the neck, armpits, ankles, etc., to cool. Fan the victim with a fan or the like.

(3) Prevention

To prevent hyperthermia, it is important to:

(i)Sleep well to avoid accumulating fatigue.

(ii) Put yourself in good physical condition by taking meals with a good nutrient balance.

(iii) Supply water and salt by drinking a sports drink.

17.7 Poisoning by Chemicals

17.7.1 Finding causal materials

If poisoning is plausible, first, find what materials might have caused poisoning by asking the victim what he or she has swallowed or inhaled. In case of a suicide, it is not certain that the victim will tell you the true material that he or she took, so you may have to suspect from the scene, bottles, packs, etc., that may be there. It is also necessary to infer the amount that the victim has swallowed from the remaining amount in a container, if possible.

17.7.2 First aid

MSDS (Material Safety Data Sheets) describe first aid measures for corresponding chemicals. Put the MSDS of chemicals, now in use, somewhere they are readily available by everyone.

(1) When a poisoning material is swallowed:

Basically, have the victim drink milk or water, and then, give stimulation to deep

inside of the throat to induce vomiting.

(Generally, milk protects stomach walls and weakens the effect of the poisoning material.)

Cases where milk must not be given:

Insecticides, petroleum products (kerosene, gasoline, paint thinner, benzine, etc.), and so on.

Since these materials are soluble in fat, drinking milk will increase the amount absorbed in the body.

Cases where you must not let the victim vomit:

Petroleum products (kerosene, gasoline, benzine, etc.)

➔ Can cause serious pneumonia if the victim inhales these materials into the windpipe.

Strong acids and alkalis (toilet cleaning chemicals, drain pipe cleaning chemicals, mold and mildew removers, bleaches, etc.)

➔ Can cause a serious burn on the esophageal mucosa.

If the victim is unconscious and has a cramp,

➔ Can choke the throat by vomit

(2) When the victim inhaled a poisoning gas:

Move the victim to a place with clean air, and keep him or her in a rest position.

(3) When a poisoning material gets into an eye of the victim:

(i) Immediately, open the eyelids wide and wash the eye with tap water, or other running water, for about 15 minutes.

(ii) Remove contact lenses, if any, if possible.

(iii) Turn his or her face sideways. Then, splash water from a kettle into the eye slowly. When using tap water directly, set the flow from the faucet to slow. If you use a strong water flow, it can cause problems.

(4) When a poisoning material is attached to the skin:

Remove the clothing that has the poisoning material, and then wash the skin with water and soap.

(5) If the victim is unconscious:

Lay the victim sideways so that any vomit will not choke them. Pull the lower jaw up, and support the body in a way that the elbow and knee on the upper side are bent.

17.7.3. Consulting with a medical institution

The victim should consult with a doctor, with the material that has been swallowed (the container and the description of the material). If further information on the product or

its toxicity is required, call Toxicity 110.

Items of information to be given to the doctor:

i) Age and weight of the victim

ii) Exact names of the causal materials

iii) Amount taken, how the materials were taken into the body, amount of time that has passed after the intake

iv) Were there spills?

v) The amount remaining in the container.

vi) Situation where the accident occurred

vii) Mistakenly swallowed, or an attempt of suicide?

viii) All the symptoms that the victim has now

ix) Has the victim vomited, or not?

Chapter 18　Emergency Communications Guideline in Case of Fire or Accident

18.1 In the Event of an Accident

In the event of an accident, it is important to immediately call the attention of nearby people to what has happened in order to get help and prevent further damage. Even if you think it is a minor accident, you need to let other people know and respond to the situation as a group. Judgments made by just one individual tend to make the situation worse and can even bring about more danger.

The general rule of thumb is to remove all materials which could exacerbate the accident and prepare for evacuation. If you consider the situation to be relatively safe and manageable, and primary emergency responses including the initial fire extinguishing has been done, then get away from the site and report the accident to the professor and associate professor of the laboratory (hereafter the faculty responsible), who should direct you what further action needs to be taken. If the faculty responsible cannot be contacted, contact the security guard. If there are people around you, share the roles, such as reporting, using fire extinguishers, etc.

It is important that everyone in the laboratory works together from when the accident is first discovered. It is important that decisions are taken as a group until help arrives. You may not be in a suitable state of mind to make decisions if you are either the person responsible for the accident or the person who discovered the accident. Be sure to make decisions with others and share the roles, if possible, in responding to the accident.

Refer to Fig. 18-1 for the appropriate responses to an emergency, and be sure to follow this procedure in the event of an accident. Make it a rule, according to the emergency procedure, to contact the faculty responsible when an accident occurs and ask for decisions as to the best response considering the situation at hand.

In the event of a fire emergency, for example, report the faculty responsible first and have him or her call the fire department, but, if you deem the situation to be especially serious, call the fire department directly.

18.2 Contacting the Emergency Services

In an emergency situation, such as a fire or an accident in the laboratory or traffic accident, the student at the site should contact the faculty responsible (or security guard, if the faculty responsible cannot be contacted) immediately and follow his or her instruction. However, if the situation requires a rapid response, follow the Emergency Communications Procedure Notes *1 and *2 (refer to Fig. 18-1) and contact the fire department, hospital or police station directly. Then report to the faculty responsible, the administration bureau, or the security guard room (ex.4631, 5840) right away.

(1) Fire

If you encounter a fire, turn on the nearest fire alarm and get the attention of people in other adjacent laboratories by shouting “Kaji (Fire)”. Call the fire department immediately. If you can protect yourself from fire, try to extinguish it and do what is possible to minimize the damage in cooperation with the faculty, staff and other students.

(2) Life or death situations

If you encounter a serious or potentially fatal accident, call a doctor or an ambulance.

(3) Contacting the police station

If you encounter a serious or potentially fatal accident, and if you judge it to be something that should to be reported to the police department immediately, you should call the police directly.

Communication under these circumstances must follow the Emergency Communications Procedure (refer to Figs. 18-1 and 18-2). The emergency contact process and phone numbers need to be posted in easy view.

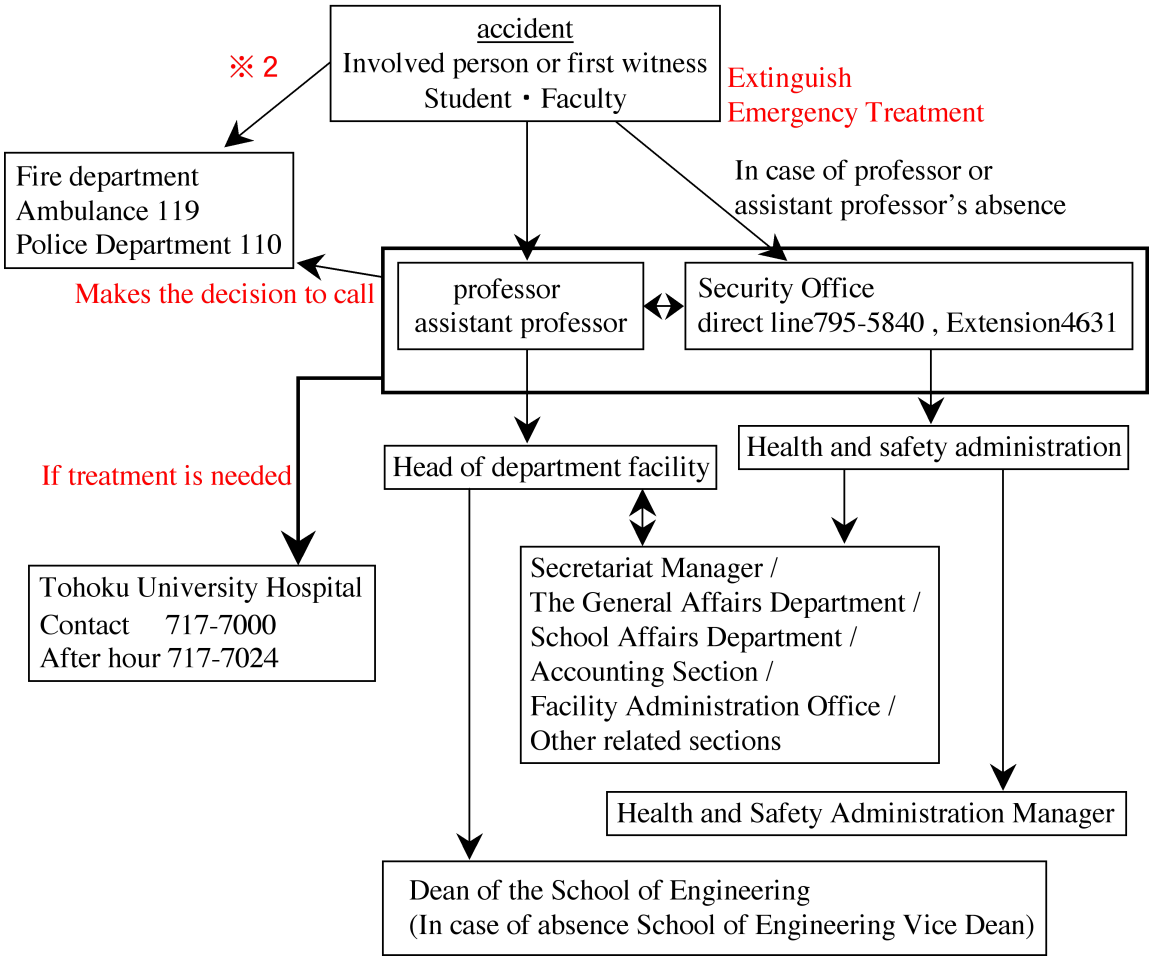
Also, each experimental room and laboratory must post emergency phone numbers for the Tohoku University Hospital and the faculty responsible in a conspicuous position. Since people tend to panic in an emergency, it is important to be prepared routinely.

18.3 Accident Reports

When an accident occurs, the student who encountered it must contact the nearest faculty or staff immediately. The faculty or staff must then report it to the professor or the associate professor in charge, or the professor responsible, regardless of the amount of damage incurred. At the same time, the faculty or staff must inform the Health and Safety Management Office about the details of the accident by filling the forms of the Accident Reports I and II. If there is an accident at sports events, notify the Health and Safety Management Office with the attachment of a filled-in form of the report for the sports event.

Emergency contact guidelines in case of fire, accident or robbery

Fire that can be extinguished immediately, non-fatal accident ※1 , ※2



*1 If a fire cannot be extinguished immediately, or if an accident is potentially fatal, the person involved or first witness must call the fire department (dial 0 then 119) for an ambulance or call the Tohoku University Hospital directly.

*2 In case of a fatal accident, a possibly fatal accident, or a robbery, all of which would require immediate police attention, the person involved or first witness must call the police department (dial 0 then 110) directly.

*3 In case of a fatal accident, or a possibly fatal accident, the person involved or first witness must report the dean of the School of Engineering directly

When an accident occurs:

	Must do	Where to call	Phone number	What to say
Injury	1. Turn off switches 2. Call for help 3. Emergency treatment Bleeding: tie with a tourniquet Loss of consciousness: perform artificial respiration 4. Call the places listed on the right column. (take a deep breath to calm down) 5, If it is a minor injury, take the victim to ER at the University Hospital	1) University Hospital ER	0-(717)-7000 After hours, Sat, Sun and holidays 0-(717)-7024	xxx is injured at the School of Engineering Department of zzz. yyy will take him/her to the hospital.
		2) Fire department (calling an ambulance)	Dial 0 to call 119	There is an injured person in the School of Engineering room ## in Tohoku University at Aobayama campus. Please send an ambulance. My name is xxx from School of Engineering with the major of ###. (My phone number is ####)
		3)School of Engineering Security Office	Extension 5840, 4631	There is an injured person in **department, **building, **floor, **room. Please guide the ambulance to the site
Fire	1. Call for help 2. Turn off switches and gas 3. Call listed places on the right column. 4. If possible, try extinguishing the fire. If it is serious, evacuate to a safe area.	1) Fire department (calling for ambulance)	Dial 0 to call 119	There is a fire in the School of Engineering room ## in Tohoku University at Aobayama campus. Please send us a firetruck. My name is xxx from School of Engineering with the major of ###. (My phone number is ####)
		2)School of Engineering Security Guard Office	Extension 5840, 4631	There is a fire in **department, **building, **floor, **room. Please guide the firetruck to the site.
Potential or actual fatality	If an accident seems potentially fatal and requires police involvement, the person involved or first witness must call the police directly. 1.Call the places listed on the right column (take a deep breath to calm down)	1)Police Department	Dial 0 to call 110	There is an accident in School of Engineering room ## in Tohoku University at Aobayama campus. Please send us police officers. My name is xxx from School of Engineering, with the major of ### (My phone number is ####)
		2)School of Engineering Security Office	Extension 5840, 4631	There is an accident in **department, **building, **floor, **room. Please guide the police car to the site.

After having made an emergency call, report to the head of the each organization including the chair of each department and the chief of each administration section.

Be prepared for an emergency, and always keep the following information ready at hand near the telephone.
-Handling and extinguishing of dangerous materials in the event of a fire.
-Addresses and phone numbers

Home page for School of Engineering Emergency Contacts
http://www.eng.tohoku.ac.jp/saigai/

How to write and submit an accident report

1. Creating an accident report
   (1) The kind of accidents that need to be reported:
      1. Injuries (treated at the school infirmary or an outside hospital) or the death of students, staff, faculty and researchers that happen during an experiment, disaster (earthquake, fire, etc), or business trip (including an internships and dispatch)
      2. When faculty, staff or students cause a fire which damages the facilities or equipment
      3. Accidents during a school-recognized sports event. (This applies to injuries treated at the school infirmary or an outside hospital). *Attach the filled-in form of the report for the sports event.
      4. Accidents during commuting (for injuries treated at the school infirmary or an outside hospital)
      5. Any other accident or illness involving faculty, staff or students that may be deemed best to report considering health and safety management
   (2) Type of accidents
      1. Serious accidents (injuries which require more than one day hospitalization, or death)
      2. Minor accidents (accidents other than serious accidents, which require outpatient treatment)

2. When to submit
   (1) Accident Report I needs to be written and submitted on the day of the accident or by the next day.
   (2) Accident Report II needs to be written and submitted within a week of the accident.
   Fill in the relevant sections to the accident.
   *If an accident occurs on a public holiday or on the weekend, submit the report on the next work day.

3. Where to submit
   (1) The person who wrote the report should submit it to the head of the organizations including the chair of the department. Then, the chair is required to pass it on to the Health and Safety Management Office through the Administration Section Chief.
   (2) If the person who wrote the report is an administrative member, he or she should submit the report to the Health and Safety Management Office through the chief or manager of the administration section.

4. Who should write the reports (I & II)
   (1) If a faculty member, technical staff member, a laboratory's undergraduate or a graduate student, or a researcher is involved in an accident, the professor, associate professor, lecturer, research associate or technical staff member should write the reports with the professor's sign for approval. If the professor is absent, the head of the organization such as the chair of the department needs to give the approval.
   (2) If administrative staff member writes the reports, the sub-section manager or chief is responsible for the forms and is required to get approval from the head of the administration section.
   (3) In case of accidents while commuting, the victim or person who received the call is required to write Report I, and the victim is required to write Report II.

5. In the event of a serious accident
   (1) An accident investigation committee will investigate the site of the accident and its cause by reviewing the health and safety management system and the daily health and safety practices at the department, unit, etc. where the accident occurred.

Form 1 (Serious Accident / Minor Accident)

Accident Report I

To: The Chief Safety and Sanitation Manager, Dean of the School of Engineering

Date created: Year (Heisei) month date

Reported by	Section		Name		Phone	
Kind of accident	Fire/explosion Inflammation/smoke Leak(gas, chemical) Exposure(radiation, etc.) Abnormal odor Bursting/breakage Falling/tumbling Other					
Date	Year (Heisei) month day time					
Place						
Injury (if many, use another sheet)	No Yes (fill in below) Name of victim: Sex: M / F Age School status: Full-time employment Part-time employment Guest researcher Student Other Section (Department, Lab name): Title or Student ID number: Description of damage or injury:					
Material damage	No Yes ( )					
Report status	Outside: Fire dept. Police station. Labor Standards Bureau. Government organization ( ), Ambulance, Hospital (Attendant:), Company the victim belongs, Family, Other ( ) Inside: Professor Associate. professor Security room Administration Bureau Other					
Summary of accident (attach a photo or map of the site)						
Accident responses (chronological order of events including time of emergency call)						
Person responsible check		Year (Heisei) month day		Signature		

*A serious accident involves injuries that require more than one-day of hospitalization or result in death. A minor accident involves injuries that require outpatient treatment.

*This form is also used for faculty, staff or student accidents that occur while commuting. In such cases, the victim or the person who received the emergency call will write the report.

Form 2

Accident Report II

To: The Chief Safety and Sanitation Manager, Dean of School of Engineering

Date: Year (Heisei) month date

Reported by	Section		Name		Phone	
Accident Report I submitted date	Year (Heisei) month day ( )					

1. Victim's condition

Victim's information (if many, use another sheet)	Name: Sex: Male / Female Age School status: Full-time employment Part-time employment Contract researcher Student Other Section (Department/Lab name): Title or Student ID number:
Victim's condition (write down a report from hospital or family if victim is in a hospital)	

*A serious accident involves injuries that require more than one-day of hospitalization or result in death. A minor accident involves injuries that require outpatient treatment.

*This form is also used for faculty, staff or student accidents that occur while commuting. In such cases, the victim or the person who received the emergency call will write the report.

2. Details of accident, cause, and prevention plan

Detail (Describe the accident site thoroughly with a photo or chart attached. If necessary, add an explanation to Accident Report I)	
Cause (Describe clearly and in detail)	
Prevention plan in the future (Itemize ideas clearly. Attach supporting materials, if applicable)	

3. Safety and sanitation management status and daily activity report

Please answer following questions. Circle the appropriate answer.

(1) Documents for safe experimental procedure

1. Was a document for experimental procedure created exclusively for this experiment? Yes, No
*If yes, please attach a copy
If no, please explain why not:

2. Was this experiment done according to the document for experimental procedure? Yes, No

3. Did the document for experimental procedure lack information regarding this experiment? Yes No
*If yes, explain how the document could be improved:

(2) Safety training for the victim

1.What kind of safety training was carried out prior to this experiment?
Attach supporting material, if applicable.

2. Was there an introductory training for new equipment? Yes, No
Did the victim attend this training? Yes, No

3. Was there a monthly safety and sanitation meeting at this laboratory? Yes, No
Did the victim attend this meeting? Yes, No

(3) In case of a serious accident

1. Did the department or group undergo safety training? Yes, No
Did everyone have a record of attendance? Yes, No

Person responsible check	Year (Heisei) month day	Sign

REPORT FORM FOR SPORTS EVENTS

To prevent sporting accidents, the applicant should understand and confirm the items below before holding a sports event. In the event of an accident, the Personal Accident Insurance for Students Pursuing Education and Research will be applied and forms should be submitted to the person in charge at the Education and Student Support Section or the Administration Office of relevant departments and then submitted to the Health and Safety Management Office together with the Accident Report Form.

The applicant must check and confirm the following with the participant and make appropriate preparations.

I. Sports Event

Name of Applicant		Student No.		Extension No.	
Type of Event					
Date	Year/Month/Day to Month/Day				
Venue					
No. of participants	(see attached sheet)				

II. Preparing for the Event

1. Attire/Protective Equipment

No.	Item	Check mark
1	Check whether a hat (or cap) is being worn (limited to outdoor sporting events).	
2	Check whether long-haired participants have their hair secured so they cannot swing their hair, have their field of vision obstructed or touch others with their hair (e.g. braiding or tying their hair or wearing a hair band)	
3	Check whether nails are properly trimmed.	
4	Check whether protective equipment such as helmets, masks, headgear, goggles, or protectors are being used (equipment differs according to event).	
5	Check whether participants wearing glasses have attached strings to keep them in place or from falling off.	
6	Check whether clothing is breathable, light and not constricting.	
7	Check whether shoes fit comfortably with socks on and will not cause blisters.	
8	Check whether shoelaces are tied properly and are not about to break, and whether the spikes on spike shoes are not worn down.	
9	Check whether watches or stopwatches are being worn.	

2. Health Check

No.	Item	Check mark
1	Check whether participants are suffering from fatigue, overwork, constipation, diarrhea, menstrual cramps, lack of sleep, or excessive drinking. *participants who have any of these symptoms should not do strenuous exercises or overdo things.	
2	Check whether participants are suffering from muscle pain. *participants who have this symptom should do extra warm-up stretching exercises and cool-down stretching exercises.	
3	Check whether participants are experiencing abnormal symptoms such as dizziness, chest or	

	stomach pain, heart palpitations at rest or abnormal palpitations during exercise, have difficulty breathing, feel lethargic, or have chills or nausea. *participants who have these symptoms should stop exercise immediately and go directly to a hospital accompanied by someone.	
4	Check whether participants have symptoms such as cold sweats, are very pale, have glassy eyes, have a rapid heart rate at rest or abnormal increase in heart rate when exercising, or have serious arrhythmia. *participants who have these symptoms should stop exercise immediately and go directly to a hospital accompanied by someone.	
5	Check whether participants have a communicable disease or infection *participants with these conditions should either not participate or do only light exercise	
6	Check whether participants have a sports disability such as lower-back pain (chronic or disabling symptoms). *participants suffering from an inflammation or disability in specific areas of the body should not participate in sports that will aggravate these areas.	
7	Check whether participants have done sufficient warm-up exercises such as jogging or stretching exercises.	
8	Check whether participants have done cooling down exercises after exercise to help recover from muscle fatigue.	
9	Check whether participants have supplies of liquid supplements such as sports drinks and have taken adequate time out to rest and rehydrate.	

3. Miscellaneous

No.	Item	Check mark
1	Check whether participants are familiar with all the rules.	
2	Check whether the number of participants is appropriate in terms of space to prevent collisions with other players.	
3	Check whether lights are not too bright or too dark (in gyms or training rooms).	
4	Check whether there is sufficient ventilation (in gyms or training rooms).	
5	Check whether temperature settings are appropriate (in gyms or training rooms).	
6	Check whether floors are decayed, damaged or aged (in gyms or training rooms).	
7	Check whether participants have had medical checkups beforehand (for participation in strenuous sports).	
8	Check whether the telephone numbers and addresses of nearby hospitals are readily available in case of an accident.	
9	Check whether all the participants are enrolled in the Personal Accident Insurance for Students.	

III. Activity Report (if a student is injured or becomes ill and receives treatment from the school infirmary or an outside hospital, please be sure to fill in an accident report form and submit it to the student's advisory teacherand the Education and Student Support Section or administration office of relevant department)

No.	Item	Response
1	Check whether any students were injured during a game.	
2	Check whether any students became ill during a game.	
3	Check whether any students were injured or became ill for reasons other than participation in a game.	

*1) This report shall be subject to the sports events that are recognized by the Undergraduate School of Engineering, Graduate School of Engineering, Graduate School of Environmental Studies, and Graduate School of Biomedical Engineering (Aobayama Campus) or their departments.

2) List of participants should be attached.

Chapter 19　Daily Safety Management System

19.1 The Safety Management System and Organization

A large variety of equipment and chemicals are used in day-to-day research and educational activities in the School of Engineering at Tohoku University. It goes without saying that electricity, water and gas services are indispensable for these activities. When we use these services, we have to observe all the related laws and ordinances. The relevant laws have been enacted as a base line for maintaining security, public health, and environmental sanitation. Therefore, all students, staff and faculty have to understand the laws related to their research and educational activities and comply with them at all times. Considering the importance of security management, the School of Engineering has established the Safety and Health Committee and other related committees to ensure each and every department has a good understanding of those laws and ordinances. In addition, the Safety and Health Committee has been engaged, among other things, in preparing safety manuals, providing safety education, carrying out inspections and evaluations of safety management, and ensuring that chemicals are managed according to the PRTR laws.

Each department and laboratory is also responsible for organizing its own committees (own Safety and Health Committee and other) dealing with safety and health, and disaster prevention issues to maintain security and a better environment.

19.2 Safety Inspections and Evaluations

The Safety and Health Committees and other related committees work together to improve safety issues by carrying out inspections and evaluations under the guidance of the Labor Standards Bureau and other regulatory agencies. The students, staff and faculty members are required to cooperate with these committees in their inspections and evaluations. In section 19.4, there is a list of all the areas taken into account during inspections and evaluations. You should make yourself familiar with them, and make an effort to maintain the safety of your work place.

19.3 Insurance

There is an insurance system in place to provide compensation for any financial damage incurred as a result of disasters or accidents.

1) Personal Accident Insurance for Students Pursuing Education and Research

This insurance covers both undergraduate and graduate students. Compensation will be provided for any damage incurred as a result of disasters and accidents which occur during research and educational activities as well as extracurricular activities outside the campus. Taking out this insurance policy is mandatory for all students at the School of Engineering. The details of this insurance are explained in Chapter 3. Please read the details of this insurance before taking it out. The Student Support Section in each department has brochures that explain the insurance in more detail. This insurance is effective for four years after it is taken out. It should be noted that renewing insurance is mandatory for those staying at Tohoku University for more than four years, whatever the reason. Note that all research and educational activities to be undertaken outside the campus must be reported in advance. No damage incurred outside campus will be compensated for by insurance without this prior notification. Contact your advisory teachers or the Student Support section at the Education and Student Support Division in your department if you have any queries.

2) Premises Operation Liability Insurance

Compensation will be paid under this insurance system for any liable damage to research facilities or equipment or for any liable injuries incurred to students* who are performing research or educational activities under the control of teachers. Loss of life is also covered. The maximum coverage for one accident is 500 million yen with a maximum 100 million yen per person and a maximum 100 million yen for loss/damage to properties. When obtaining and maintaining this insurance policy, support has been provided by the Aoba Kougyoukai, which is the alumni association of the School of Engineering.

(Students* includes undergraduate and graduate students, research students and non-degree students at the Undergraduate/Graduate School of Engineering, Graduate School of Environmental Studies, Graduate School of Information Sciences and Graduate School of Biomedical Engineering (Aobayama Campus).)

19.4 Safety Evaluation Checklist

Assuring safety is the most important aspect of everything we do in our university. It is crucial that everyone understands the importance of maintaining safety and does what is required of them. Safety inspections and evaluations are considered indispensable for

maintaining and improving our health and environment. Refer to the evaluation checklist below to see what the safety considerations are, and then make an effort to keep your particular circumstances in the condition marked “A”. Note that there is flexibility in how each of the evaluation items listed is interpreted, depending on the peculiarities of each situation.

I. Safe laboratory environment

1. <Safety in the laboratory room>

(1) Ventilation of the entire room

P: Not required

A: Clean air with no odor of chemicals

B: Stagnant air and a slight odor of chemicals

C: No ventilation system or a disabled ventilation system

(2) Local exhaust ventilation

P: Not required

A: A draft chamber or local exhaust ventilation hood is in place and all the harmful chemicals are treated there.

B: Some harmful chemicals are used on the lab bench.

C: There are no draft chambers or local exhaust ventilation hood, or they are out of order.

(3) Room temperature control

P: Not required

A: The room temperature is controlled comfortably.

B: The room temperature is not always comfortable.

C: The room temperature cannot be controlled.

(4) Heating system

P: Not required

A: The heating system does not pose a fire hazard.

B: The heating system does not use a naked flame, but there is a risk that it makes flammables catch fire.

C: The heating system uses a naked flame.

(5) Room lighting

P: Special lighting is not necessary.

A: The light is bright enough and the lighting is maintained well.

B: Maintenance is insufficient.

C: The room is poorly lit.

(6) Passageways

P: Special attention is not necessary with regard to the passageways in the laboratory

A: There is enough space for experimental work and passageways (80 cm or wider).

B: There is equipment or materials blocking the passageways.

C: None or very narrow passageways.

(7) Emergency escape route

A: There is a clear escape route for emergency.

B: There are obstacles blocking the emergency escape route.

C: There is only one exit in the room and no emergency escape route.

(8) Emergency lighting system

A: Lighting is secured under power interruption.

B: There is a flashlight but not for exclusive use.

C: There is no emergency lighting system.

(9) Locking system

P: Only an assigned person manages the locking system, and no specific concern is necessary when conducting an experiment.

A: Student, staff and faculty members are controlled when entering and leaving the room by the locking system.

B: There is a locking system but it is not in operation.

C: There is no locking system

(10) Cleaning and organizing

A: The laboratory room is well organized and cleaned up regularly.

B: The laboratory room is cleaned and put in order occasionally.

C: The laboratory room is unorganised and not clean.

2. <Hallway>

(1) Circumstance

P: There are no hallways

A: The hallway is clear. No equipment or materials are left in the hallway.

B: Some equipment or materials are left temporarily in the hallway.

C: Equipment or materials are left habitually in the hallway.

(2) Fire control area

P: There is no designation for a fire control area.

A: The fire control area is protected by an automatic fire shutter.

B: A fire shutter is installed but its functioning is not assured.

C: There is no fire shutter.

II. Equipment

1. < Fire prevention system under the Fire Service Law>

(1) Fire prevention in laboratory

A: The fire prevention system* is installed and the emergency security procedure is prepared.

B: There is no equipment for eye washing.

C: The fire prevention or emergency security system is insufficient.

The fire prevention system* includes a fire alarm system, fire extinguisher and eye shower.

(2) Inspections of the fire prevention system

A: The system is inspected regularly.

B: The system is inspected occasionally.

C: The system is rarely inspected.

2. <High pressure gas equipment>

(1) Safety device for high pressure gas equipment

P: Not applicable.

A: A safety device is installed for experimentally important equipment.

B: A safety device is not always installed for the equipment.

C: There is no safety device installed.

(2) Management of the high pressure gas equipment

P: Not applicable.

A: The equipment is inspected regularly according the established inspection guideline for corrosion and material degradation.

B: The equipment is inspected regularly.

C: The gas system is inspected occasionally.

(3) Management of high pressure gas containers

P: Not required.

A: High pressure gas containers are under the management in accordance with good safety management practices*.

B: High pressure gas containers are under the management though there is a concern for safety.

C: Safety practices and management are insufficient.

Safety practices* includes signs, overturning prevention, piping, gas leak detector.

3. <Chemicals and hazardous materials storage equipment>

(1) Installation of chemicals storage cabinet

P: Not applicable.

A: There is a fireproof storage cabinet for chemicals.

B: There is a storage cabinet for chemicals, but it is not fireproof.

C: There is no storage cabinet for chemicals and bottles are put on the floor.

(2) Preventing bottles from falling

P: Not applicable.

A: All the storage cabinets are prevented from overturning by fixing them to the floor, wall or ceiling, and bottles are prevented from falling by putting them in trays to counter earthquakes.

B: The storage cabinet is partially protected from overturning.

C: The storage cabinet is not protected from overturning.

(3) Sorted storage of chemicals with their indications

P: Not applicable.

A: All the chemicals are stored in a sorted manner with their indications.

B: All the chemicals are stored in a sorted manner but there are no indications.

C: No sorted storage and no indications.

(4) Storage quantity and managing status of chemicals

P: Special management is not necessary.

A: Chemicals are correctly registered with their quantities into the Management System for Lab-chemicals and the faculty members in charge figure out the quantities.

B: Some chemicals are registered into the Management System for Lab-chemicals but others are not.

C: No chemicals are registered into the Management System for Lab-chemicals.

(5) Warehouse for chemicals and hazardous materials

P: Not applicable.

A: There is a warehouse for chemicals and hazardous materials and it is managed by a safety supervisor (hazardous materials officer).

B: There is a warehouse for chemicals and hazardous materials, but it is not managed properly.

C: There is no warehouse for chemicals and hazardous materials, and hazardous materials above their designated quantities are left randomly in the laboratories.

4. <Refrigerator for chemicals>

(1) Management of the refrigerator

P: Not used

A: All the hazardous materials are stored and managed strictly in the refrigerator, which is protected from explosion.

B: The refrigerator is inspected regularly but there are no storage management standards.

C: The refrigerator is not under the storage management. Both chemicals and food are stored in the same refrigerator.

5. <Self-made experimental equipment for unmanned operation>

(1) Maintenance of high speed rotating equipment, etc.

P: Not applicable.

A: The equipment is inspected regularly and repaired properly.

B: The equipment is inspected occasionally.

C: The equipment is not inspected.

(2) Safety check for self-made equipment

P: Not applicable.

A: Safety check has been done by the person responsible at the time of designing and manufacturing.

B: Safety check has been done to a certain level at the time of designing and manufacturing.

C: Safety check has not been done.

(3) Automatic operation equipment

P: Not applicable.

A: A person responsible is assigned to manage the equipment, and a rapid detection and response is possible in an abnormal situation. Emergency measures are well-established.

B: A system for a rapid detection and response is installed, but the emergency measures are not sufficient

C: There are no safety measures.

6. <Electrical equipment>

(1) Installation and management of electrical equipment

P: No special equipment

A: The equipment is inspected regularly for adequate installation according to the checklist for electrical equipment.

B: Easy combustibles are left around the electrical equipment, and there are burn marks on the surface of the terminal connector. Safety measures are insufficient.

C: The equipment is not inspected and repaired until it breaks down.

(2) Electricity wiring

P: No special wiring

A: The wiring is inspected regularly for adequate management according to the checklist for electrical equipment.

B: Inspections are not carried out. Safety measures are insufficient.

C: Safety is lacking since electric cords are jammed and cross a passageway.

7. <Equipment for DNA recombination>

(1) Security cabinet

P: Not applicable.

A: The cabinet is inspected regularly.

B: The cabinet is not inspected regularly, but it operates normally.

C: The cabinet is not inspected and does not operate normally.

(2) Sterilizer

P: Not applicable.

A: The sterilizer is inspected regularly.

B: The sterilizer is not inspected regularly, but it operates normally.

C: The sterilizer is not inspected regularly and does not operate normally.

(3) Centrifuge

P: Not specifically necessary.

A: The centrifuge is inspected regularly.

B: The centrifuge is not inspected regularly, but it operates normally.

C: The centrifuge is not inspected regularly and does not operate normally.

III. Experiment

1. <Preliminary measures>

(1) Hazard prediction and assuring safety

P: Not specifically necessary.

A: The experimental procedure is created. Safety issues including the hazard prediction are reviewed and the appropriate safety countermeasures are established.

B: Some particular points and certain themes are subject to hazard prediction.

C: No hazard prediction is conducted.

(2) Experimental procedure

A: The experimental procedure is created and kept.

B: The experimental procedure is created, though important points or safety items are missing, and is incomplete.

C: The experimental procedure is not created.

(3) Clothing and footwear

P: Special attention is not necessary.

A: During the experiment, it is required to wear safety gear such as a lab coat, protective glasses, mask, gloves, etc.

B: During the experiment, it is required to wear part of safety gear.

C: There are no rules regarding clothing and footwear.

2. <Safety gears>

(1) Maintenance of safety gear

P: Not applicable.

A: Safety gear is always kept in good condition. The use standards and handling procedure are established and well understood by everyone, and they are worn or used properly.

B: Safety gear is kept, but the handling procedure is not well understood by everyone.

C: No safety gear is kept in the laboratory.

(2) Indication of the place for safety gear

P: Not applicable.

A: The place of safety gear is indicated. The safety gear is under regular maintenance and kept in good condition.

B: Safety gear is kept in a pre-determined place, but maintenance is not sufficient.

C: There are no pre-determined places for safety gear. The safety gear is not under good maintenance.

3. < Workbench>

(1) Apparatus on the workbench

A: Apparatus are always kept in order. They are protected from overturning and falling.

B: Apparatus are not always kept in order.

C: Apparatus are put on a messy workbench without being protected from overturning or falling.

(2) Chemicals on the workbench

P: Not applicable.

A: A person responsible for management is assigned, and only the necessary chemicals are put on the workbench in an orderly manner.

B: Only the necessary chemicals are put on the workbench.

C: Unnecessary chemicals are also left on the workbench.

4. <Management of waste and laboratory waste liquid>

(1) Treatment of wastes

P: Not applicable.

A: Wastes are sorted according to the predetermined rules. Their storage and treatment are managed properly.

B: Some wastes are sorted. Their storage and treatment are not managed properly.

C: Wastes are not sorted.

(2) Management of laboratory waste liquids and their containers (plastic containers)

P: Not applicable.

A: Laboratory waste liquids are sorted properly in respective plastic containers according to the Classification Table of Laboratory Waste Liquid. Request to collect them is addressed to the ECRI through its Waste Liquid Management System.

B: Laboratory waste liquids are sorted in plastic containers, but a request to the ECRI for collection is not made. Containers are placed randomly in the room.

C: Plastic containers are not available.

5. <Poisonous and deleterious substances>

(1) Management of poisonous and deleterious substances

P: Not applicable.

A: A person responsible for management is assigned. Poisonous and deleterious substances are managed through the storage cabinet locking system, MSDS utilization and the Management System for Lab-chemicals.

B: Some poisonous and deleterious substances are not managed properly.

C: There is no management for poisonous and deleterious substances.

6. <Fire>

(1) Management of fire prevention

P: No fire is used in the laboratory.

A: Easy combustibles are sufficiently managed to prevent a fire.

B: Easy combustibles are managed to prevent a fire, though not sufficiently.

C: There is no management for fire prevention.

7. <Proper handling of equipment>

(1) Maintenance of manuals

P: Not applicable.

A: Manuals, experimental procedures, etc. are ready to use and proper handling of equipment is well understood.

B: There are manuals, experimental procedures, etc., though handling of equipment is not well understood.

C: There are no manuals, experimental procedures, etc. for use.

8. <When ending the experiment>

(1) Management at the time of ending the experiment

P: Not specifically necessary.

A: The procedure to be taken when ending the experiment is prepared and it is properly performed.

B: There is no predetermined procedure for ending the experiment, but practices for ending the experiment is managed.

C: Ending the experiment is not managed.

(2) Management when finally leaving the experimental room

P: Not specifically necessary.

A: There is a manual for a last person leaving the room, describing what to do such as writing in the log book, checking across and locking the room, and so on. Final practices are properly managed.

B: There is no manual, but final practices are managed.

C: Final practices are not managed at all.

IV. Health and safety management

1. <Work environment>

(1) Management of the work environment

P: Not specifically necessary.

A: The work environment is managed properly in compliance with the relevant laws and ordinances.

B: The work environment is managed to a certain level, but not sufficiently.

C: The work environment is poorly managed.

(2) Experimental design for DNA recombination

P: Not applicable.

A: The experimental design for DNA recombination has been notified in a proper manner.

B: The experimental design has been notified, though in an imperfect manner.

C: The experimental design has not been notified.

2. <Indication signs>

(1) Posting the indication signs

P: Not specifically necessary.

A: There are signs indicating the prevention of miss-operation, emergency exit and emergency evacuation area.

B: There are signs posted in certain areas, but not sufficient in number.

C: There are no signs posted.

3. <Books and papers>

(1) Orderly arrangement of books and papers

P: Not applicable.

A: Books and papers are arranged in order in a regular interval. They are prevented from falling and are always kept in order.

B: Books and papers are kept in an orderly arrangement, but are not well prevented from falling.

C: Books and papers are not kept in an orderly arrangement.

V. Management system and education & training

1. <Safety management organization>

(1) Safety management organization of each department

A: A standing committee for safety management is organized and its meeting is held on a regular basis.

B: The committee meeting for safety management is held occasionally.

C: There is no committee for safety management, or if there is, a meeting is not held.

(2) An own safety management system for each experimental room

P: Not applicable.

A: A standing committee for safety management is organized and its meeting is held on a regular basis.

B: The committee meeting for safety management is held occasionally.

C: There is no committee for safety management, or if there is, a meeting is not held.

2. <Safety inspection and evaluation>

(1) Inspection and improvement

A: Inspection is regularly performed by a supervisor, and accordingly improvements are made.

B: There are comments and points for improvement, but improvements are not sufficient.

C: Inspection is not regularly performed by a supervisor.

3. <Safety education>

(1) Undertaking safety education

A: An education program for safety issues is effectively organized and is open to all students, staff and faculty. The level of understanding is evaluated.

B: There is an education program for safety issues, but the level of understanding is not subject to evaluation.

C: There is no systematic education program for safety issues.

4. <Emergency drill >

(1) Holding an emergency drill

A: An emergency drill is held at regular intervals, which allows appropriate

responses to fires or earthquakes.

B: An emergency drill is held occasionally.

C: There is no emergency drill.

5. <Emergency procedure>

(1) Procedures for actions in an emergency

A: There are appropriate procedures for actions to take in an emergency, such as a fire, injury, and earthquake.

B: Most people know what actions to take in an emergency.

C: Appropriate actions to take in an emergency are poorly known.

Chapter 20　Disaster Response in the Event of a Major Earthquake

20.1 Introduction

The Miyagi Prefecture offshore earthquake broke out in 1978 causing significant damage to Sendai and its surrounding areas. Tohoku University as well suffered from damage including fire. In August 2005, there was another earthquake and the university had some damage. There is a 99% probability of another earthquake within the next thirty years that is centered offshore of Miyagi Prefecture. The School of Engineering has been prepared for large earthquakes and has established all possible preventive measures. Its Disaster-Response Risk Management Manual decides the responses and actions to be taken by each of the organizations and their members in an earthquake disaster. There is also an emergency communication network that allows informing each member of the status of damage at the university and actions to be taken. The safety report system aims to find out about the safety of all people at the university by receiving a safety report from them. All students, staff and faculty are expected to thoroughly read and understand this chapter and take rapid and appropriate actions when a large earthquake occurs.

20.2 Emergency organization

The School of Engineering has a disaster prevention head office to counter the occurrence of disasters such as earthquakes. The head office has seven branch offices. It is headed by the dean of the Graduate School of Engineering along with the dean of the Graduate School of Environmental Studies (or a person appointed by him/her), dean of the Graduate School of Biochemical Engineering (or a person appointed by him/he), director of NICHE, manager of the Health and Safety Management Office, fire-prevention supervisor (administration office manager) the radiation protection supervisor as the sub-heads (Fig. 20-1). Each department has its own emergency team which is responsible for routinely stocking emergency supplies, including helmets and medicine and taking measures to prevent lockers, cabinets, bottles from overturning or falling. When an emergency occurs, the emergency head office is launched for emergency responses and restoration. It is organized the same as the disaster-prevention head office. Also, each department has its emergency branch office.

20.3 Emergency Evacuation Area

When a large earthquake occurs, it is critical to evacuate to a safe place by giving the highest priority to life. A predetermined evacuation area is located near the building of each department, organization and research institute so that confirming safety, making emergency communication and taking action on a organized basis are easy (Figs. 20-2 and 20-3). Everyone is required to check his/her own evacuation route and place in advance.

20.4 Communication in the Event of an Emergency

In an emergency, good communication is imperative to let others know you are safe, to report damage, and to ensure a smooth response. Be familiar with the predetermined emergency procedures including the emergency head office, each department's emergency branch office and the emergency communication network that connects the students, staff and faculty members through the Internet/Telephone(Fig. 20-4). Everyone is required to contact the university through the Internet or the Telephone to inform that he or she is safe.

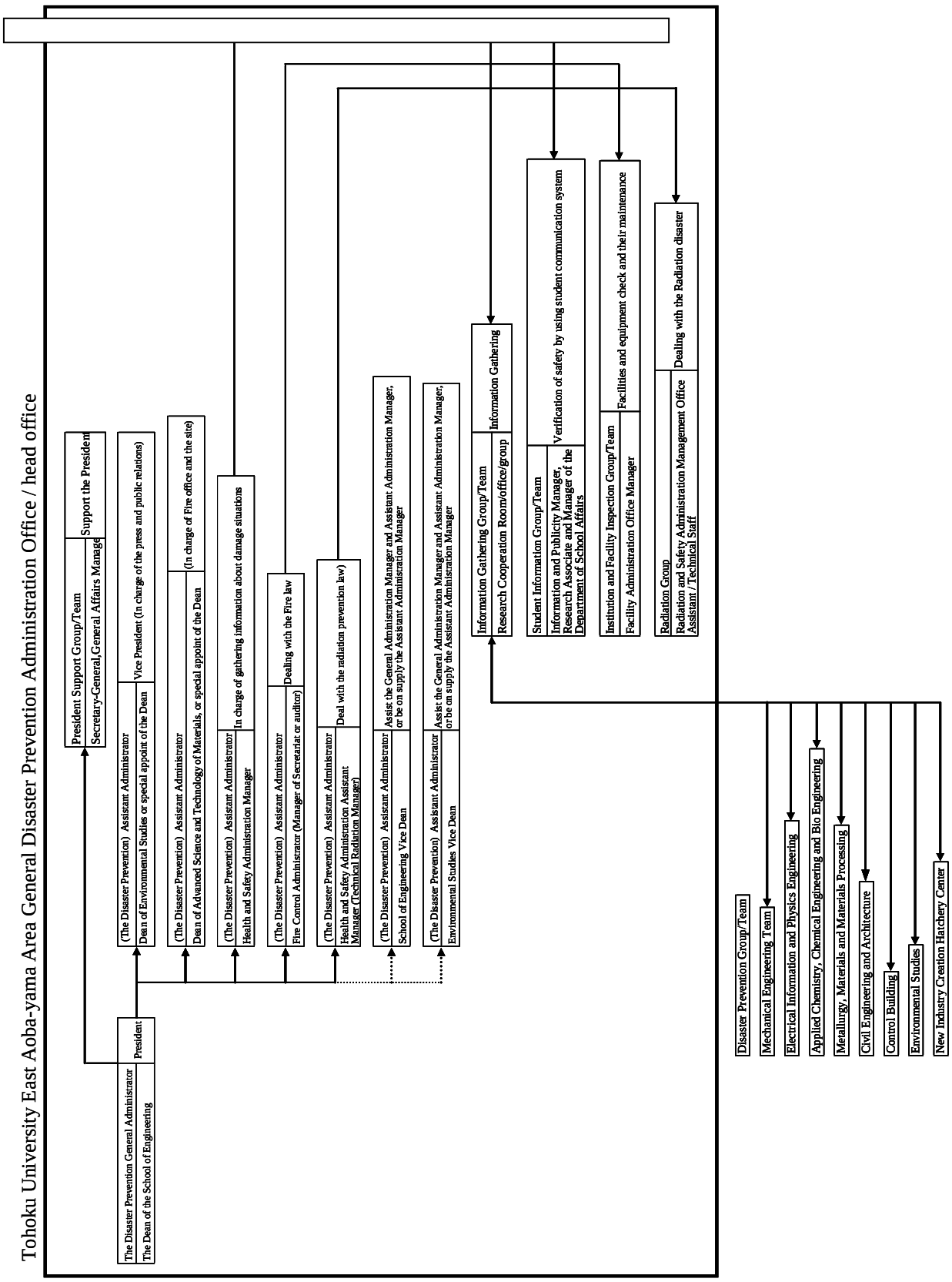


Fig. 20-1 Graduate School of Engineering Disaster Prevention (Emergency) Office

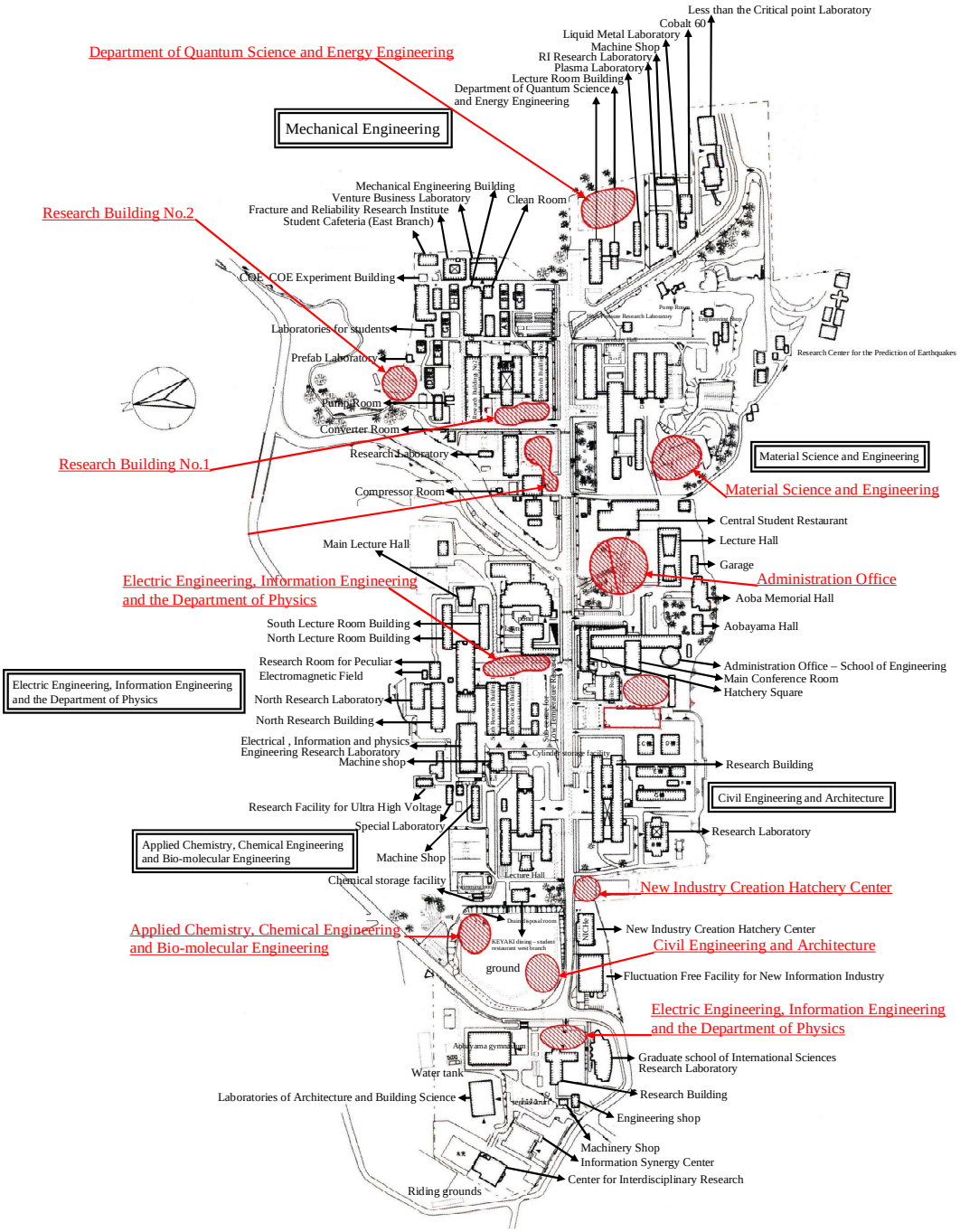


Fig. 20-2 Map of the emergency head office and branch offices and evacuation areas at the School of Engineering (Aobayama Campus)

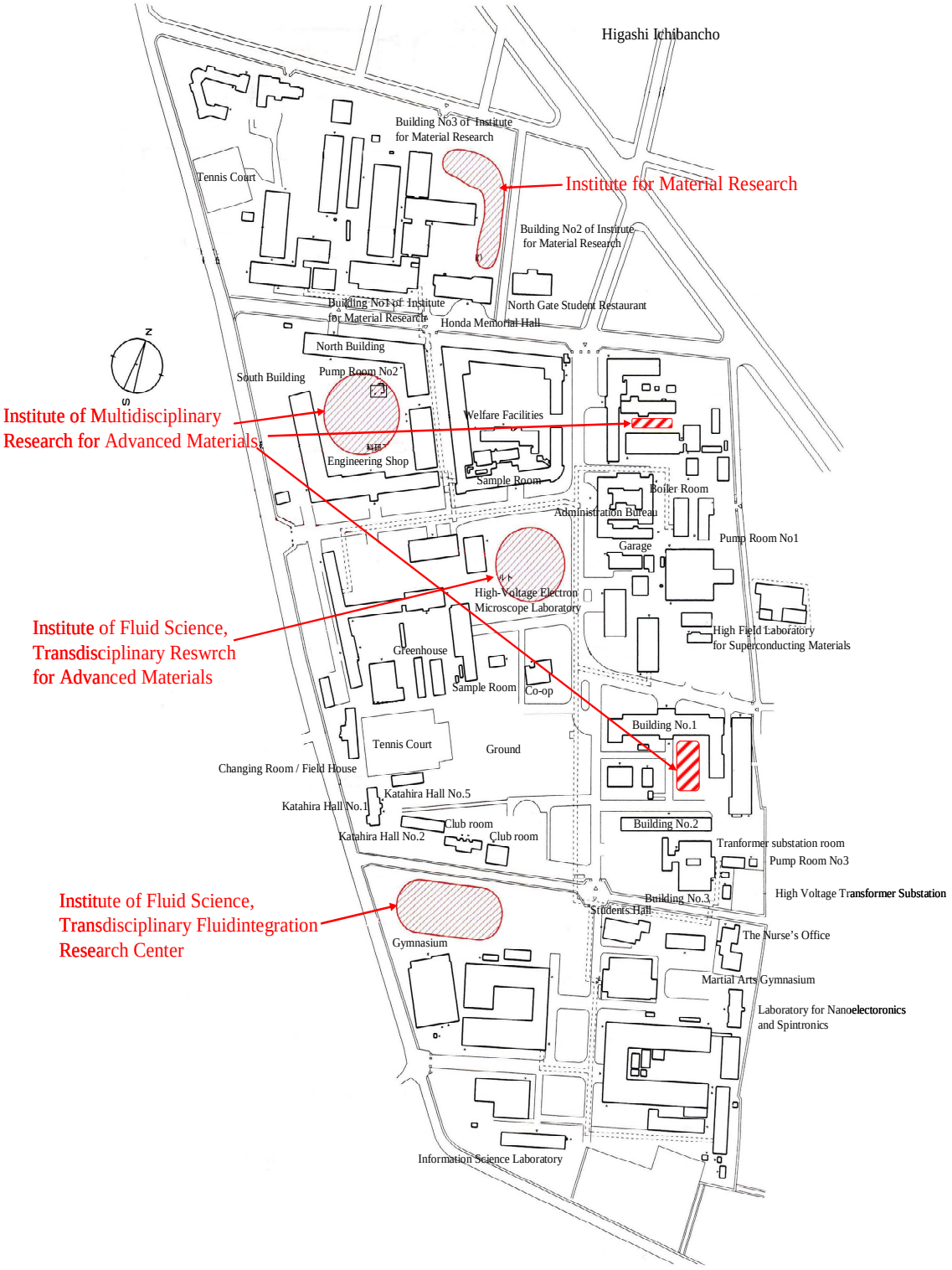


Fig. 20-3 Map of the evacuation areas at the Katahira Campus

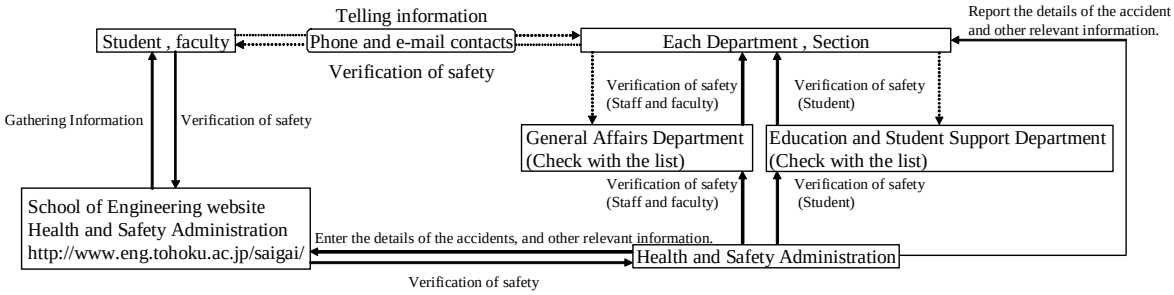


Fig. 20-4 Emergency Communication Network

(1) Safety report through the School of Engineering website.

In an emergency, please access http://www.eng.tohoku.ac.jp/saigai/index-e.html, enter the safety report form and send it back.

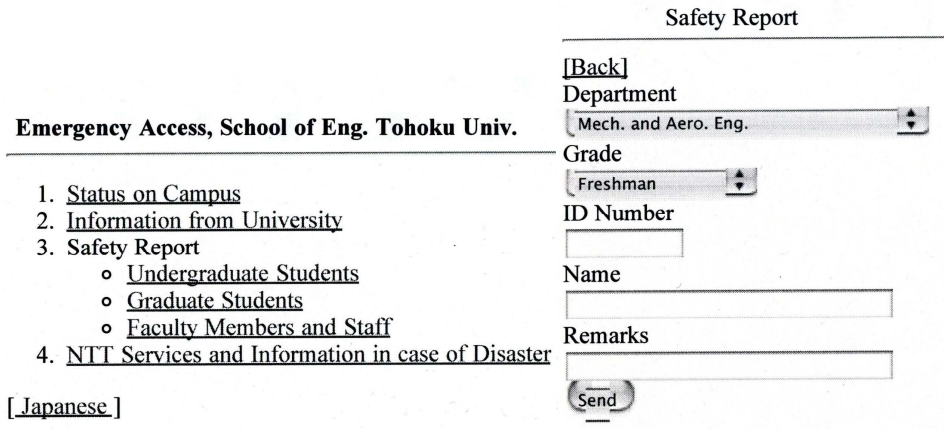


Fig. 20-5 Emergency access homepage of the School of Engineering and its safety report form

(2) Emergency contact by telephone and e-mail

If the web site cannot be accessed, all students, staff and faculty should inform others in their laboratory that they are safe by telephone or e-mail. Refer to Table 20-1 below for the relevant numbers and e-mail addresses. The emergency head office at the School of Engineering and the emergency office of each department will contact you, if necessary, by telephone or email. To ensure this goes smoothly, make sure your contact details are always kept up to date, and inform the appropriate office when you take long periods of

absence. In particular, each of the students of the 3rd grade or below are asked to submit his/her new address, telephone number, email address, if changed, to the appropriate office without delay.

Table 20-1 Emergency contact list by telephone and e-mail

Department Office	Telephone Number (022-795-****)		E-mail address ****@***tohoku.ac.jp	
	Students	Staff	Students	Staff
Mechanical and Aerospace Eng.	7030	7028	Kc-kyomu@bureau	kc-shomu@bureau
Information and Intelligent Systems.	7185	7182	kyoumu@ecei	shomu@ecei
App. Chem./ Chem. Eng. / Bio. Eng.	7205	7286	che-kyom@bureau	che-syom@bureau
Materials Science and Engineering	7373	7340	kyomu@material	shomu@material
Civil Engineering and Architecture.	7489	7487	ningen-k@bureau	shom-nin@bureau
Manage. Science and Technology	3863	3863	office@most	office@most
Graduate School of Environ. Studies	4504	7414	kyomu@mail.kankyo	somu@mail.kankyo
NICHC		7105		liaison-office@niche
Graduate School of Eng. Administration Office	5822 (Students)	5809 (Staff and faculty)	eng-kose@bureau	eng-jin@bureau
	3791 Health and Safety Management Office		eng-anze@bureau	

(3)Use of NTT Emergency Message Call

NTT provides an Emergency Message Call system for use during emergencies in the event that telephone lines are jammed after disasters, such as earthquakes and volcanic eruptions. The messages are distributed by TV, the radio and the Internet. To use this system, dial 171, and follow the voice guidance to leave your message. Note that this can only be done through fixed telephone lines, but the message can be retrieved by any type of telephone. Please refer to the following website for more information: http://www.ntt-east.co.jp/voiceml/

Chapter 21　Safety Education and Documents for Safety Management

21.1 Experimental Procedure

Most accidents and injuries can be avoided if proper safe practices are conducted. However, oral instruction alone is not enough to secure safe practices, and thus, safety education is required to make people understand each work practice. To provide for this, it is important to prepare the work procedure, which is called the "experimental procedure".

The experimental procedure needs a clear description for each work practice so that an experiment is conducted safely. Those responsible for preparing an experimental procedure should take the following basics into consideration:

(1) An experimental procedure should be prepared for each experiment even when the principle between the experiments is similar.
(2) An experimental procedure should be prepared to ensure the experiment proceeds well. This means that each practice of the experiment should be carried out in a "safe", "correct", "smooth" and "easy" manner. The experimental procedure will not be stuck to unless it targets streamlined practices. Conducting an experiment in an inefficient manner may lead to an accident, which may be avoidable if the experimental procedure is well written.

The following describes important points when to prepare, keep, review and use the experimental procedure

21.2 Requirement and Handling of the Experimental Procedure

1. Objective:
   This requirement is established to determine the rules to prepare and keep the experimental procedure in order to improve it and prevent accidents by false experimental practices.
2. Application:
   This requirement applies to all anticipated experimental practices conducted at each laboratory.
3. Form:
   The experimental procedure should be prepared using the predetermined form. (see Fig. 21-1)
4. Preparation:
   The experimental procedure should be prepared as follows:
   (1) The procedure should be prepared by undergraduate and graduate students who carry out the experiment under the instruction of the advisory teacher
   (2) The teacher should check the content of the draft.
   (3) All students, and faculty should participate in reviewing the draft so that the experimental procedure is completed with their full understanding.

5. Revision:

The experimental procedure should be revised in the following cases:

(1) When equipment is modified or improved, or the content of work practices are changed.

(2) When an accident or an injury occurs.

(3) The experimental procedure should be reviewed at least once a year to update it.

6. Keeping and distribution:

Three copies of the experimental procedure should be prepared. One should be kept in the professor's room, one in the laboratory, and the other should be placed readily available (being put in a plastic case, etc.) near the relevant equipment.

21.3 When Preparing and Revising the Experimental Procedure

1. Intention:

The experimental procedure form is shown in Fig. 21-1, and an writing example is shown in Fig. 21-2. Please take into consideration the following when preparing and revising the experimental procedure.

2. Unit:

The experimental procedure should be prepared for each experimental unit.

3. Remarks:

(1) In the boxes at the top left corner of the form, write the type of equipment to be used, the location of the equipment, and the title of the research project.

(2)On the top right corner of the form, write the date the experimental procedure was prepared, and also the date it was revised.

(3)On the top of the left, large column of the form, write the name of a specific practice. Below, write the step-by-step content of the practice in numerical order to carry out the experiment. Each step of the procedure should be simple and, basically, must not exceed one line in length.

(4) The extent of the risk involved in the important steps of the procedure should be marked using ◎ (a risk of an accident which may result serious injury) and ○ (a risk of an accident which may result minor injury). Accidents should include both that are predicted and actually occurred,

(5) At the uppermost line of the middle, large column, the name of each apparatus, tool and measuring device used in the experiment should be written in with a mark (letter such as a, b and c). Then, put a relevant mark or marks to the corresponding step where the apparatus(s), tool(s) and measuring device(s) is/are used.

(6) Safety know-how and key points for the experiment should be specifically and clearly written in corresponding steps in the middle, large column.

(7) Necessary protective equipment such as protective glasses, gloves, and heat resistant clothing should be written with marks (letters such as A, B and C) at the uppermost line of the right, large column. Put a relevant mark or marks on the corresponding step where the relevant protective equipment is used. (If wearing a safety cap, safety shoes, spats and the like is the

essential requirement for the targeted experimental unit, you do not need to write them.)

(8) In the rightmost column, clearly indicate all the risks involved in the corresponding steps.

(9) At the bottom of the form, all accidents and injuries, which have occurred in the past or are predicted in the future while carrying out this experimental unit, should be written. For predicted accidents, write them in the numbers of the corresponding steps above in an occurring order.

(10) Also write important points of health and safety considerations from the perspective of the whole experimental unit.

(11) If a diagram or a flowchart allows easy understanding, attach such a diagram or a flowchart (any form can be used).

4. Revision:

The experimental procedure should be reviewed on an annual basis. If it is revised, be sure to indicate the date of the revision in the top right corner of the form.

21.4 Important Matters to Introduce and Use the Experimental Procedure

1. Once the experimental procedure has been decided, then it is imperative to prepare and implement the experimental procedure in a complete manner. If an accident occurs, the accident investigation and pursuing managerial responsibility at the time of the accident will be based on the prepared experimental procedure.
2. It is necessary to explain the objectives and the importance of the experimental procedure and ensure that all undergraduate and graduate students, who carry out experiments, prepare and comply with the experimental procedure.
3. When an accident occurs during the experiment, investigate to see if the experiment was carried out according to the experimental procedure. If the experimental procedure was not observed properly, the cause and reason should be pursued.
4. Protective equipment is effective not only to prevent accidents during the experiment, but they can also minimize an accident if it occurs. It is strictly forbidden to carry out experiments without protective equipment written in the experimental procedure because of budget reasons, etc.
5. If an accident occurs in one laboratory, the same type of accident may occur in other laboratories. To prevent similar accidents, it is necessary to hold a meeting in each laboratory to review the present experimental procedure.

21.5 References on Safety Issues

References on safety issues are available at the Engineering Library for students who want to deepen their safety understanding and expand their knowledge on safety.

For details concerning safety issues, please inquire to the faculty in charge of experiments and research or members of the health and safety committee of each department or organization.

Experimental procedure

Written 2000 / July
Reviced 2000 / November
Revised 2001 / October

Name of device	
Place	
Theme	
Unit Name of Procedure	

Risk of injury	Number	Number of Procedure	Equipment/ instruments	Crux of procedure	Protective Equipment	Safety points
Accident case			Possible accidents			
Equipment number						

Experimental procedure

Name of device	Non-consumable electrode Argon arc furnace
Place	Furnace Room (C1)
Theme	Metal and alloy dissolution

Written 2000 / July
Reviced 2000 / November
Revised 2001 / October

Unit Name of Procedure		Metal and alloy dissolution	Equipment/ instruments	(a)plus Screwdriver (b)Geissler tube	Protective Equipment	(a)electricity resistant gloves
Risk of injury	Number	Number of Procedure		Crux of procedure		Safety points
	1	Turn on the coolant switch.		Indicate that the dissolution chamber is in use by the「使用中」sign.		
	2	Open the dissolution chamber and change the mold.	a	Clean the O ring.		
○	3	Run off the coolant.		If other furnaces are in use, check the water pressure.		
	4	Turn on the rotary oil pump and oil diffusion pump.		Male sure the R.P. leak valve is closed.		
	5	Turn on the electrode and put the dissolution staple on the mold.				
	6	Close the dissolution room to make a rough vacuum.		Make sure the leak valve of the main body is closed.		
	7	Put the Ar gas in after making a complete vacuum with the rotary oil pump.	b	Check the vacuum level with the Geissler tube.		
	8	Repeat steps 6 and 7.				
	9	After making a rough vaccum, then make a complete vaccum with a rotary oil pump.				
	10	Check the vaccum level with an Ionization Gauge.		Be careful. The Ionization Gauge will be damaged. If you use it when the vaccum level is in.		
	11	Turn off the oil diffusion pump.		Open the vernier valve to turn off the rotary oil pump.		
	12	Put Ar gas into the dissolution chamber.				
	13	Turn off the swich on the east side of the distributor.			A	Make sure your hands are dry.
○	14	Turn on the control swich.			A	
◎	15	Step on the footswitch to discharge the arc.				Check the preserve glass.
◎	16	Dissolve the getter.		Slowly increase the electric current.	A	Pay attention to the temperature of the electrode, the main body and the mold.
◎	17	Dissolve the sample.		Slowly increase the electric current.	A	Pay attention to the temperature of the electrode, the main body and the mold.
◎	18	Step on the footswitch to stop the arc.				
○	19	Turn over the sample and repeat steps 15 to 18 as many times as required.			A	
○	20	Turn off the control switch.			A	Make sure your hands are dry.
	21	Turn off the swich on the east side of the distributor.				
	22	Open the dissolution chamber and take the sample out.	a			
	23	Clean the dissolution room, electrode and the mold. Change the mold.	b	Clean the O ring.		
	24	Close the dissolution room to make a rough vacuum.				
	25	Turn off the rotary oil pump.		Open the R.P. leak valve once before closing it.		
	26	Stop the coolant.				
	27	Turn off the coolant swich.		Change the「未使用」sign to show the dissolution chamber is no longer in use.		
	28	Clean around the device.				
Accident case		none	Possible accidents	Electric shock 13 14 16 17 19		
				Burns 16 17		
Equipment number		い－13 Number 244(Department of Materials, Science and Engineering)				

Chapter 22　Total Management System for Hazardous Substances

22.1 Overview of the System

In 2001, Department of Applied Chemistry, Chemical Engineering and Biomolecular Engineering introduced a management system for lab chemicals for trial and examined its advantages. As a result, managing lab chemicals has been put into actual practice on a department basis and a laboratory basis.

Main targets were:

(1) To acquire the names and amounts of chemicals kept at specific storage areas (storage cabinets, laboratories and buildings) and those of the chemicals controlled under specific laws (PRTR law, Poisonous and Deleterious Substances Control Law, Fire Service Law, Labor Safety and Sanitation Law, etc.).
(2) To acquire the usage history of each chemical
(3) To acquire the specified amounts of hazardous materials per group under the control of the Fire Service Law.
(4) To acquire the annual purchase amounts of the PRTR Law-related materials with their consumed amounts.
(5) To obtain MSDS (Material Safety Data Sheets).

Based on this practice, the whole university decided to establish a Total Management System for Hazardous Substances as a two-year project beginning in 2005 for the management of lab chemicals and experimental waste liquids. The first year of the project encompassed the introduction of the management system for lab chemicals to the whole university, and the second year the management system for waste liquids. These systems are now running at each place. We are now examining introducing the management system for high pressure gases in 2008 and after.

The introduction of the Total Management System for Hazardous Substances aims at thoroughly managing hazardous materials on the basis of the whole university and each department. Also, it aims to largely improve work efficiency by networking ECRI with each department for experimental waste liquid treatment.

22.2 Operational Rules of the Total Management System for Hazardous Substances under the Supervision of the Client Terminal of the School of Engineering

The School of Engineering Safety and Health Committee Meeting held on October 10, 2006 decided the Operational Rules of the Total Management System for Hazardous Substances as follows. All the students, staff and faculty who use the system are required to adhere to the rules.

Operational Rules of the Total Management System for Hazardous Substances Running on the Client Terminal of the School of Engineering

Established: Oct. 10, 2006
Revised: Apr. 1, 2008

1. Structure of the organizations

   Organizations that are subject to these rules are as follows:

   (1) Graduate School of Engineering and Undergraduate School of Engineering
   (2) Graduate School of Environmental Studies
   (3) Graduate School of Biomedical Engineering
   (4) New Industry Creation Hatchery Center
   (5) Environment Conservation Research Institute
   (6) Graduate School of Information Sciences

2. Administrative organization

   (1) Appoints a supervisor to the Technology Division of the School of Engineering as an administrator who manages the Total Management System for Hazardous Substances (hereafter referred to as the System).
   (2) Appoints a middle supervisor to each department and organization of the School of Engineering as a person who manages operational issues of the System and acts as a window to the supervisor when making an application.
   (3) The Health and Safety Management Office makes a legal notification and application to the appropriate authorities based on the results of totals per chemical and per organization obtained from the System.
   (4) The supervisor, middle supervisors and the manager of the Health and Safety Management Office (hereafter referred to as administrator(s)) have the right to browse each laboratory's content and must not leak what they find through System management.
   (5) When the administrator cannot implement his/her duties due to unavoidable circumstances such as a long duty-trip, his/her surrogate implements the duties.

3. Hazardous materials to be registered into the System

   Laboratories that handle the following hazardous materials must register them into the System without fail and adequately manage them.

(1) Chemicals that are controlled under the following laws (The other chemicals for which the System has their Chemical Master data should also be registered.)

i) Poisonous and Deleterious Substances Control law

ii) Fire Service Law ("hazardous materials" in the law, including fuels such as kerosene, light oil, gasoline)

iii) Labor Safety and Sanitation Law (organic solvents and specified chemical substances)

iv) Narcotics and Psychotropics Control Law

v) Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (PRTR Law)

(2) High pressure gas cylinders (in 2008 and after)

(3) Laboratory waste liquid

4. How to manage chemicals

Chemicals should be managed by the laboratory unit in the following way:

(1) Poisonous substances under the Poisonous and Deleterious Substances Law are subject to weight management (weigh the weight of the substance including its container using a balance, etc. and register the whole weight).

(2) Chemicals other than the toxic substances are managed either for weight or bottle number (when all the chemical is consumed, this amount is registered as the consumed amount), depending on the server you access.

5. Responsibilities of the laboratory

(1) The system shall be put on a personal computer having the following browser that is connected to the university LAN.

1. Windows: Internet Explorer 6.0 or later
2. Macintosh: Internet Explorer 5.1 (OSX), 5.2 (OSX), Apple Safari or later

(2) The laboratory shall correctly use the system based on the instruction manual of the Total Management System for Hazardous Substances.

(3) The laboratory shall follow instructions of the administrator for system operation, and promptly communicate to the administrator when any problem occurs.

6. Group ID and user name

(1) A uppercase alphabetic 3-letter group ID is assigned to each laboratory before starting to use the system. The group ID is to be determined by the middle-supervisor which the laboratory belongs to, and the alphabetic initial letter for identification shall be based on the departments of the Graduate School of Engineering and the Undergraduate School of Engineering, and other organizations.

However, the residents of the Engineering Laboratory Complex building are included in respective departments and organizations they belong to. Laboratories of the Graduate School of Environmental Studies, Graduate School of Biomedical Engineering and Graduate School of Information Sciences located in the Aobayama Campus (Kogaku Campus) are included in the department or organization where they reside.

School of Engineering Department of Mechanical and Aerospace Engineering	A
Department of Information and Intelligent Systems	B
Department of Applied Chemistry, Chemical Engineering, Biomolecular. Engineering	C
Department of materials Science and Engineering	D
Department of Civil Engineering and Architecture	I
Other	Z
Graduate School of Environmental Studies (Main Building)	F
New Industry Creation Hatchery Center	G
Environment Conservation Research Institute	E
Graduate School of Information Sciences	H
Middle Supervisor	M

(2) The user name shall be “full name” for faculty and staff members and abbreviation such as “Student1, Student2” for students depending on the number of applications. The faculty and staff in charge of the laboratory must manage the user names that students use.

(3) There shall be three patterns of operation permissions: “Teacher” for technical staff and faculty,; “Administrative staff” for administrative staff; “Student” for students. Each user shall be able to operate functions authorized with the pattern of operation permissions.

(4) When newly starting the system (addition of group or user), changing the laboratory name, terminating use due to faculty/staff transfer or graduation of student, or change in detail of user registration, the laboratory shall prepare "User Registration Application Form (Form 1)" and submit it to the supervisor via the middle supervisor to make an entry into the Users Master.

7. Password

(1) The laboratory shall get permission for use of the system from the supervisor via the middle supervisor before starting to use the system and be given the initial password.

(2) The staff/faculty member in charge of the laboratory shall manage the passwords responsibly to ensure they are not disclosed.

8. Chemical Master

(1) The chemical manufacturers that are registered in the Chemical Master of the System are as follows:

i) Kanto Chemical Co., Inc.

ii) Wako Pure Chemical Industries, Ltd.

iii) Nacalai Tesque Inc.

iv) Sigma-Aldrich Japan K. K.

v) Tokyo Chemical Industry Co., Ltd.

(2) When a laboratory tries to register a chemical that has not been registered in the Chemical Master and that is the product of a manufacturer other than the above chemical manufacturers (1), select the name of the product of the above manufacturer that has the same CAS register number, weight or volume, concentration, and register it.

(3) When it is impossible to register a chemical using the above registration method, a laboratory can register into the Chemical Master by applying to the supervisor via the middle supervisor with the filled-in “Chemical Master Registration Application Form (Form 2)”

9. Storage Location Master

(1) Registration in the Storage Location Master is made by entering into the Storage Location (1) the name of the building, into the Storage Location (2) the name of the room, and into the Storage Location (3) the name of the cabinet or rack. The names of the building and the room should be written with the

standardized names shown in the building ground plains collected in the School of Engineering Administration Information System. Names of the rooms should be registered by the room number only otherwise there is no room number. Buildings and rooms that are not shown in the building ground plains should be written by the standardized names of each department and organization.

(2) When changes are made to the Storage Location Master because of, for example, installation of a new storage cabinet, discarding of a storage cabinet, relocating a laboratory, the relevant laboratory should fill in "Storage Location Master Registration Application Form (Form 3)" and apply to the supervisor for registration into the Storage Location Master via the middle supervisor.

10. Briefing on use

(1) The supervisor shall hold a briefing on use for staff, faculty and students who newly start to use the system under the client computer of the School of Engineering at the beginning of a new school year.

(2) Staff, faculty and students who newly start to use the system shall join a briefing on use, which is held by the supervisor.

11. Miscellaneous

(1) Requirements related to the system operation shall be discussed in the safety and health committee of the School of Engineering, etc.

(2) Needed information on the system shall be communicated to the laboratory via the middle supervisor, or posted to the message window of the system by the supervisor.

(3) Equipment and consumption articles needed to operate the system shall be prepared by each department, organization, or laboratory.

Form 1

User Registration Application Form

1. Information of the applicant

Department/organization name:

Applicant	Name		Course & position	
	Tel (extension)		Email	

2. Information of the group

Application category	New		Change		Finished		Group ID	
Name of applicant group				Name of group after change				
Reason for application				Management of chemicals other than poisonous materials				

3. Information of the user

Application category			User name	Password	Authorization pattern		
New / addition	Change	Finished			Faculty	Administrative staff	Student

Form 1

User Registration Application Form (Example of writing)

1. Information of the applicant

Department/organization name: *Department of Information and Intelligent Systems*

Applicant	Name	*XXXXX*	Course & position	*ZZZZZ Course, Assistant professor*
	Tel (extension)	*YYYYY*	Email	*YYYYYYYYYY*

2. Information on the group

Application category	New		Change	○	Finished		Group ID	*KKK*
Name of applicant group	*XX library*			Name of group after change			*YY laboratory*	
Reason for application	*The name of the laboratory was changed*			Management of chemicals other than poisonous materials			*Bottle number*	

3. Information of the user

Application category			User name	Password	Authorization pattern		
New / addition	Change	Finished			Faculty	Administrative staff	Student
○			Student20				○
		○	□□□□	AAAAAAAAA	○		

(Notes)

1. The applicant is required to apply to the middle supervisor of each department/organization. Do not directly apply to the supervisor. Applications not via the middle supervisor are not acceptable.
2. Fill in box 2 with the information of the group, and box 3 with the information of the user.
3. Write in “weight management” or “bottle management” in the box of “Management of chemicals other than poisonous materials.”
4. Enter ○ in the appropriate boxes of “Application category” and “Authorization pattern.” When you have forgotten the password, enter ○ in the box of “Change” of the “Information of the user.”
5. When the application is “New”, a group ID is decided and entered by the middle supervisor. When it is “Change” or “Finished”, the user is required to enter the group ID.
6. The box “”Name of the group after change” is filled in only when the name of the group is changed.
7. For staff and faculty members, the user name is written by the family and given names. For students, the user name is written in an abbreviated style such as “student1” or “student2.”
8. When the application is “New”, a password is decided and entered by the supervisor. When it is “Change” or “Finished”, the user is required to enter the password.

Form 2

Chemicals Master Registration Application Form

Department/organization name:

Applicant	Name		Course & position		
	Tel (extension)		Email		
Group ID			Name of the group		
Name of the chemical (product)					
Name of the manufacturer				CAS number	
Amount			Management of chemicals		

○ When making an application, be sure to send the copy of MSDS to the middle supervisor.

Form 2

Chemicals Master Registration Application Form (Example of writing)

Department/organization name: *Dept. of Applied Chemistry, Chemical Engineering and Biomolecular Engineering*

Applicant	Name	*XXXXX*	Course & position	*ZZZZZ Course, Technical staff*	
	Tel (extension)	*YYYYY*	Email	*YYYYYYYYYY*	
Group ID			Name of the group	*XX laboratory*	
Name of the chemical (product)					
Name of the manufacturer				CAS number	
Amount			Management of chemicals		

○ When making an application, be sure to send the copy of MSDS to the middle supervisor.

(Notes)

1. The applicant is required to apply to the middle supervisor of each department/organization. Do not directly apply to the supervisor. Applications not via the middle supervisor are not acceptable.
2. The box of “Management of chemicals” is filled in with “Weight management” for the registration of toxic materials. Fill in the box with either of “Weight management” or “Bottle number management” for the registration of chemicals other than toxic materials.
3. Be sure to send a copy of MSDS. The supervisor registers chemicals into the Chemical Master using the information written in this application form in addition to MSDS. Registration cannot be done without MSDS.

Form 3

Storage Location Master Registration Application Form

Department/organization name:

Applicant	Name			Course & position				
	Tel (extension)			Email				
Application category	New		Change		Finished		Group ID	
Name of the group								
Reason for application								
Storage location of (1) ※building name								
Storage location (2) ※room name								
Storage location (3) ※cabinet/rack name								

Group name (authorized for using/browsing)	Group ID (authorized for using/browsing)	Group name (authorized for browsing only)	Group ID (authorized for browsing only)

Form 3

Storage Location Master Registration Application Form (Example of writing)

Department/organization name: *Dept. of Mechanical and Aerospace Engineering*

Applicant	Name	*XXXXX*			Course & position	*ZZZZZ Course, Assistant professor*		
	Tel (extension)	*YYYY*			Email	*YYYYYYYYYY*		
Application category	New	○	Change		Finished		Group ID	PPP
Name of the group	*XX laboratory*							
Reason for application	*Purchased a new cabinet for storage.*							
Storage location (1) ※building name	*Dept. of Mechanical and Aerospace Engineering building*							
Storage location (2) ※room name	*Room No. 101*							
Storage location (3) ※cabinet/rack name	*Storage cabinet 1*							

Group name (authorized for using/browsing)	Group ID (authorized for using/browsing)	Group name (authorized for browsing only)	Group ID (authorized for browsing only)
YY laboratory	PPP	*QQ administration office*	*PRR*
ZZ laboratory	PCV		

(Notes)

1. The applicant is required to apply to the middle supervisor of each department/organization. Do not directly apply to the supervisor. Applications not via the middle supervisor are not acceptable.
2. Enter ○ in the appropriate box of “Application category”
3. Location of storage (1) is filled in with the building name, location of storage (2) with the room name and location of storage (3) with the cabinet/rack name. The names of the building and the room should be written with the standardized names shown in the School of Engineering Administration Information System. Names of the rooms should be registered by the room number only otherwise there is no room number. Buildings and rooms that are not shown in the Information System should be written by the standardized names of each department and organization.
4. Write down the group name and group ID now in use into the boxes of “authorized for using/browsing” for groups authorized for both using and browsing.
5. Write down the group name and group ID now in use into the boxes of “authorized for browsing only” for groups involved with totaling work but not with incoming and outgoing inventory management.
6. The supervisor and middle supervisors are authorized for both using and browsing.
7. One storage cabinet needs one registration application using one sheet of this form. Entry should be made by using two-byte characters.

Total Management System for Hazardous Substances Instruction Manual

What is Total Management System for Hazardous Substances?

This is a total system for the management of hazardous substances, which comprises of the Management System for Lab Chemicals (IASOR5) and the Management System for Waste Liquid (FLUID WASTES).

This service is provided by the server that is deployed in the Tohoku University Cyberscience Center. The Total Management System for hazardous Substances can be used from any client personal computer that is connected to the university network.

The Management System for Lab Chemicals enables us to manage chemicals by the control number (barcode label) assigned to each chemical bottle in terms of "When", "Who", “Which supplier”, What", "Why", and "How much of chemicals purchased or consumed” by each laboratory.

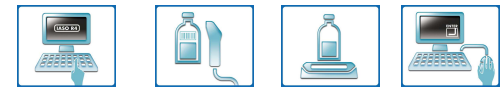
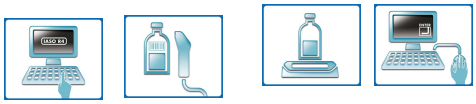
The Management System for Lab Chemicals incorporates catalog data provided by 6 lab chemicals manufacturers: Kanto Chemical Co., Inc., Wako Pure Chemical Industries, Ltd., Sigma-Aldrich Japan K.K., Tokyo Chemical Industry Co., Ltd. and Nacalai Tesque, Inc. When you purchased lab chemicals, make a data entry on the server using this lab chemicals database, and every time you take out or return laboratory chemicals, follow the instructions on the screen to enter necessary information in the system using the control number (barcode) as a key.

Two different servers are installed for the Total Management System for Hazardous Substances : Bottle Based Management Server and Weight Based Management Server. Which server you connect to depends on the management method that the laboratory uses.

Address of Bottle Based Management Server:
http://192.168.7.8/
Address of Weight Based Management Server:
http://192.168.7.9/

The Bottle Based Management Server is set up to implement "**Weight Based Management**" for the chemicals that are specified as poisonous substances in the law, and it implements "**Bottle Based Management**" for other chemicals that are controlled under the law.
The Weight Based Management Server is set up to implement "**Weight Based Management**" for all chemicals.

System operating procedure

Method	When taking out chemicals	When returning chemicals
Weight Management	 Login ⇒Enter information ⇒Weight ⇒Accept	 Login ⇒Enter information ⇒Weight ⇒Accept
Bottle Management	 Login ⇒Enter information ⇒Accept	 Login ⇒Enter information ⇒Accept

Operating Instructions of the "Management System for Lab Chemicals"

- **Start the Total Management System for Hazardous Substances:**

① Start the Web browser (Internet Explorer 6.0 or later recommended) and enter one of the following addresses depending on the laboratory.

Address of Bottle Based Management Server:
http://192.168.7.8/

Address of Weight Based Management Server:
http://192.168.7.9/

If your client is connected successfully to the server, the system selection screen ("Management System for Lab Chemicals" and "Management System for Waste Liquid") appears (see Fig. 1).

② When the "Management System for Lab Chemicals" is selected, the login screen Appears (see Fig. 2).

Fig. 1 System selection screen

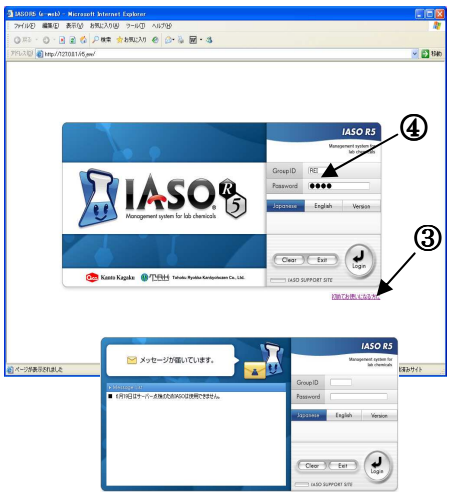


Fig.2 Login screen

③ The link of "Getting Started" is under the Login button. When you click this link, you will see the setup method of IASO on your PC. Carefully read it and set up your PC.

④ Enter the group ID (alphabetic 3 letters) and the password (case sensitive) to log in R5 (e-web).

※When you log in for the first time, the password change screen appears.

※Any messages from the administrator appear on the login screen..

※You can log in to either the bottle based management or weight based management server. When you cannot log in to either, please contact the middle supervisor of the department/organization.

⑤ After login, the main screen (see Fig. 3) appears, and the group name and user name are displayed in the middle of the upper part.

⑥ Menu items - Check-out/Return, Registration, Change location, Inventory entry, Waste registration, Barcode print, and Master application - are displayed. Click on any item you want to execute.

※ Master application" is dimmed and cannot be clicked as this function is optional.

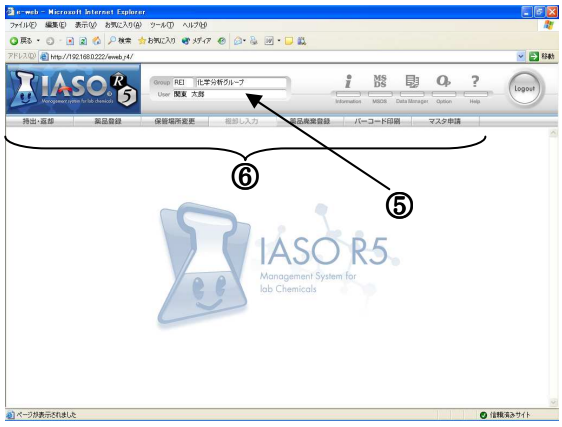


Fig. 3 Main screen

● To print the IASO barcode label for management:

① Clicking the "Barcode print" button on the menu bar displays the pull-down menu. Select the label size you want to print (see Fig. 4). The type R is a format of 44 labels per sheet and type S is 80 labels per sheet.

② When you select "Individual", you can directly enter the barcode number in the designated field. When you select "Range", you can enter the start and end numbers of barcode in the designated fields.

③ Clicking the "PRINT" button displays the print preview. Select File (F) -> Print (P) to print out the label.

※This function uses ActiveX. Select Permit when a dialog box prompting for the use of ActiveX controls appears.

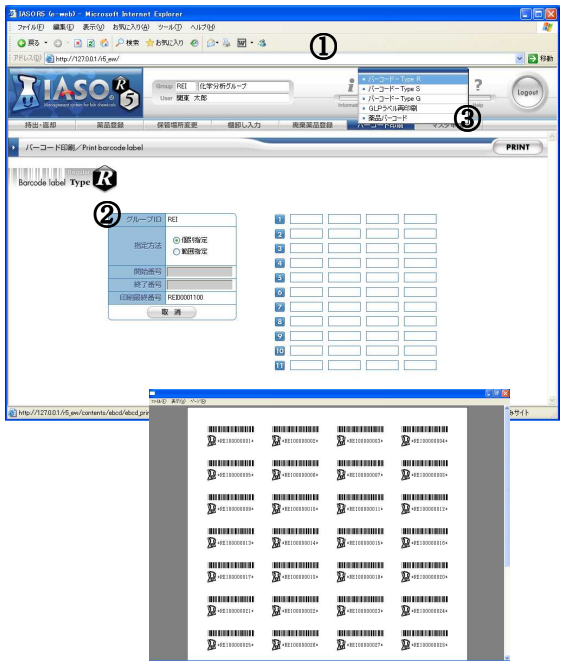


Fig. 4 Barcode print screen

● Chemicals registration (registration of purchased chemicals)

① Click “Registration” button on the menu bar to switch to the chemicals registration screen (see Fig. 5).

② Read the barcode attached to the chemicals you want to register or identify the chemicals using “Search for chemicals”.

③ When you identify using search for chemicals, click the “Search” button.

④ The sub form for search for chemicals (see Fig. 6) appears. Select the search criteria (chemical name, CAS No., Molecular formula, Catalog number, etc.), and click “Stock” button for inventory search or “All” button for full search. Search results will be displayed. Click the corresponding chemical to specify it. To narrow the results, select the search criteria again and click the “Limiting search” button to specify the chemical.

※ Inventory chemicals are indicated by symbol .

⑤ When a chemical to be registered is identified, the screen will appear as shown to the right (see Fig. 7). Select the storage place by clicking “Storage location” button. According to the necessity, enter the chelf life,, condition on delivery, dealer, Lot No., purchase price and comment II (entering them is not mandatory). Then, click the "ENTER" button.

⑥ Clicking the button displays a bar code number issue screen (see Fig. 8). Attach the printed IASO barcode to the container and read it with a barcode reader.

⑦ When putting an already opened chemical in storage, select the corresponding checkbox,

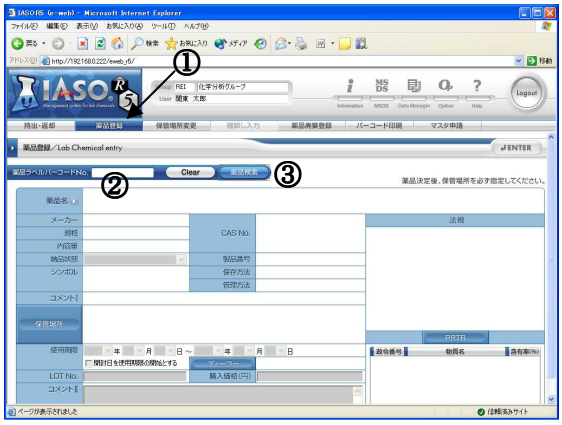


Fig. 5 Chemicals registration screen

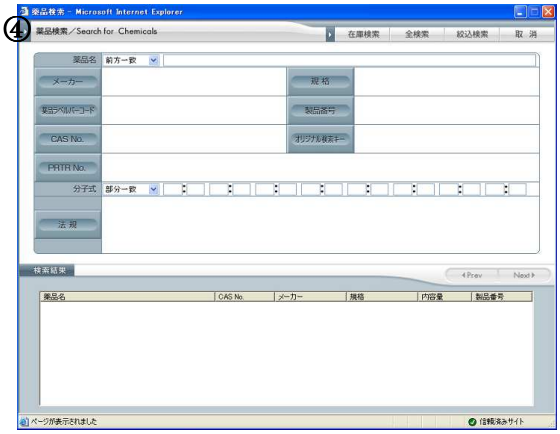


Fig. 6 Chemicals search screen

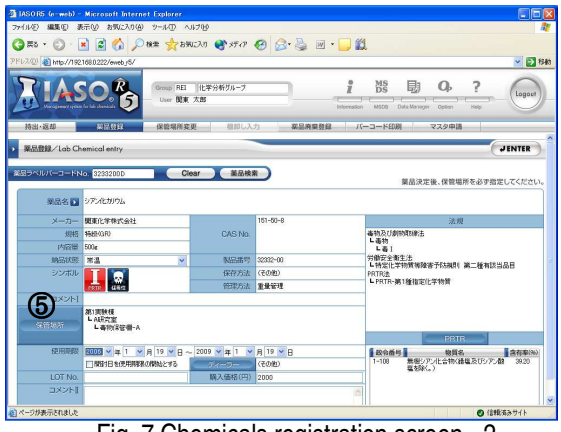


Fig. 7 Chemicals registration screen - 2

and then click the "OK" button to register them.

When you want to continuously put same chemicals in storage, repeat steps from item 4.

※With the checkbox selected, the input field for initial volume is displayed. Enter the estimated remaining amount of chemicals you are going to register. The initial volume is displayed as default.

Fig. 8 Barcode number issue screen

●Check-out/Return process of chemicals

Check-out process

① Clicking the "Check-out/Return" button on the menu bar switches to the check-out/return process screen (see Fig. 9).

② Read the IASO barcode label.

※When opening an unopened chemical, the message "Did you open it?" appears.

③ Select "Purpose of Use".

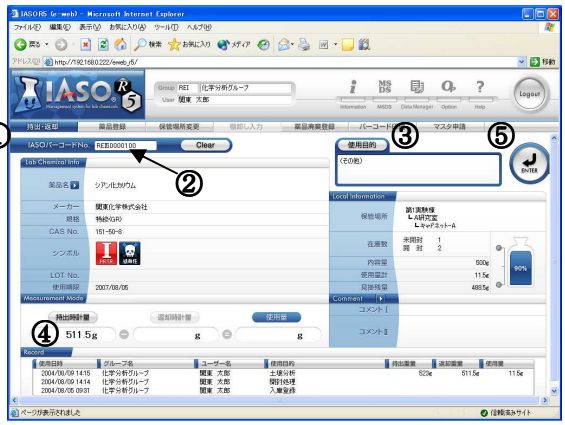


Fig.9 Check-out/Return process screen

④ In the case of chemicals for weight based management, enter the gross weight in the "Weight at Check-out" field. Auto entry from electronic scale or manual entry from keyboards is available. In the case of chemicals for bottle based management, "Weight at Check-out" field is dimmed or disabled for entry.

⑤ Click the "ENTER" button to complete registration.

※ When the scale supported by IASO R5 is connected, the weighed value is automatically entered by clicking the "Weight at Check-out" button. Electronic scales from the following manufacturers are currently supported: Mettler, Sartorius, Shimadzu and A&D (existing models).

Return process

① Clicking the "Check-out/Return" button on the menu bar switches to the check-out/return process screen (see Fig. 10).

② Read the IASO barcode label.

③ In the case of chemicals for weight based management, as in Check-out, enter the gross weight into the "Weight at Return" field.

④ Click the "ENTER" button.

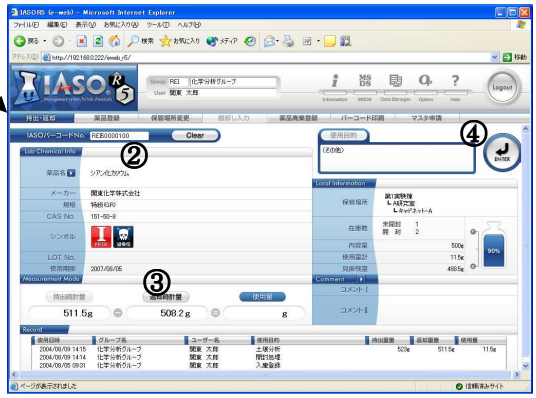


Fig. 10 Check-out/Return process screen (Return)

⑤ The "Registration Confirmation" screen (see Fig. 11) will appear. Click the "Registration" button to complete return process.

※ In the case of empty bottles, click the "Register Empty Bottle" button to complete registration. There is "Waste registration" button on the menu bar to register waste chemicals (see Fig. 3). Note that this button should be used in disposing of chemicals, not in processing empty bottles.

⑥ You can enter any comment on your use as records.

Fig. 11 Registration confirmation screen

● Change in Storage Location

① Clicking the "Change location" button on the menu bar displays the sub form. Select "Change in storage location" or "Batch change in storage location".

You can change the storage place of chemicals per bottle with the "Change in storage location" and in a lump with the "Batch change".

※ The change in storage location screen is shown on the right (see Fig. 12).

② Read the IASO barcode of the chemicals that you want to move.

③ Select the “Relocation (Destination)”.

④ Click the “ENTER” button to complete.

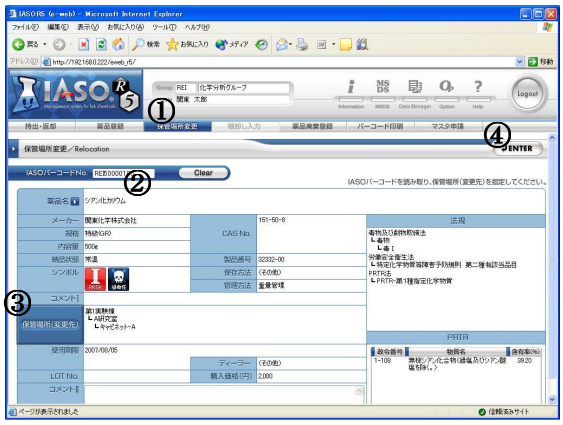


Fig. 12 Change in storage location screen

● Functions of buttons

① Clicking the “Information” button displays chemical information, stock information, list of chemicals in use and emergency numbers (see Fig. 13).

② Chemical information: Click this button in check-out/return process or registration of chemicals to confirm information of the corresponding chemicals (see Fig. 14).

Fig. 13 Toolbar screen

List of chemicals in use: Displays list of chemicals not returned.

Stock information: Displays inventory information on a storage place basis.

Emergency numbers: Displays pre-defined emergency contacts.

③ Click “MSDS” to start Acrobat Reader to confirm MSDS. When checking-out, returning or registering chemicals, clicking this button enables you to confirm MSDS of the corresponding chemicals.

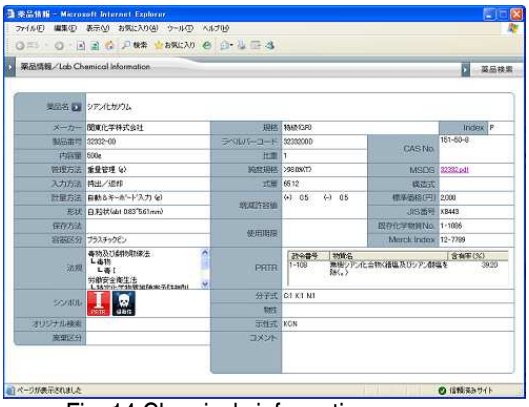


Fig. 14 Chemicals information screen

④ Click “Data Manager” to start the Data Manager.

⑤ Click the “Help” button to see the manual for this system.

● To start the Data Manager

① You can start the Data Manager, an application program with a tallying function for IASO R5, in either of the following ways:

・Click the “Data Manager” button on the menu bar of R5.

・Enter the URL corresponding to each laboratory into the address field.

Address of Bottle Based Management Server:
http://192.168.7.8/r5_dm/

Address of Weight Based Management Server:
http://192.168.7.9/r5_dm/

Fig. 15 Login screen

② As in the case of R5 (e-web), enter the group ID (alphabetic 3 letters) and the password (case sensitive) to log in (see Fig. 15).

● Functions of the Data Manager

The Data Manager provides you with the following summaries for chemicals owned and consumed in the group:

(1) Tallying of inventories (opened or unopened chemicals are identified)

(2) Tallying the amount consumed (by regulations, purpose and user)

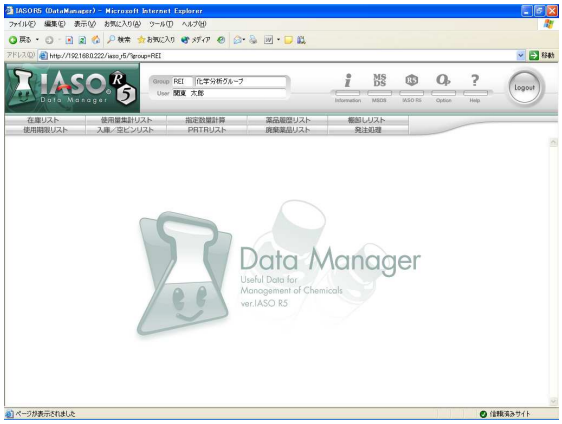


Fig. 16 Main screen

(3) Calculation of quantity of chemicals that are designated by the Fire Service Law
(4) Inventory count results
(5) List of chemicals of which the validity date has expired
(6) List of purchased (stored) chemicals
(7) List of consumed (empty bottle) chemicals
(8) Tallying of PRTRs (purchased amount, inventory, and amount discharged/transported)
(9) Tallying of disposed chemicals

●Basic operation of the Data Manager

Tallying method

To tally chemicals, follow these steps (see Fig. 17):

① Select the item for which you want to make a tally from the menu bar. The screen will be switched to the corresponding one.

② Counting period: Specify the date range in the date format of YYYY/MM/DD – YYY/MM/DD.

③ Number of display: When there are many tallied or selected results, you can specify the number of results to be displayed. The default is 10.

④ Storage location/Regulations/Chemicals: You can specify "Storage location", "Regulations", or "Chemicals" as conditions for tallying. When specifying a chemical, the sub form for search for chemicals (see Fig. 18) will appear. Select the search criteria (chemical name, CAS No., Molecular formula, Catalog number, etc.), and click “Stock” button for inventory search or “All” button for full search. Search results will be displayed. Select the checkbox(es) next to the chemical name and then click “Determine” to specify chemical(s). To narrow the results, select the search criteria again and click the “Limiting search” button to specify the chemical.

※ Inventory chemicals are indicated by symbol

⑤ Detailed list: Select the checkbox to make a tally on a bottle basis.

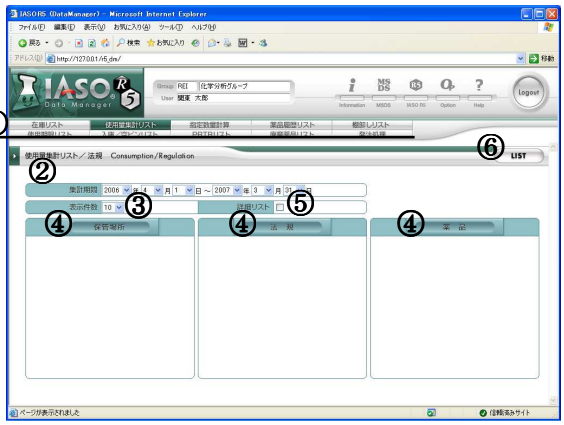


Fig. 17 Example of tallying screen

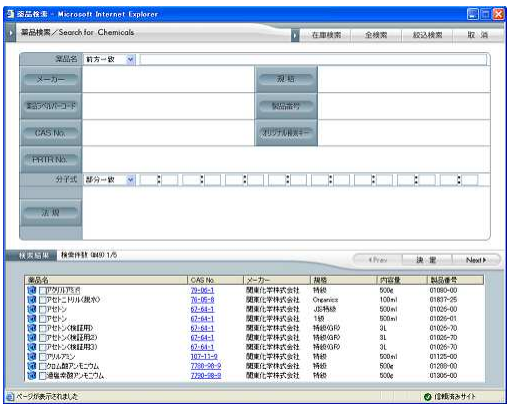


Fig. 18 Chemicals search screen

⑥ Then, click the "LIST" button. The corresponding tallied results are displayed (see Fig. 19). Clicking the chemical name displays tallied results on a bottle basis.

※For chemicals to which unit control is applied, the consumption is displayed after processing empty bottles. "Consumption" and "Apparent residue" in use are indicated by＊＊＊

⑦ Click "Download". The display will be switched to "Download of file". You can create a file in CSV format.

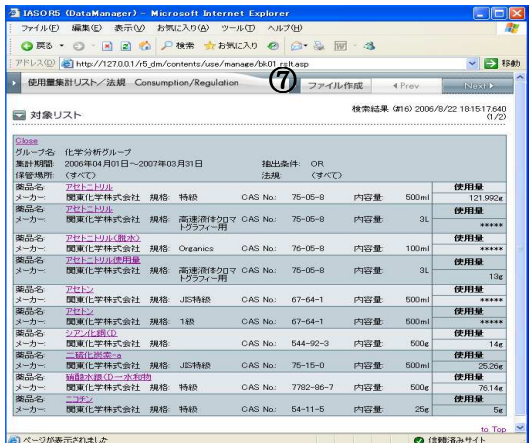


Fig. 19 Example of tally list screen

● Creating the poisonous materials management register

① For the poisonous and deleterious substances management register, a tally can be made for each category (regulations/intended use/user) of Consumption list (see Fig. 20).

② Specify number of display, counting period, storage location, etc. as conditions for tallying, and then click the ”LIST” button.

③ The poisonous and deleterious substances management register that lists date/time of use, user, purpose of use and amount consumed will be displayed. You can output the detail in CSV format by clicking "Download".

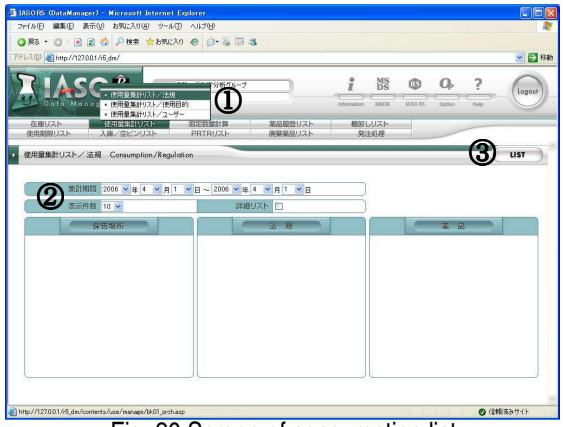


Fig. 20 Screen of consumption list

● Calculation of Specified Quantity of Hazardous Materials in the Fire Service Law

① Clicking the “Specified quantity” switches the screen to the right one (see Fig. 21).

② Specify the storage location for which you want to perform calculation of specified quantity.

③ Click the “List” button.

④ The results of calculation of specified quantity are displayed on the sub form. The results are

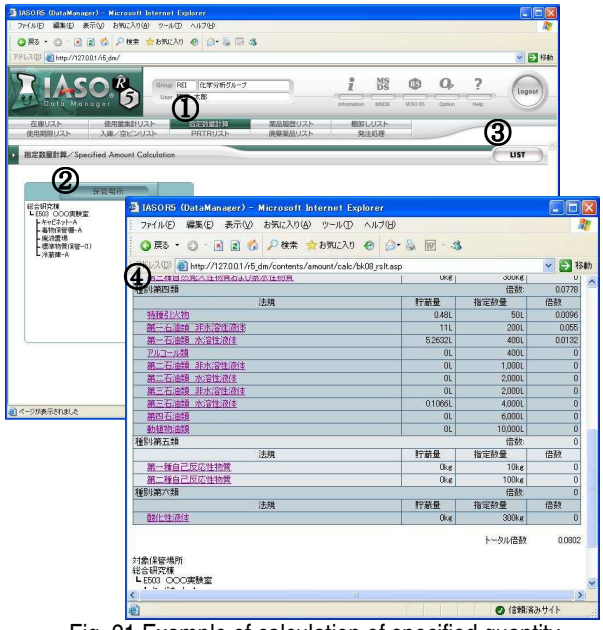


Fig. 21 Example of calculation of specified quantity

tallied per item specified in the attached table provided by the ordinance of the Fire Service Law along with the ratio of the storage quantity to the specified quantity (multiple) in the rightmost column. Total multiple is shown in the last row.

●Browsing the history of chemicals

① Click the "List of record" to switch to the chemicals history screen (see Fig. 22).

② Enter the IASO barcode No. of the chemical bottle for which you want to browse its history.

※ For a chemical bottle whose IASO barcode No. is unknown, you can identify the chemical with "Search" and then identify the corresponding IASO barcode from "Select barcode".

③ Click the "LIST" button.

④ Bottle-based management information and history from purchase up to now are displayed for each chemical.

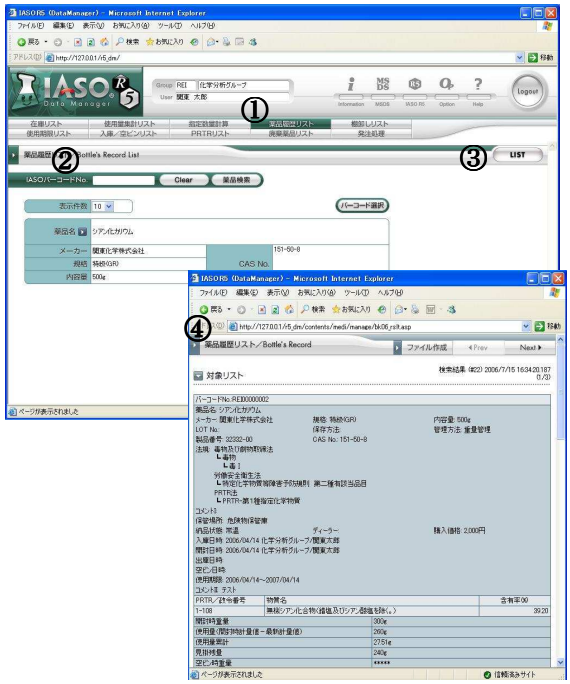


Fig. 22 Example of list of chemicals history

Operating Instructions - The Management System for Waste Liquid (FLUID WASTES)

● To start the Management System for Waste Liquid:

① Start the Web browser (Internet Explorer 6.0 or later recommended) and enter one of the following URLs in the address field depending on the laboratory.

Address of Bottle Based Management Server:http://192.168.7.8/

Address of Weight Based Management Server:
http://192.168.7.9/

If your client is connected successfully to the server, system selection screen (Management

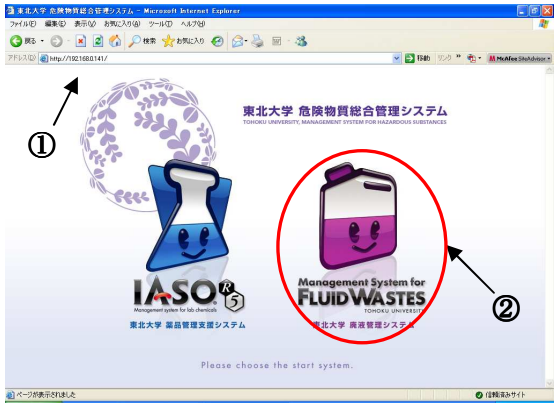


Fig. 23 System selection screen

System for Lab Chemicals and Management System for Waste Liquid) appears (see Fig. 23).

② When the Management System for Waste Liquid is selected, the login screen appears (see Fig. 24).

③ Enter the group ID (alphabetic 3 letters) and the password (case sensitive) to log into the Management System for Waste Liquid.

※ When you cannot log in, please contact the middle supervisor of the department/organization.

④ After login, the main screen (see Fig. 25) appears, and the group name and user name are displayed in the middle of the upper part.

⑤ Menu items - Register tank, Enter waste liquid, Fill-up, Delete history, Create slip/Check status and List - are displayed. Click on any item you want to execute.

※Functions of "Create slip" and "Delete history" are available only for the person in charge of discharge (faculty/staff member excluding researchers). These menu items are dimmed and no one except for the person in charge of discharge can click to enter.

Fig. 24 Login screen

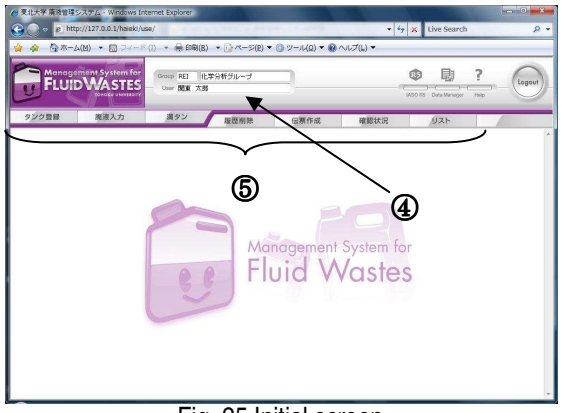


Fig. 25 Initial screen

●To register the control number of the waste liquid tank:

※Check the control number attached to the waste liquid tank.

① Click the "Register tank" button to switch to the right screen (see Fig. 26.)

② Directly enter the control number attached to the waste liquid tank in the "Control No." field and then click the "OK" button.

③ Selection of the waste liquid classification of the empty tank appears. Select an appropriate waste liquid classification and then click the "OK" button to register the

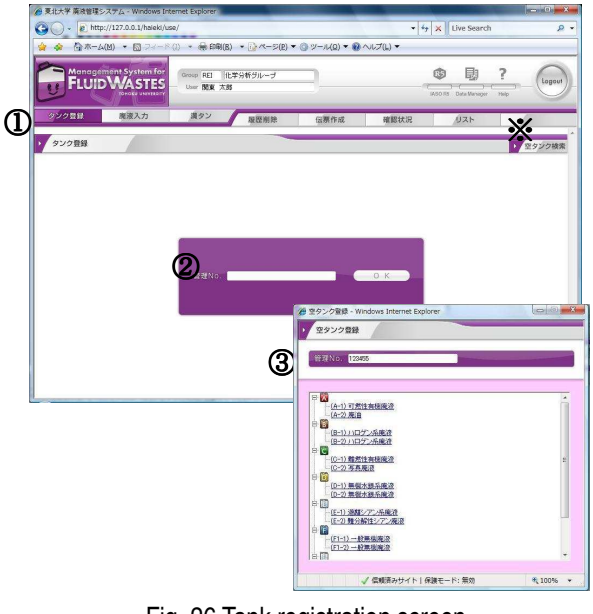


Fig. 26 Tank registration screen

control number into the system.

※ When you reuse the control number

Click the “Search for empty tank” button to show the list of registered control numbers. You can make a registration from the list.

● To enter waste liquid:

① Click the “Enter waste liquid” button on the menu bar to switch to the waste liquid entry screen (see Fig. 27.)

② The list of control numbers of registered tanks will appear. Select the corresponding control number from the list.

③ The waste liquid registration screen (see Fig. 28) will appear. Enter or select “Material name”, “How used”, “How much”, “CAS No.”, “PRTR No.”, “Content” and “Regulations”.

※ “Material name”, “CAS No.”, “PRTR No.”, “Content” and “Regulations” should be entered as much as possible using “When entering materials data from materials search” (vide infra).

※For materials that are not registered in the materials master, refer to MSDS in the chemicals management system to enter/register accurate data.

※For disposal of a solution, make an entry with the solute and solvent separated.

※For disposal of a solute (unit is “g”, “kg”, “ppm”, etc.), make an entry with “l (liter)” after converting the unit into “liters” using specific gravity.

④ Click the “Register” button to register the data.

※The maximum number of logs for “How used” is 10.

※If you entered the incorrect amount of waste liquid, you should adjust and correct it by

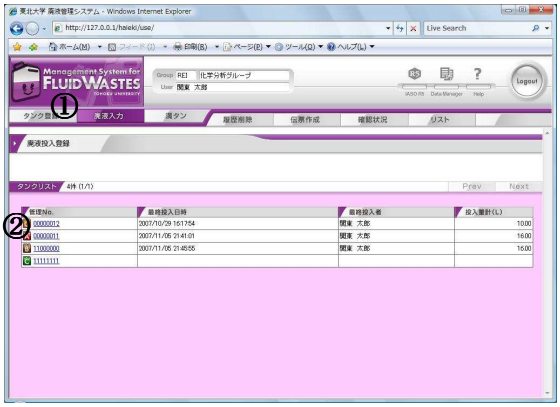


Fig. 27 Waste liquid entry screen - 1

Fig. 28 Waste liquid entry screen - 2

entering a minus amount.

◎When entering materials data from materials search

⑤ Click the “Material name”.

⑥ Materials search screen (see Fig. 29) will appear. Enter information you want to search such as material name, CAS No., PRTR No., and regulations, and then click the ”Materials master” or “History of waste liquid disposal”.

※ Materials master: Search is executed based on materials data stored in the system and the result is displayed.

※ History of waste liquid disposal: Search is executed based on the disposal history entered in the management system for waste liquid and the result is displayed.

⑦ When you click the material name on the search result, the waste liquid entry screen is refreshed accordingly.

Fig. 29 Materials search screen

●Fill up:

① Click the “Fill up” button on the menu bar to switch to the fill-up entry screen.

② The list of control numbers will appear. Select the corresponding control number you want to register as fill-up.

③ The disposal history will appear. Check the disposal history and then click the “Fill-up” button to register it (see Fig. 30.)

※Note that you cannot perform “Enter waste liquid” and delete “Disposal history” if you click the “Fill-up” button.

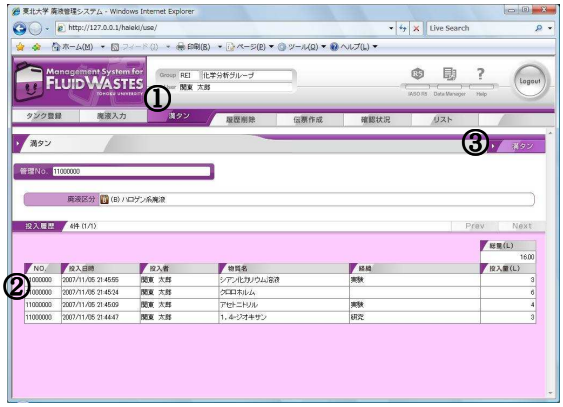


Fig. 30 Fill-up registration screen

●To delete history (available only for person in charge of discharge):

※This is used to delete all tank information (control No. and disposal history) before fill-up

entry. Note that you cannot delete the history after fill-up entry.

① Click the “Delete history” button on the menu bar to switch the delete history screen.

② Enter the control number of the tank you want to delete in the “Control No.” field and then click the “OK” button.

③ The history deletion screen will appear (see Fig. 31.) Click the “Delete” button after confirming the detail of the disposal history.

※Note that the entire disposal history is deleted by clicking the “Delete” button.

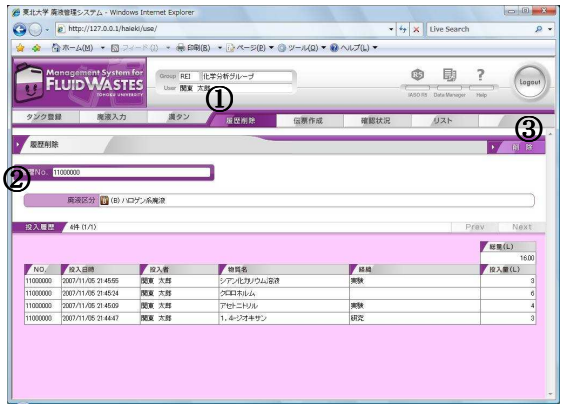


Fig. 31 History deletion screen

● To create the request slip (available only for person in charge of discharge):

① Click the “Create slip” button on the menu bar to switch to the create slip screen (see Fig. 32.)

② The list of control numbers of filled-up tanks will appear. Select the corresponding control No.

③ The request slip creation screen (see Fig. 33) will appear. Enter or select “Waste liquid classification”, “Storage warehouse”, “pH” and “Comments”.

④ Enter “Constituent name”, “Constituent ratio” and “PRTR subjected” field for each constituent. Click the “Add” button to display. another set of blank fields.

※ If you want to delete “Constituent name”, “Constituent ratio” and “PRTR subjected”, click the “Delete” button.

※Click the “Disposal detail” button to show disposal detail of the waste liquid.

※ If the pH is unknown for the waste liquid such as that classified into the A-1 group, use 7. If nothing is entered, registration is not performed.

⑤ Click the "Register" button to register (save)

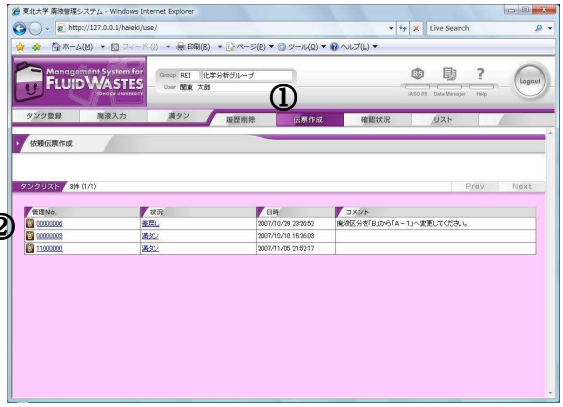


Fig. 32 Request slip creation screen - 1

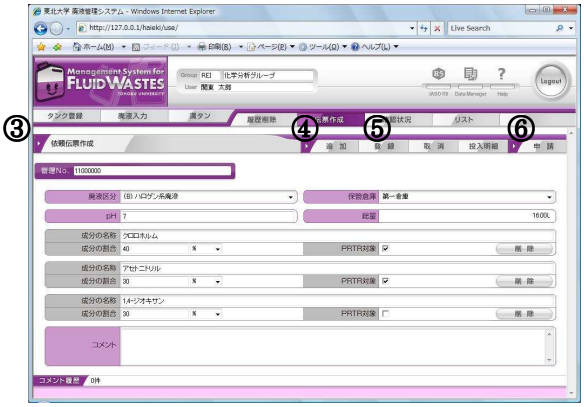


Fig. 33 Request slip creation screen - 2

the entry.

⑥ Click the "Application" button.

※When you click the "Application", the entry will be sent to the Environmental Conservation Research Institute.

⑦ The request slip for waste liquid (see Fig. 34) will be created. Print out the screen, attach it to the waste liquid tank and then discharge the waste liquid tank.

Fig. 34 Request slip creation screen - 3

●Confirmation status

① Click the "Confirmation status" button on the menu bar to switch to the confirmation status screen (see Fig. 35).

② Select "Tallying period", "Waste liquid classification" and "Status", and then click the "List" button.

③ The corresponding list will be displayed.

※1 If your application is passed back, the status of ③ is indicated as “Pass back.” In this case, reapplication to the Environmental Conservation Research Institute is necessary. Click the control No. to create the request slip again. If the waste liquid tank has been passed back, treat the content in an appropriate way, create the request slip again, print it out, attach it to the tank and bring the tank to the waste liquid storage warehouse. If the status is “Slip has been checked”, you can see the request slip by clicking the “Control No.”

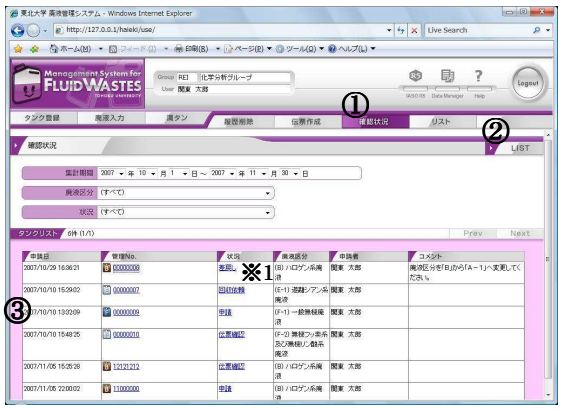


Fig. 35 Confirmation status screen

● Special note

The Total Management System for Hazardous Materials is application software based on a Web environment, and is designed and verified for operation under Internet Explorer 6.0 and SAFARI. It may not work properly on other versions of the browsers or other browser applications. Please note the following:

① Timeout

If approximately 20 minutes have passed without any operation, you will be forced to log out of the system. In this case, when you try to operate something, you are forced to the log-in screen and you have to log in again.

② Logout

After you log in from the password screen, “Logout” menu item is displayed on every screen. After completion of your work, click the “Logout” before you exit the browser.

③ Do not use Back and Forward buttons

Back and Forward buttons on the browser enable you to navigate already-displayed pages. The displayed page is not always refreshed and movement between pages may not be consistent. It is recommended that you do not use Back and Forward buttons on the browser as validity cannot be assured when moving between pages.

●IASO barcode label

Barcode label sheets are available from:

☆A-ONE CO., LTD. [A4 size/44 labels (Type R)]

- 20 sheets (880 labels) Product No. 28388 List Price JPY 1,200
- 100 sheets (4,400 labels) Product No. 28368 List Price JPY 5,000
- 500 sheets (22,400 labels) Product No. 28648 List Price JPY 22,800

☆Kanto Chemical Co., Inc. [A4 size/80 labels (Type S)]

- 25 sheets (2000 labels) Product No. 96970-04 List Price JPY 2,500

●If you have any questions about the Total Management System for Hazardous Materials or its workings:

・For the Management System for Lab Chemicals IASOR5, contact Supervisor, middle supervisor of the department/organization, Health and Safety Management Office

・For the Management System for Waste Liquid, contact the Environmental Conservation research Institute, Health and Safety Management Office

Technical Question

IASO Web site

URL: http://www.iaso.info

Kanto Chemical Co., Inc.,

TEL (03)3667-6471 / FAX (03)3667-6892

E-mail: iaso@gms.kanto.co.jp

Chapter23　Mental Health of Students

In this chapter, we will give an explanation of mental health, one of commonplace issues, so that you can spend a healthy and enjoyable student life.

23.1 What is Stress?

Stress is a psychological and mental strain that affects health. Psychological response, such as cabin fever, and physical reaction, such as hypertension, can affect health when it lasts for an extended period of time. Recently, our life has been of a highly susceptible nature to be stressed easily, and a national survey reported that approximately a half of people of 15 to 24 years of age, nearly your generation, are stressed. The causes of mental conflict and stress are shown below;

Causes of mental conflict and stress

Ranking/sex	Male	Female
First place	Academic work, exams, advancement of themselves	Academic work, exams, advancement of themselves
Second place	Human relationships to other than family	Human relationships to other than family
Third place	Motivation in life	Love affair

23.2 Reactions to Stress

What reactions do we make in the situation of being stressed? A reaction when adapting to stress is to clarify and understand the situation of stress of one's own, to think how to handle it in one's own way, and to act it out. We may take active action to resolve the problems, or relieve the strain by enjoying hobbies or entertainment.
When we take maladaptive reactions instead of these appropriate reactions, we may fall into an unhealthy physical and mental situation such as psychosomatic disorder, depression, and anxiety disorder. Typical maladaptations are presented as follows.

1. Psychosomatic disorder

Psychosomatic disorder is a medical problem which is largely involved by stress. Examples include gastric and duodenal ulcer, bronchial asthma, hypertension, tension-type headache, and diabetes mellitus. In fact, psychosomatic disorder is thought

to cause stress-involving headache and stomachache. In these situations, you should consult the Health Administration Center or medical institutions (of internal medicine or psychosomatic medicine).

2. Depression

Recently, depression is also called a mood disturbance that is susceptible to everyone and, therefore, often expressed as “flue of the mind”. Although it is susceptible to people with long-lasting anxiety, fatigue and strain and can lead to death (suicide). Depression is curable. It is a commonplace disorder that is experienced in several, out of a hundred people, in their entire life, and when you feel uneasy, you should not think imprudently of it and consult with the Health Administration Center or University Counseling Center.

* For more information about depression, please see “About Depression” in Health Guide No.31 which is available at the Health Administration Center.

○ Please check the simple self-diagnostic items for depression

(1) You feel sad, blue or in a grave mood
(2) You are uninterested in anything, or joyless
(3) You easily fatigue, feel lusterless, or listless
(4) You feel that your spiritual energy, motivation, or concentration is decreasing
(5) You have trouble falling asleep at night and you wake up early most mornings and cannot get back to sleep
(6) You have lost your appetite
(7) You do not want to meet others
(8) You are in a bad mood or feel sick in the morning, compared to in the evening
(9) You are caught up in feelings of worries and you feel like that you are running in circles
(10) You cannot recover from shock of failure, grief, or disappointment
(11) You blame yourself and feel as if you were worthless. You feel guilty for no real reason
(12) You do not want to live anymore.

※If you are in either case of (1) or (2) everyday and it has lasted for more than one month, you should consult with the Health Administration Center, University Counseling Center, or other medical institutions as soon as possible to get appropriate instructions. In cases other than (1) or (2), you should also contact the Health Administration Center.

○ When you find that someone in your laboratory has one of the cases below, you should consult with the advisory faculty, or contact the Health Administration Center or University Counseling Center.

(1) He (She) has dark expression on his (her) face and looks out of blood, which was not seen before

(2) He (She) expresses a feeling of unwellness (such as pain in the body and fatigue) more than before

(3) His (Her) efficiency in his (her) study looks lower and makes more mistakes than before

(4) He (She) keeps himself (herself) away from people around them.

(5) His (Her) tardiness, early dismissal or absence is increased.

(6) He (She) avoids hobbies, sports or going outside

(7) His (Her) amount of drinking is increased.

○About depression - by a counselor of the University Counseling Center

Some students come to consult with the University Counseling Center after they wondered if they were depressed and needed to consult with a neuropsychiatrist. At the counseling center, students talk with counselors to organize their minds, physical condition and their daily lives, and then they decide to see how it works for a while or to consult with medical institutions.

3. Anxiety symptom

Anxiety is one of signals that our minds give off and one of the most common emotions among all the emotions we experience. Although anxiety brings about a mental symptom, it is also experienced on a daily basis not only in the field of psychiatric care but also in the field of physical care. It is easy for you to understand that the feelings of anxiety would occur if you are in bad condition. Not only for people with some diseases but also for healthy people, feelings of anxiety occur on a daily basis and there is no one who has not had them. Those who are filled with a feeling of anxiety are encouraged to contact the Health Administration Center, University Counseling Center or medical institutions.

* For more information about anxiety disorder, please see “About Anxiety Disorder” in Health Guide No.35, which is available at the Health Administration Center.

○ About anxiety symptoms - by a counselor at the University Counseling Center

There is no one who does not feel anxious when presenting at seminars, thinking about their future path, or spending student life in a complicated human relationship.

Reactions by anxiety such as frustration or worry are accompanied with physiological alternation such as an increase in cardiac rate, alternation in blood flow, respiratory change or sweating. Although anxiety symptoms are a necessary biological life support function, it is a complicated feeling that might be a difficult feeling to live with.

23.3Ways of Dealing with Stress

As mentioned in chapter 23.2 “Reactions to Stress”, the key point in dealing with stress is to take a reaction approach that is adaptive to stress. Examples of dealing with stress are presented below, which are often seen in the students at the Undergraduate and Graduate School of Engineering, and Graduate School of Environmental Studies.

○An example of dealing with stress, reported by a counselor at the University Counseling Center.

(1) People with a devoting temperament who give themselves up to study or extracurricular activities without consciously taking weekly rest tend to become indifferent, distracted and uninterested. The Checked items in the depression checklist often apply to these people..

<Stress management>

In order to prevent worsening and recurrence of depression, it may be useful to learn the method of “time management”. Staff at the University Counseling Center can help students who want to learn the method.

(2) After entering the university, especially when starting in their laboratories, it often happens that students cannot step forward in their academic work or study without instructions from the advisory faculty. However, if students are not good at asking for advice or whose advisory faculty is too hardheaded to be asked, it is likely that they may suffer loss of motivation, loss of self-confidence or a depressive mood, consequently, leading to school refusal.

<Stress management>

It may be useful to learn “communication skill” or “how to communicate with people hard to get along with. Staffs at the University Counseling Center can help students who want to learn the method.

23.4Visiting the Health Administration Center and University Counseling Center

Please feel free to use the support of these centers which are ready to be of help to you for your university life. It is “an ability” to get over difficult matters with the help of

others. There is nothing to be ashamed of to contact and consult with the Health Administration Center, University Counseling Center, or the Academic Counseling Office.

○ When you feel anxiety in your educational advancement
○ When you feel “energyless or distressed” when facing problems
○ When are absent from college and you think of yourself changing something in the present situation.
○ When you are in conflict or are not doing well in a personal relationship
○ When you want to be of help to friends in trouble
○ Others

＊ Health Administration Center
Consultation by a neuropsychiatrist is available from Tuesday to Thursday every week (prior appointment by telephone is necessary.)
Hours: 09:00-11:30, 13:00-16:30 (Consultation is only in the morning on Wednesdays)
Consultation by: Dr. Naoto Yamazaki
Tel: 022-795-7829
hoken@bureau.tohoku.ac.jp

＊ University Counseling Center
Open: Monday to Friday every week (excluding Saturdays and Sundays, year-end and New Year holidays, and national holidays; prior appointment by telephone is necessary.)
Hours: 09:30-17:00
Six counselors are available.
Tel: 022-795-7833
gakuso@bureau.tohoku.ac.jp
What was talked about is kept confidential.

＊ Academic Counseling Office
Open: Monday to Friday every week (excluding Saturdays and Sundays, year-end and New Year holidays)
Hours: 10:00-16:00 (appointment by telephone, facsimile, or email is desirable)
Two advisors (Emeritus professors of the Graduate School of Engineering, Graduate School of Information Sciences, and Graduate School of Environmental Studies) are available.

If you are wondering where to get advice, or you have problems about your school life or way of living, do not hesitate to contact the Academic Counseling Office. Referral to other appropriate advisors and the University Counseling Center is also available.

Tel (Fax): 022-795-4922, 5886

gakuso@bureau.tohoku.ac.jp

What was talked about is kept confidential.

Chapter 24　Conclusion

This Safety Manual was written with the intention of providing instruction and knowledge about chemicals and poisonous materials as well as hazardous risks, in the main, to students who carry out experiments and research at the School of Engineering. Although intended to cover all possible substances and hazardous events, enough cannot be said. People may encounter accidents at any moment, and some of the accidents may be due to carelessness. Students are required to understand and be routinely prepared on how to respond and remain calm in the event of an accident. Students are advised to pay attention to each other to prevent fires and accidents, especially in the laboratory. No one should ever perform experiments alone.

It is very important that every student takes out Personal Accident Insurance for Students Pursing Education and Research and is insured in case of unexpected accidents. Advise anyone you know, if he/she is not yet insured, to take out insurance coverage.

Even though the Undergraduate and Graduate School of Engineering, Graduate School of Environmental Studies, and Graduate School of Biomedical Engineering offer lectures and education on safety issues using this manual, it is not enough, because of time-restricted lectures, to ensure a through understanding of all the safety considerations included in this manual. We expect every student to peruse this manual and have a good solid understanding of safety considerations to spend a safe and pleasant life at school.

This manual has been revised many times since the Safety Manual Working Group of the "Research and Education Safety Committee" at Tohoku University School of Engineering published the first edition in April 1994. In the 2008 edition, we revised or added and enriched the following chapters based on the responses to a questionnaire that was conducted in July 2008 targeting the staff, faculty and students at the School of Engineering.

Chapter 1 "Introduction": Indices on important matters and items were added to make this manual more understandable.

Chapter 2 "High Pressure Gas": This chapter was newly written since there are many people who handle high pressure gases at the School of Engineering.

Chapter 10 "Laboratory Waste Treatment": Partially revised since a Total Management System for Dangerous Materials was introduced and there were changes in the Organic Waste Liquid Classifications and the Quick-reference Guide for Sorted Collections.

Chapter 11 "Electricity": A Checklist for Electrical Equipment was inserted since there were two electrical fires in 2007.

Chapter 17 "First Aid": This chapter illustrates the latest first aid which was newly written by Associate Professor Ogawa, an advisor of occupational medicine.

Chapter 22 "Total Management System for Dangerous Materials: The instruction manual for a new Management System for Waste Liquid was added.

Chapter 23 "Mental Health of Students": This chapter was newly written since there are a few students who have mental health problems.

In addition, important points were colored in red or underlined to emphasise them and legal terms were changed to easy terms with an intention to make the manual clear and easily understandable.

Wewould like to thank those who allowed us to use many of their references. Opinions, suggestions and requests were provided by many people, which were very helpful when

editing the manual. With the Health and Safety Management Office in a leading position, we are going to improve this manual through continued revision by adding and changing its content in future years so that further safety considerations will be addressed by the students, staff and faculty. We are expecting opinions and requests relating this manual to improve it.

Examples of Near Misses and Accidents

We received a lot of valuable information on experiences regarding accidents from students, staff and faculty. It is our hope that you refer to them to secure your own safety. Note that special care is required when carrying out procedures involving ignition, explosions, electric shocks and dangerous substances, which are, in some way, the causes of most of the accidents reported here.

1. Ignition and inflammation

-When I put the remaining magnesium-aluminium alloy in a cardboard box, it ignited.

-When I took out iron oxalate that had been thermally decomposed in a low vacuum, it ignited.

-When a rare earth metal was polished in water, its powdery remains dried later and accidentally ignited.

-When I took superfine powders out of the vacuum chamber, they ignited.

-Alkali metal ignited and my plastic gloves caught fire.

-I accidentally spilled water over sodium hydride, leading to ignition.

- When I tried to wash the equipment after processing metallic sodium with methanol, the unprocessed sodium remaining ignited, making methanol spills flash off, and then the surroundings near the sink caught fire. There was a fear that explosion would break out if organic solvents caught fire, but, fortunately, I was able to put out the fire with a fire extinguisher so that damage was limited to the sink.

-When I was washing a flask that still had a small amount of ether inside, the flame of the hot water supply equipment caused ether to catch fire.

-Right after washing the equipment with organic solvent, the solvent caught fire from a cigarette butt from a passing student.

-I dropped a three-liter hexane bottle on the floor, and it caught fire from the flame in the heater.

-After doing glass work, I left the product on the lab bench while it was still hot. It burned the lab bench and ignited a chemical which had been left there.

-When aluminum powder caught fire, I poured water over it and the fire got worse.

-When I added too much hardening agent, it rapidly generated heat, and the cold embedding resin caught fire.

-I put a paper towel, which had been used to mop up toluene, in a plastic bag, and then put the plastic bag in the incinerator. Flames burst out and burned both of my arms when I lit it with a lighter.

-After treating the metal specimen cutting power by wet air combustion, it was put in the bowl and ignited. Unexpectedly, it flamed vigorously and scattered sparks. My right hand got burned. The cause was that insufficient evaporation of water with a remaining small amount of alcohol.

-I threw metal lithium, which is classified into the water-prohibiting substance, in the trash bin. Ignition was caused by the moisture in the bin. The bin burned.

2. Explosions, ruptures

-A sealed tube exploded because the temperature control in a sealed tube reaction experiment was not working properly.

-When I tried to pump off oxygen filled in the chamber using a rotary pump, the chamber exploded.

-When I put a flask into a dryer after washing it with acetone, it exploded.

-When I was measuring acetyl peroxide with a spatula, it exploded.

-When I quenched molten metal quickly, it created a phreatic explosion.

-A mixture of oxygen and hydrogen gases exploded. Fortunately nobody was injured.

-While injecting the equipment with liquid nitrogen through a tube, it suddenly burst and scattered its shattered pieces all around.

-The label on the chemical bottle was illegible. I was told that it was a chloride so I poured it into water. It generated a spark, and I found out it was a hydrogen compound.

-When I was trying to neutralize hydrochloric acid, I accidentally added too much sodium bicarbonate and the beaker containing the hydrochloric acid exploded.

-I was performing an extraction with a separatory funnel. When I mixed an organic solvent and water, pressure from inside the funnel pushed the glass plug out because I did not remove the gas thoroughly. The organic solvent sprayed onto my lab coat and on others as well.

-When I was collecting residual tetrahydrofuran using the same solution again and again, it exploded. (Peroxide generates ether)

-When I stored chemicals in an ordinary refrigerator, they exploded. A low-boiling-point chemical leaked from an unsealed container and vaporized, then ignited by a spark. (When storing chemicals, use an explosion proof refrigerator)

-While handling chemicals that are unstable in heat, a decompression distillation apparatus exploded when I was carrying out a procedure that had not been communicated between the members. Two people were injured by the shattered glass from the apparatus.

-During an experiment that accumulates hyperoxidation silicon film by the CVD (Chemical Vapor Deposition) method, a monosilane gas leaked and exploded. Two students died and the explosion ignited organic solvents, which then started a fire.

-When I was operating the autoclave, the gas came gushing out.

-A student put a wet tin into an autoclave that was still hot, which caused the water to boil rapidly. It suddenly released a lot of steam which burned another student's face. Since that accident, we purchased large safety googles and made it mandatory to wear them.

-I synthesized an aluminum and lithium alloy according to the Mechanical Alloying method with an Attritor mill. Later, when I was washing the mill, the vessel of the mill suddenly exploded and the bolts fixing the lid ripped off.

-The cooling part of the distillation apparatus being used in the draft chamber was clogged and the flask burst. Hot water (containing phenol) in the flask spattered on my hand and I got a burn. The cause was that the compound crystallized and the apparatus was sealed, causing its internal pressure to increase and, as a result, the flask burst.

-When I vacuum enclosed a specimen into a quartz tube, heated it, and put it into water, the quartz tube burst, and its scattered pieces stuck into my left arm causing bleeding.

-When I was solder connecting button-shaped batteries in series, the batteries burst.

3. High temperature, high pressure

-I forgot to use a thermocouple when I raised the temperature of a tubular furnace. I did not realize it until the temperature was dangerously high.

-Hydrogen that was heated to approximately 900°C leaked in to the air. Fortunately there was no explosion.

-I accidentally dropped a quartz sample with a temperature of nearly 1,000°Cand it burned the floor. Although it did not catch fire, smoke filled the room. This happened because we did not seal the bottom of the electric furnace properly.

-I accidentally unscrewed the bolt on a container of high-pressure gas and the gas gushed out all at once. It could have been a serious accident if the unscrewed part of the container had flown off.

-A regulator detached from a high-pressure cylinder, causing high-pressure gas to gush out.

-When we were putting gas into a vacuum chamber, high-pressure gas gushed into the chamber all at once and broke the window of the chamber. This happened because we did not confirm the secondary pressure of the gas cylinder.

-While I was looking directly at the regulator of some high-pressure gas, the bourbon tube inside the regulator broke and injured my eye. Since that accident happened, in the laboratory looking directly at the regulator is not allowed, but must be viewed from an angle or using a mirror, especially when opening the cylinder head..

-When we were heating a sealed silica tube, the tube exploded and its shattered pieces flew out of the electric furnace because the pressure of the metallic fumes was too high. The person who was looking at the electric furnace sustained an eye injury. Since then, we instruct students to observe this kind of electric furnace through an eye protector or by using a mirror.

-To place a lid back on the heated crucible, which had been a little displaced, I unintentionally touched it with my bare hand and got a burn from it.

4.Electricity, electric shock

-During the daytime, I set the voltage and electric current higher than usual to quickly increase the temperature of the electric furnace. It created an overload with the temperature above 1,200 degrees Centigrade and a part of a firebrick melted. It is necessary to set the electric furnace properly, and make sure there is always someone there to watch when carrying out long term experiments.

-I soldered together two electric wires to make an extension and then used plastic tape as an insulator to cover them. When I tied the two wires together, the sharp edges of the soldered wires punctured the plastic tape and a short-circuit occurred. The fuse went off immediately when I turned on the switch.

-I received an electric shock. Even though it is only 100 volts, it is still very dangerous when you are unable to release your hands right away.

-When I turned on an electric switch while I was holding a bottle of acetone, it burned my hand.

-At a scheduled power outage, I was about to disconnect an electric line. To my surprise, fluorescent light started to illuminate the room while I was holding the prongs and I realized that the power was on. Fortunately I was wearing rubber gloves and nothing happened. It was my mistake because I did not communicate beforehand with the staff in charge of re-energizing the line.

-Caused by the moisture, the power distribution board short-circuited, resulting in a spark leading to a fire with combustibles around the distribution board.

-An electric plug was left insufficiently inserted to the receptacle. The exposed prongs gathered dust, causing a short-circuit leading to a fire with papers in the surroundings.

-While I was repairing a vacuum gauge, I accidentally touched a high-voltage condenser that was apparently fully charged. After my work was done, I measured the voltage and it was 2.5 – 3 kV. There was no sign warning of high voltage.

-While I was melting iron in a high frequency furnace, I touched the thermocouple that measures temperature and got an electric shock because I did not notice that a high frequency was applied. Later on, I grounded the thermocouple after sealing it.

-When I turned off a high voltage power supply, I got an electric shock because it was still charged. There was not enough electric current to do any damage, though.

-I almost got an electric shock because I turned off the wrong breaker. (I did not check the breaker.)

-I started repairing an electric furnace without having enough sleep. Although I always turn off the breaker before I start working, I forgot to do so this day. As a result, I got an electric shock and lightly burned my hands.

-Do not put a power strip on the floor. When there was water leaking on the floor, I did not experience a short-circuit because I was not using the power strip on the floor.

-When I turned on an old electric heater, there was a spark. Never use electric equipment with deteriorated wire insulation . It is the worst kind of short-circuit.

-When I was pulling a plug out of the receptacle, its rubber cover came off. I touched the bare conductor and had numbness and pain from the tip of my left hand to the left chest.

5. Dangerous substances and hazardous substances

-Liquid nitrogen spilled on my leg.

-While I was using liquid nitrogen, there was a lack of oxygen, and I collapsed.

-I was wearing only thin plastic gloves when I was pouring liquid nitrogen from one container into another. I got a fright when a small amount of liquid nitrogen spilled on my hand.

-When I was using hydrofluoric acid, it increased in temperature and started generating smoke.

-One student injured his finger with hydrofluoric acid. His finger went black. With severe pain he could not sleep. It was because the gloves he was wearing had a hole in them.

-When I was reducing the volume of radioactive waste, it boiled and scattered inside the draft chamber while I was looking away.

-When I mixed methanol with nitric acid, red smoke that smelled like hydrochloric acid was generated, and the whole laboratory panicked. I should have used ethanol instead of methanol.

-While distilling dried benzene, I forgot to open the cock on the nitrogen line and heated it in a vacuum condition. Benzene gushed out and was ignited by the heat of the hot oil bath, which generated a fire. Distillation must be performed in a well ventilated space.

-Sulfuric acid adhered to the frame of my safety glasses, and the upper left eyelid got burned.

-When I was injecting a reagent into a flask using a syringe, it spattered and the skin near the upper left eyelid got burned. The cause was that I was wearing neither safety glasses nor protective gloves.

-When I was handling NaOH powder, some adhered to my skin. A few seconds later I got a sever pain.-I was handling concentrated NaOH and soon realized my fingernail was melting because there was a hole in my glove.

-As soon as I unscrewed the lid on the hexane can, hexane gushed out and some got in my eyes.

-When I was using a large amount of triethylamine, its smell made me sick.

-Be careful with handling volatile selenium compounds, otherwise dangerous selenium vapour may be generated.

-During a soaking experiment with 8N nitric acid, the solution leaked and melted the lab bench and gas was generated all through the night. A person who came to the laboratory the next morning found that there had been an accident. He ventilated the room immediately.

-After handling potassium cyanide, I drank tea without washing my hands. I became dizzy and almost fainted. Someone in the laboratory took me to the hospital for gastric irrigation, and I was saved.

-While distilling toluene, I realized that I had forgotten to apply zeolite. When I added zeolite, toluene suddenly spewed out and the glass cap blew off. (Even if it does not look like it is boiling, never apply zeolite after heating.)

-In a low temperature laboratory, the oxygen concentration in the room became dangerously low because of the sudden vaporization of large amounts of liquid nitrogen. Two people died (one of them was a student) of anoxemia from inhaling concentrated low-oxygen air.

-When I was filtering aqueous mercury nitrate (conc. 3%), the funnel supporter overturned. The solution splashed my left arm and I got burned.

-I dropped a Tammann tube containing molten salt on the floor, and my hands got burned.

6. Laboratory instruments and devices

-While operating a laser, my eyes were accidentally exposed to the light when I bent down to pick up a pen from the floor.

-When I was replacing mirrors of the laser appliance, the reflected light came into my eyes. A shadow remains in my field of vision.

-I almost touched the machine part that was radiating X-rays.

-Because the gas burner table for doing glass work was in poor condition, the burner almost fell on me. Use a good solid bed.

-Since our thermocouple was out of order, the equipment became much hotter than the temperature which was displayed.

-My finger was almost caught in the experimental equipment.

-I got caught rolled up in the mixer and was injured.

-When I was inserting a glass capillary into a gas detector, it was broken and it stuck me in the left hand. The cause was that I inserted it beyond necessary force.

-When I was doing an experiment using a special high pressure gas, there was a gas leak at the connection between tubes. The gas touched the skin of my right hand and I got burned.

-When I was loosening the cap that had been inserted in the apparatus to release nitrogen from it, a stainless rod ran off from the joint, and hit the middle finger of my left hand. Conventionally water or ethanol is used for the experiment instead of nitrogen. In addition, the cap I loosened was the one that was not conventionally loosened to release gas. The cause was that fixing to the joint was loose.

-While operating the cement mixer, I was trying to stop the machine, and my hand got caught.

-I was creating a dried surface condition of a fine aggregate during a concrete experiment. When I tried to pick up the fine aggregate, another student turned the mixer on and my hand was caught between the mixer blade and the vessel wall. Even though I was lucky not to get seriously injured, I got a huge scare.

7. Processing and operation

-A specimen flew out from the crystal cutter. I got a fright because I was looking inside the machine just seconds beforehand to check how well the specimen had been cut.

-While I was operating the cutter with bare hands, I cut my finger.

-When I was working underground, I became so obsessed with my work that I hit my head.

-While doing radiation maintenance, I hit my head on an obstacle above me. I should have been wearing a helmet.

-When I was removing the optical adjustment table with a knife, I dropped it and the knife hit my thigh and I got a 3 cm cut.

-When I was cutting wire, the cut section hit me at the eye due to the reaction of the cutting force.

-When I was trying to cut a plastic tube covering the glass tube, my hand slipped and I got a wound on my left hand.

-A faculty member was checking a recently placed lightning rod by standing on a stepladder on the rooftop. The stepladder slipped, and he fell and hit his head and died.

-While carrying a heavy solenoid on a cart, the solenoid fell and injured my toe. I ended up having my toe amputated because of that accident.

-When I was trying to force a glass tube inside a vacuum rubber tube, the glass tube broke and I cut my hand.

-When I was filing a workpiece with a rotating lathe, the file got caught in my zipper and flew up. It hit my nose and I got injured.

-When I was replacing drills on the drilling machine, someone accidentally turned on the switch and the machine started moving.

-While punching a hole into a workpiece on the drilling machine with my gloves on, the glove got entangled in the drill and my hand was injured.

8. Laboratory and hallway

-A two-story shelving unit broke during an earthquake and the upper shelf fell and almost killed me. A computer fell off the desk as well. All laboratories must have earthquake proofing.

-During an earthquake, chromium sulfuric acid stored in a cabinet leaked and melted the floor. Using trays is necessary.

-The room is so small that we trip over the heater on the floor. (We cannot find a safe place for the heater.)

-I tripped on the wiring of the experimental equipment and almost fell. Since then, we try to organize wiring between the equipment using pit wiring, wiring ducts or putting the wires under the floor.

-When I was walking down the hallway, suddenly a door burst open and I almost got hit.

-While the hallway was being waxed, I slipped and fell and broke my leg.

-I saw a gas cylinder standing against the wall unprotected in the hallway. Fix it using a chain or the like to prevent it from overturning.

9. Noise, fatigue and lack of sleep

-I got a scare when I heard a sudden loud sound. Although I understand that students need to do experiments, I want everyone to consider others. This is a public facility.

-As soon as I entered the building, I heard a thundering sound. I got such a fright that my heart almost stopped.

-I mixed the wrong chemicals in an experiment because I was tired.

-Since I was lacking sleep, I almost dropped my experimental apparatus.

-I was working hard until late in the night and fell asleep during an experiment.

-I tripped and fell, then hit the stair edge hard on the head. I was wounded, tearing the frontal region of my head.

- Please report all accidents and disasters which occur during work, study or your commute as soon as possible. Use the designated forms.
- Even if there was no damage, please report any incident that nearly became an accident.
- Contact : Health and Safety Management Office