

Safety Manual

Supplement 1. Safety Instructions for Hazardous Materials

April 2008

1. Hazardous Materials

Hazardous materials (including dispersible particles) such as organic solvents (Table 1) and specified chemical substances (Table 2) must be handled with extreme care, as instructed below. These materials are strictly regulated under the Ordinance on Prevention of Organic Solvent Poisoning and the Ordinance on Prevention of Hazards due to Specified Chemical Substances.

- 1) Use a draft chamber (a laboratory fume hood with a local exhaust ventilation system) when handling Class 1 and Class 2 organic solvents (Table 1) and Type 1 and Type 2 specified chemical substances (Table 2).
- 2) All draft chambers (laboratory fume hoods) must provide a controlled air velocity of >0.4 m/s at the face of the hood when organic solvents are being handled. When specified chemical substances are being handled, velocity readings must be >0.5 m/s.
- 3) Protective clothing, goggles, respiratory equipment (mask), and gloves must always be available and worn when required.
- 4) Safety showers and eyewash fountains must be installed for use in the event of exposure to hazardous substances.
- 5) Laboratories in which Class 1 and Class 2 organic solvents (Table 1) and specified chemical substances (Table 2) are handled must not be used as common areas. Drinking, eating and smoking are prohibited in these laboratories.
- 6) All personnel, including full-time, part-time and visiting researchers, are required to undergo specialized medical checkups when working with hazardous substances.
- 7) When handling chemicals requiring special management (Table 2), such as benzene, work in draft chambers (laboratory fume hoods) and avoid direct contact.
- 8) For the possible effects of hazardous substances on human health, see Appendix 1-1: "Classification of hazardous substances" and Appendix 1-2: Effects of cyanides and heavy metals on human health". For the threshold limited values (TLV) of hazardous substances, see Appendix 1-3: "Tentative threshold limit values".
- 9) For carcinogens and possible carcinogenic substances, see Appendix 1-4: "Carcinogens".

Notes:

- 1) The Ordinance on Prevention of Organic Solvent Poisoning and the Ordinance on Prevention of Hazards due to Specified Chemical Substances state specifically and in detail the items that must be included in medical checkups and recorded in order to protect the health of employees.
- 2) Class 1 and Class 2 organic solvents are more toxic and have higher vapor pressures than Class 3 solvents. The regulations for Class 3 substances are not as strict because they contain petroleum and plant solvents that are mixtures of various hydrocarbons with boiling points below 200°C.

- 3) The consumption limit of an organic solvent (W: grams) is determined by the volume of air in the laboratory (A: m³). Class 1 is $W = (1/15)A$, and Class 2 is $W = (2/5) A$. The volume of air here refers to a laboratory space with a height not more than 4 m. Use 150 m³ if the room volume exceeds 150 m³.
- 4) The categorization of the specified chemical substances (Table 2) is intended to prevent health problems such as cancers, dermatitis and neurological disorders. Type 1 chemicals are particularly hazardous, and permission to manufacture them is required, as stipulated in Article 56 of the Industrial Safety and Health Law. Type 2 chemicals may cause chronic symptoms. Although high-level exposure to Type 3 chemicals may cause acute poisoning, these chemicals are not strictly regulated by law for the prevention of long-term health problems, as Types 1 and 2 are.

2. Poisonous and Deleterious Substances

Chemical substances specified in the Poisonous and Deleterious Substances Control Law (Table 3 and Table 4) must be handled with extreme care, as instructed below. Poisonous and deleterious substances have low lethal doses and thus pose a greater risk of criminal use. As such, the Poisonous and Deleterious Substances Control Law focuses on the storage and management of these substances.

- 1) Store poisonous and deleterious substances in a separate and well-defined area (such as a designated cabinet) under locked conditions.
- 2) Storage cabinets for poisonous and deleterious substances must be labeled “Poisonous Substances Not for Medical Use” or “Deleterious Substances Not for Medical Use.”
- 3) When buying, using and disposing of poisonous or deleterious substances each substance must be managed every time by using UTCRIS (Management system for reagents).
- 4) Examine the quantity of each stored poisonous or deleterious substance periodically (in July, November and March).
- 5) The supervisor will determine the necessity of a poisonous and deleterious substance when a subordinate requests such purchases.
- 6) Do not use food containers to store poisonous substances. Containers for poisonous substances must be unbreakable and resistant to corrosion. Cracked or broken containers must not be used.
- 7) When handling extremely poisonous chemicals, wear protective clothing, goggles, respiratory equipment (mask), and gloves, as required.
- 8) For more information on the management system, see Appendix 2-1: “Management Organizational Chart for Prevention of Hazards due to Non-medical Poisonous and Deleterious Substances”.
- 9) Emergency procedures:

- a) If a poisonous or deleterious substance leaks or spills because its container is broken, prevent further damage by immediately taking measures in accordance with the Emergency Protocols in the “Collection of Ordinances for Poisonous and Deleterious Substances,” the revised and enlarged edition (edited by the Safety Division, Pharmaceutical and Safety Bureau, Ministry of Health, Labor and Welfare, 1995, Yakumu Kohosha).
 - b) Contact and report the incident to the appropriate personnel or offices indicated in the Emergency Directory.
- 10) Poisonous and deleterious substances must be disposed of properly by agreement with the Environmental Science Center of the University of Tokyo. All disposals must be recorded and records must be maintained.

3. Combustible, Flammable and Explosive Substances

Combustible, flammable and explosive substances, especially those specified by the Fire Services Law (Table 8) must be handled with extreme care, as instructed below.

3.1 General Safety Precautions

- 1) Hazardous substances greater than the specified quantities (see Appendix 3-1: “Specified quantities (the Fire Services Law)”) must be stored in a warehouse for dangerous objects (such as an indoor hazardous substance storage area), as designated by law.
- 2) If the quantity of hazardous substances exceeds one fifth of the specified amount, this must be reported. Hazardous substances greater than this quantity must not be stored in laboratories. A method for calculating storage quantities (hazardous factor) is described in Appendix 3-2: “Procedures for calculating hazardous factors”.
- 3) In areas where hazardous substances are handled, explosion or ignition sources such as a naked flame, electric sparks, high temperature materials, static electricity, shock, and friction must be tightly controlled to ensure safety. Fire extinguishers must always be ready for use.
- 4) Fumes from organic solvents are generally heavier than air and spread along the floor. Therefore, be aware that fumes may cause a fire or explosion at an ignition point away from the source of the fumes.
- 5) Work only in well-ventilated areas when handling chemicals that may generate an explosive vapor when mixed with air. Store such chemicals in an explosion-resistant refrigerator.
- 6) Store hazardous substances in a way that protects them against theft and prevents deterioration or contamination that may increase risk. In order to prevent fire and explosion in the event of an earthquake, some hazardous substances must not be stored in the same location. See Appendix 3-3: “Ignition and explosion hazards due to hazardous mixture of substances”.
- 7) When handling extremely hazardous chemicals, use appropriate protective equipment such as goggles and shields in order to ensure personal safety.

3.2 Explosives

Substances that ignite or explode due to heat, fire, shock or friction are defined as explosives. Among these are: compounds with N-O, N-N, O-O and O-halogen bonds; acetylene and its heavy metal and halogen derivatives; and heavy metal oxalates (see Appendix 3-4: "Structure of explosive compounds"). For synthesis, see Safety Instructions for Chemical Experiments, 4th ed., Chemical Society of Japan.

These substances must be handled with care, as instructed below.

- 1) Avoid handling large quantities of explosive chemicals and their mixtures.
- 2) Exoergic reactions (condensation and oxidation) must be handled with extreme care as they may become uncontrollable.
- 3) Do not use metal spatulas or glass stoppers.
- 4) Take the same precautions as for handling flammable solvents.

3.3 Combustible and Flammable Substances

- 1) Know the ignition points, flash points and explosive limits of substances. See Appendix 3-5: "Fire and explosion hazards of flammable substances".
- 2) Before glass containers that contain combustible or flammable gas or vapor are processed, thoroughly purge the containers with air, nitrogen or water vapor.
- 3) Know the locations of fire extinguishers. In particular, keep a fire extinguisher nearby when a flame is likely to be generated.
- 4) The space above a solvent container is often the space that will be subjected to the force of an explosion if one occurs. Ensure that the container is tightly sealed, and use extreme care to avoid a fire when using small amounts of these substances.
- 5) During distillation and reflux of flammable solvents, pay particular attention to the cooling water, other chemicals and the equipment.
- 6) Do not store volatile solvents such as ether in laboratories for long periods.

3.4 Spontaneously Combustible Substances

Some chemicals readily generate heat or ignite when exposed to air. These include organolithium, organoaluminum, yellow white phosphorus, reduced nickel, reduced palladium, silane, and phosphine. These chemicals must be handled with care, as instructed below.

- 1) These chemicals may ignite if exposed to air. They must be handled in nitrogen or argon-filled dry boxes.
- 2) These substances are potential ignition sources for other solvents, and as such, must be kept away from

them.

3.5 Substances that may form a hazardous mixture

A hazardous mixture arises when two or more chemicals are mixed and the mixture is more toxic than its components. Although these substances form mixtures that may be toxic or corrosive, only combustible and explosive hazards are described in this section.

- 1) Hazardous mixtures that immediately generate heat or flames or form a combustible or explosive compound when mixed are listed in Appendix 3-6: "Ignition and explosion hazards due to hazardous mixtures".
- 2) Examples of hazardous mixtures that immediately generate heat or flames are as follows:
 - a) Oxidizing compounds such as sodium peroxide, chromic anhydride, potassium permanganate, and bleach powder mixed with flammable substances.
 - b) Oxohalogen salts such as potassium chlorite, potassium chlorate and potassium bromate mixed with a strong acid such as concentrated sulfuric acid.
 - c) In addition to substances shown in "Ignition and explosion hazards due to hazardous mixtures," spontaneously flammable substances and water-reactive substances are also, in a broad sense, categorized as substances that may form hazardous mixtures.
 - d) To prevent hazardous mixtures being generated, know which combinations of chemicals are hazardous and take care when handling these chemicals during chemical experiments.
 - e) To prevent ignition by accidental mixture due to earthquakes, chemical cabinets must be stabilized and equipped with railings to contain chemical spills from fallen or broken containers. It is essential to establish a good shelving arrangement that will not allow chemicals to become mixed and cause accidental ignition, even if a spill occurs.

3.6 Water-reactive Chemicals

Water-reactive chemicals generate heat or flames when exposed to water. These chemicals include organic metal compounds such as alkaline metal, metal hydride, metal carbide, and organolithium. These chemicals must be handled with care, as instructed below.

- 1) Avoid direct contact with skin or exposure to moisture.
- 2) Have dry sand available.
- 3) Neutralize before disposal.

4. High-pressure Gases

When high-pressure gases are used in manufacturing, operating or storage facilities, they must be handled in accordance with the technical standards and safety guidance specified in the High-pressure Gas Safety Law.

When a large amount of a high-pressure gas leaks, it spreads rapidly and widely and is a serious hazard. If it is flammable, explosive or toxic, the consequences can be extremely serious. Be particularly watchful for leaks and corrosion in pipes, and thoroughly examine the operation of valves and the location of gas cylinders. Gases supplied through a pipe or a gas cylinder, even if at low pressure, are regulated under the High-pressure Gas Safety Law. Liquefied gases such as liquid nitrogen must also be handled in accordance with this law.

The High-pressure Gas Safety Law classifies gases into the following four categories:

- 1) Inert gases: 9 kinds of gases, including helium and argon.
- 2) Flammable gases: 40 kinds of gases, including acetylene and hydrogen, with explosive limits within the specified range.
- 3) Toxic gases: 33 kinds of gases, including carbon monoxide, hydrogen sulfide and other gases whose upper limit (TLV) is 200 ppm or less.
- 4) Specified high-pressure gases: 7 kinds of gases, arsine, disilane, diborane, hydrogen selenide, phosphine, monogermanium, and monosilane (Table 9).

4.1 High-pressure Gas Cylinders

4.1.1 High-pressure Gas Cylinders

High-pressure gas cylinders and the quantities of gases are regulated as shown below.

- 1) High-pressure gas cylinders are made of high quality steel and in accordance with JIS B8241. Such cylinders are able to withstand pressure. Generally, cylinders for high-pressure gas are made without seams, and cylinders for low-pressure gas are welded. All cylinders are tested for pressure and air tightness in accordance with the High-pressure Gas Safety Law, and only cylinders meeting these specifications can be used.
- 2) Information is recorded on the shoulders of high-pressure gas cylinders, as shown in Appendix 4-1: "Information recorded on high-pressure gas cylinders."
- 3) The gas-type is indicated by the color on the cylinder, as stipulated in the regulations (see Appendix 4-2: "Color code for high-pressure gas cylinders and gas properties." Do not fill a cylinder with a gas other than that designated by the regulations.
- 4) The structure of the valve is shown in Appendix 4-3: "Outline of valve structure." Outlets for flammable gases have a left-handed thread, but outlets for other gases have a right-handed thread. Exceptions are helium, which may have a left-handed thread, and methyl bromide and ammonium, which may have right-handed threads.

5) The maximum allowable pressure for high-pressure gas, which remains gaseous after compression, is 150 kg/cm^2 at 35°C . Therefore, the volume of the high-pressure gas cylinder determines the maximum amount of gas that can be compressed into it. Handle all cylinders as if they were completely full.

6) The maximum amount of compressed liquefied gas, which is mainly liquid inside the cylinder, is determined by its weight. The following equation is used to calculate the weight of a liquefied gas:

$$G = V/C,$$

G: Weight of liquefied gas (kg), V: Volume of the cylinder (L), C: Constant for each liquefied gas.

7) Acetylene is stored in a cylinder in a compressed form. It is dissolved in acetone that is held in a porous material inside the cylinder.

4.1.2 Precautions for Installing and Transporting High-pressure Gas Cylinders

1) When decreasing the pressure through the decompression valve for experiments, operations with gas pressures greater than or equal to 1 MPa (0.2 MPa for acetylene and liquefied gas) require permission from the Committee for High-pressure Gas Handling of the relevant authority.

2) Before transporting high-pressure gas cylinders, remove the regulator, close the valve, cover it with a protective cap, and use a cart that is specifically intended for the purpose. Do not hold the valve protection cap when lifting a cylinder.

3) When a cylinder cart cannot be used, tilt the cylinder slightly and move it by rolling it on the edge of the bottom of the cylinder. In this case, particular care must be taken not to drop the cylinder, especially on a slippery floor.

4) High-pressure gas cylinders must be secured in an upright position by attaching them to a cylinder stand, laboratory bench, pillar or wall using a strap or chain to prevent them falling. Two positions of cylinders should be attached.

5) In general, high-pressure gas cylinders should not be lying down when they are being used. If a high-pressure cylinder is lying on its side at any time, it should have a chock underneath it to stop it from moving. (Do not lay liquid gas or acetylene gas cylinders on their sides at any time.)

6) The use of fire or ignition sources is strictly prohibited within 2 m of flammable gas cylinders, unless special measures are taken. Do not keep combustible or flammable substances near cylinders.

7) High-pressure gas cylinders must be handled with extreme care; avoid shock, extreme temperature, direct sunlight, fire, and electricity.

8) Do not keep cylinders in the rain for a long period, or in a dusty environment. Store cylinders at below 40°C .

9) Do not keep cylinders in a corrosive environment.

10) Do not keep cylinders in hallways or emergency stairways.

- 11) When hoisting cylinders, do not use chains, but instead use designated equipment that safely lifts the cylinder.
- 12) Empty cylinders should be returned immediately to the supplier for reuse. Do not dispose of a cylinder, even if it is small.

4.1.3 Precautions for Using High-pressure Gases

- 1) The misuse or accidental mixing of high-pressure gases may cause a serious accident. Know the name of the high-pressure gas and its characteristics before using it.
- 2) High-pressure gas cylinders must be handled with consideration of the hazards caused by their possible toxic, flammable or explosive properties.
- 3) Select the appropriate regulator (such as decompression valve and pressure gauge), pipe and hose in accordance with their purpose of use. Before using these fittings, read the instructions carefully, consult experts if you have questions, and be sure that you fully understand the mechanics involved. In particular, an inappropriate choice of fittings for oxygen gas may cause an explosion.
- 4) Always keep the contact points of the cylinder's connectors and regulator clean. Use a new gasket of suitable diameter and material.
- 5) When mounting the regulator, use only the wrench provided to tighten the hexagonal cap nut. The regulator must be attached tightly to the cylinder, but be careful not to overtighten, which could damage the gasket or the nut.
- 6) It is extremely important to prevent gas leaks. Leaks can be detected by applying soapy water to the joint when it is under pressure. A gas leak will cause bubbles to form. If a leak is found, decompress the cylinder and then re-tighten the connector. Cylinders must be used in a well-ventilated area in order to reduce the potential hazard caused by gas leaks.
- 7) The main valve of high-pressure gas cylinders must be opened or closed slowly. They must be kept closed when not in use. When opening the main valve, make sure there is no one in the direction of the gas outlet. Before opening, close the outlet valve and make sure the decompression valve is not under pressure. If a cylinder is connected to a pipe and the closed-valve is opened too quickly, the gas is heated due to adiabatic compression and the gas flow increases; thus resulting in friction and static electricity, which may cause the gas to ignite. In particular, acetylene gas must be handled with caution.
- 8) During use, the valve must be sufficiently opened. However, for acetylene, the valve must not be turned more than 1.5 rotations.
- 9) Do not release gas unnecessarily. In order to reduce the risk of fire and toxic hazards, gases must be detoxified before being exhausted.
- 10) Close all valves after use. Remove the regulator and place the valve protection cap on the cylinder.

- 11) High-pressure gases must not be transferred from one cylinder to another because of the high risks involved.
- 12) In general, the pipe from the cylinder must be made of metal. However, do not use copper or a copper alloy for acetylene gas.
- 13) When using a rubber hose, connect it securely with a hose clamp. If the hose becomes disconnected during use, close the valve and reconnect the hose tightly. Be careful to prevent the gas coming into direct contact with clothing.
- 14) High-purity gas must be used after sufficient purging of the regulator and any connected pipe.
- 15) When warming the regulator, valves and pipe, use a heated wet cloth or warm water below 40°C.
- 16) Examine the equipment before and after each use. Request a specialist to carry out repairs or replace the part if any fault is found.

4.2 Cooling Media (Such as Liquid Nitrogen)

The following are precautions for using liquid air, nitrogen, oxygen or helium as a cooling medium.

4.2.1 General Safety Precautions

- 1) Be careful to avoid damage due to cold.
- 2) Cooling media such as liquid nitrogen and liquid helium may cause an oxygen deficiency when used in a tightly sealed room. Be sure there is adequate ventilation. Condensed vapors are asphyxiants, and must not be inhaled. See <http://safetymanual.t.u-tokyo.ac.jp/safetymanual/furoku/appen8.htm> for more information on oxygen deficiency.
- 3) Liquid nitrogen evaporates rapidly at room temperature and undergoes a 700-fold increase in volume as it does so. Do not seal the container tightly.
- 4) Using liquid oxygen in a tightly sealed room may cause pulmonary hyperemia due to an abnormally high oxygen level. Special cautions must be taken to ensure adequate ventilation.
- 5) When using liquid air or liquid oxygen, keep it away from flammable substances (such as organic compounds and metal powder) to prevent ignition or explosion.
- 6) Oxygen in liquid air becomes concentrated during use or storage due to the loss of nitrogen by evaporation. Take the same precautions as those for liquid oxygen.
- 7) When using liquid nitrogen for long periods in an open container, the nitrogen evaporates continuously while the oxygen in the air dissolves into the liquid nitrogen and becomes concentrated. Ensure that liquid nitrogen does not come into contact with flammable substances.
- 8) Fire hazards from exposure to liquid oxygen:
 - a) Metals such as iron, aluminum and magnesium powders can explode.
 - b) Organic compounds can cause large explosions. In particular, the following substances must be

handled with care: organic solvents (alcohol, acetone, ether, and petroleum compounds), plastics (bakelite, polyvinyl chloride, acrylic, epoxy compounds and others) and other materials (wood, charcoal, sulfur, pulp, cotton, starch, and others).

4.2.2 Precautions for Handling

- 1) When transferring the cooling medium into a container, be careful not to damage the container by rapid cooling. First, pour a small amount of the medium into the container, and then slowly swirl the medium in the container to cool it down thoroughly. Continue to pour in additional medium slowly and gradually.
- 2) Wear a protective mask and leather gloves for protection in the event that the container breaks. Do not use cotton gloves as it may cause cold damage.
- 3) Use protective equipment (such as a blast shield) around the container for protection in the event of an explosion due to rapid expansion.
- 4) The container must be transported carefully to prevent it being dropped.

* For examples of possible laboratory accidents, see the database of accidents at: <http://safetymanual.t.u-tokyo.ac.jp/accident/index-accident.htm>.

4.3 Gases with Special Components

Gases with special components are specifically used in the manufacture and research of semiconductors. Most of them are toxic or able to ignite spontaneously and may cause explosive decomposition; thus it is possible for a minor accident to lead to a disaster.

Since the High-pressure Gas Safety Law was revised in December 1991, which was aimed to prevent accidents, seven kinds of gases (silane, disilane, arsine, phosphine, diborane, hydrogen selenide, and germane) have been regulated under this law as “specified high-pressure gases,” regardless of their quantities. In addition, the Tokyo metropolitan government has issued the “Guideline for the Use of Gases with Special Components” and listed 39 such gases (Table 9); these include seven specified high-pressure gases and an additional 32 gases that are similarly hazardous.

- 1) All personnel must complete a safety training program before using gases with special components for the first time.
- 2) When using gases with special components in non-compressed, non-gaseous forms (liquid or solid at room temperature and normal pressure) as reagents for chemical synthesis, the following precautions must be taken:
 - a) Use glassware or glass ampoules as containers.

- b) The total storage amount must not be more than approximately 1 kg within a single laboratory, and must be stored in a safe place such as in a draft chamber (laboratory fume hood) in order to minimize problems in the event of container breakage.
 - c) No single experiment should use more than approximately 100 g.
 - d) Chemical reactions must be carried out in a draft chamber (laboratory fume hood) using a glass flask at around room temperature and normal pressure.
 - e) Toxic gas generated by the reaction must be dissolved in alkaline solutions for detoxification.
- 3) Flammability and explosiveness
- a) The gases with special components are mostly hydrogenated or halogenated heavy elements that belong to groups IIIb, IVb, Vb, and VIb in the periodic table. The hydrides are all flammable. See Appendix 4-4: "Information on the flammability and explosiveness of major gases with special components." These gases generate large quantities of solids when burnt.
 - b) Because gases with special components continue burning at lower temperatures than ordinary hydrocarbon gases, their explosive ranges are significantly broader. As such, gases with special components pose a higher risk.
 - c) Silane, disilane, phosphine, trialkylgallium, and trialkylindium have extremely low ignition points and ignite spontaneously in air at room temperature.
 - d) Dichlorosilane, diborane, germane, and trichlorosilane must also be handled with care because they have ignition points higher than room temperature but much lower than those of other compounds.
 - e) Germane gas, tin hydride, stibine, and hydrogen telluride spontaneously explode by self-decomposition without an oxidizing agent (explosive decomposition). Of these, germane is extremely hazardous, because it has a low pressure limit of 0.16 atm for explosive decomposition.
 - f) Silane must be handled with extreme care because of its unique property; its explosion concentration is lowered when it is mixed with inert gases such as nitrogen and argon. Consequently, general-use fire extinguishers such as halon increase a fire started from a silane explosion, and therefore must not be used in such instances. Further, a nitrogen extinguisher is also ineffective for a fire fed by silane because silane requires only a low level of oxygen for combustion. The only way to put out a silane fire is to actually remove the silane.
- 4) Toxicity
- All gases with special components are toxic. The major toxic hazards of these gases are listed below.
- a) The TLV of silane is 5 ppm. Inhalation of silane severely irritates respiratory mucous membranes leading to pain in the upper respiratory tract and coughing. In the event of accidental inhalation, immediately move to an area with fresh air and seek medical attention. Twenty-four hour monitoring is required as pulmonary edema may develop following silane inhalation.
 - b) The TLV of arsine is 0.05 ppm (short-term exposure limit: 0.5 ppm). Arsine has a unique garlic

odor and causes hemolysis if inhaled. Arsine causes immediate death at 250 ppm, death within 90 minutes at 25–50 ppm and poisoning occurs after several hours at 3–10 ppm. In the event of accidental inhalation, move to an area with fresh air, keep warm, and remain at rest. The patient should be given oxygen. Seek immediate medical assistance. If respiratory failure occurs, cardiopulmonary resuscitation (CPR) must be performed on the patient.

- c) The TLV of phosphine is 0.3 ppm (short-term exposure limit: 1 ppm). Phosphine has a rotten fish odor. Acute toxicity starts with headache and vomiting, followed by breathing difficulty, coma and death. In the event of inhalation, the patient should be given oxygen and kept warm.
- d) The TLV of diborane is 0.1 ppm. Diborane has a sweet odor that causes nausea. It irritates the mucous membranes, and symptoms such as choking, chest pain and vomiting appear within a certain time. In the event of inhalation, immediately move to an area with fresh air and seek medical attention.

The TLVs of all gases with special components are listed in Appendix 4-5: “Hazards due to Gases with Special Components”.