Purpose

Para. 1 This manual is intended to specify those matters that are required for the handling of special gas materials and to prevent accidents in the Tokyo Institute of Technology (‘the Institute’).

Definitions

Para. 2
2.1 In this manual ‘special gas materials’ refers to high pressure gases whose handling requires particular care in order to prevent accidents; such high pressure and liquefied gases are listed in the Appendix. The definition of high pressure gas is those gases specified in Article 2 of the High Pressure Gas Safety Law.

2.2 In this manual ‘special high pressure gases’ refers to those special gas materials which are high pressure gases and whose handling in particular requires particular care in order to prevent accidents. This refers to compressed or liquefied silane, phosphine, arsine, diborane, hydrogen selenide, monogermanium and disilane specified in Article 7 of the Enforcement Ordinance (‘the Ordinance’) to the High Pressure Gas Safety Law.

Scope

Para. 3 This manual covers all matters relating to the handling of special gas materials in the Institute.

Chief maintenance engineers for the usage of special high-pressure gas

Para. 4
4.1 Each laboratory handling special gas materials (‘laboratory’) will appoint a chief maintenance engineer for the usage of special high-pressure gas for the handling of special gas materials (the ‘chief maintenance engineer for the usage of special high-pressure gas ’), who will manage activities related to the safe use of special gas materials.

4.2 The chief maintenance engineer for the usage of special high-pressure gas will be appointed from among the professors, associate professors and lecturers who use the particular laboratory, and will report to the President. The same will apply when a new chief maintenance engineer for the usage of special high-pressure gas is appointed.

4.3 The President upon receiving a report envisaged by the previous item will promptly report to the Prefectural Governor. However, this will only apply if the laboratory handles special gas materials.
4.4 In order to raise safety levels in the laboratory, the chief maintenance engineer for the usage of special high-pressure gas will be thoroughly familiar with the High Pressure Gas Safety Law and related legislation and prefectural guidelines on the handling of special gas materials etc, and will always make every effort to collect the latest information on the properties and handling of special gas materials and other high pressure gases.

Users

Para. 5 Persons able to handle special gas materials (‘users’) will have undergone the education and training in accident prevention run by the General Safety Management Center (‘the Center’) or will on application be recognized as users by the Center.

Requests and reporting procedures for new gas using equipment, or its modification or disposal

Para. 6

6.1 Any person intending to install new equipment to handle special gas materials should submit an application to the President through the Dean&Directors of the relevant Department, attaching documents describing the location of the facilities that will use the gases, their structure and equipment and how the gases are to be used. When the President receives the application, he/she will, with the agreement of the Center, notify the Prefectural Governor up to 20 days before use of the gas is to commence.

6.2 Any person intending to alter the location, structure or equipment of any equipment using special high pressure gases, or to alter the types of such gases or the ways in which they are used, should submit an application to the President through the Dean&Directors of the relevant Department. When the President receives the application, he/she will, with the agreement of the Center, notify the Prefectural Governor. However, this procedure is not required in the case of the minimal changes listed in Article 57 of the General High Pressure Gas Safety Regulations.

6.3 Any person intending to dispose of equipment for using special high pressure gases should report to the President through the Dean&Directors of the relevant Department. When the President receives the report, he/she will promptly notify the Prefectural Governor.

Obligation to comply

Para. 7 Users shall comply with the items in this manual and the relevant legislation, and instructions from chief maintenance engineer for the usage of special high-pressure gas intended to prevent accidents.

Chapter 2 Gas handling and using equipment

Requirements for laboratories

Para. 8 Laboratories handling special gas materials shall satisfy the following requirements:

1. Provide structures and/or facilities to prevent the accumulation of gas leaks
2. Place warning signs in readily visible locations near the exits to the laboratory and the building
3. Erect plans of the piping, showing the structures and numbers of storage devices held and the types and flows of gases, and state the manner in which the gas is used. Also post the name and emergency contact details for the chief maintenance engineer for the usage of special high-pressure gas and the procedures in case of emergency etc
4. Provide at least two exits that can be easily used for evacuation in case of emergency. Emergency passageways should maintain a width of at least 1.2 m and a height of at least 1.8 meters, and should allow evacuations in two directions.

5. Provide appropriate protective equipment to ensure safety in emergencies.

6. Provide emergency evacuation lighting or emergency evacuation signs for evacuations in emergencies.

7. Provide the necessary fire-fighting equipment in locations where equipment using flammable gases is located (container storage, supply rooms for supply equipment, cylinder cabinets for supply equipment, apparatus using the gases and abatement system). Fire-fighting equipment shall be water spraying facilities with hoses with spray nozzles attached, and water supply facilities such as fire hydrants etc. Fire-fighting equipment will be selected having sufficient regard to the reactions between the gases and the fire-extinguishing chemicals and the nature of the surroundings. When powder-type fire extinguishers are used, at least three portable extinguishers that comply with the provisions of the Fire Services Act and have performance equivalent to B-10 should be provided.

8. Provide at least one of the following communications devices to allow rapid contact if necessary in an emergency:
   a. Paging System
   b. Internal loudspeaker system
   c. Siren
   d. Portable loud hailer

9. Secure power supplies should be provided for the following in order to ensure safety:
   a. Abatement System
   b. Warning system for gas leak detector
   c. Emergency isolation equipment
   d. Fire extinguishers
   e. Emergency lighting
   f. Communications equipment
   g. Automatic control devices to ensure the safety of the equipment using the gas
   h. Device to automatically control equipment in cylinder cabinets
   i. Equipment needed to ensure the safety of the exhaust and other devices in cylinder cabinets

Requirements for equipment using gases

Para. 9 Equipment using special gas materials must meet the following requirements:

1. All filled containers of special gas materials must be housed within a cylinder cabinet.

2. The dual structure casings and tubing of cylinder cabinets, supply devices and CVD units and other equipment using the gases must be connected to safety exhaust and accident prevention facilities.

3. The purge lines attached to the gas using and supply equipment are to be connected to accident prevention facilities such as the abatement system for treated exhausts.

4. A gas leak detection and warning system must be provided to issue an alarm when a gas leak occurs, and an emergency isolation device for special gas materials must also be provided that can be operated from a safe location in emergencies.

5. The materials used for this equipment must possess chemical compositions and mechanical properties that render the equipment safe from the chemical and mechanical effects of the gases, having regard to the types, natures, temperatures and pressures etc of the gases.

6. High pressure gas equipment (storage equipment, pipes and low pressure equipment, and the pipes between such equipment) excluding containers must comply with pressure tests conducted at not less than 1.5 times normal pressure using water or any other safe liquid (or pressure tests using a gas such as air or nitrogen gas etc at not...
less than 1.25 times normal pressure if there is any problem with using a liquid) and airtightness tests at not less than normal pressures or equipment recognized by the Minister for Economy, Trade and Industry as equivalent (‘authorized equipment’).

Restrictions on locations of equipment

Para. 10 The positions of equipment for handling special gas materials must be separated by at least 8 m from any place where fire is used.

Cylinder cabinets

Para. 11 Cylinder cabinets must meet the following requirements.
1. The materials of which cylinder cabinets are formed must be non-flammable if the gases handled are inflammable or are susceptible to burning, and must be corrosion-resistant if the gases handled are corrosive.
2. Cylinder cabinets must be provided with windows to allow monitoring of the cabinet interiors.
3. Negative pressure must be maintained within cylinder cabinets, and equipment must be provided to enable checking the pressure differential remotely, such as from an observation room, or from the exterior.
4. Gas leak detection and warning systems suited to the nature of the special gas materials must be provided.
5. Fixing clamps must be provided in order to prevent containers holding gases overturning.
6. Emergency isolation devices that operate automatically in power failures etc and that can be operated from outside the cylinder cabinet in response to a signal from a gas leak detector and alarm system must be provided in the high pressure valves of gas containers and the pipes connected to them.
7. Gases that could cause accidents if mixed must be handled in separate cylinder cabinets.
8. Parts through which high pressure gas passes, such as pressure regulators, valves and pipes etc that are connected to gas containers inside cylinder cabinets shall have welded joints (or flange or screw joints of sufficient strength for safety if welded joints would be inappropriate), and equipment which has not been authorized must pass pressure testing with the equipment in which it is installed at at least 1.5 times normal pressure, and must pass airtightness tests at at least normal pressure.
9. Inert gas must be provided for purge lines. If there is any risk of accidents due to the mixing of the gases being handled, the supply of inert purge gas and the purge pipes must be separate.
10. Emergency isolation devices that are linked to devices to prevent reverse flows or reverse flow detectors must be provided in the pipes that link gas using equipment such as CVD apparatus and purge lines and pressure regulators that are connected to gas containers.
11. Measures must be taken to eliminate static electricity when flammable gases are stored.
12. The type of gas and direction of flow should be indicated on pipes.
13. Valves should indicate the open and shut directions, and whether they are open or shut.
14. The structures of pipe connections and equipment in cylinder cabinets should facilitate inspection.
15. Explosion-proof construction should be used if flammable gases are stored.
16. An alarm should be sounded if the exhaust equipment in a cylinder cabinet stops.

Pipes etc

Para. 12 The pipes of gas using equipment must meet the following requirements.
1. Pipes should be as simple as possible, and converging flows and bends should be avoided at joints and branches if at all possible.
2. The pipes from gas supply equipment and between the gas using equipment and abatement system should be made of non-inflammable material and should be airtight.
3. Necessary measures should be taken to prevent pressures from high pressure areas flowing directly into the pipes and apparatus in low pressure areas.
4. Pipes should be joined by welding. However, flange or screw couplings of sufficient strength to ensure safety can be substituted if welding would be inappropriate. The types and directions of flow of gases should be indicated on pipes.
5. Joints in pipes should have double structures and be provided with gas leak detector and alarm systems, unless the pipes carry permissible levels of not more than 1 ppm of toxic gases (excluding cylinder cabinets).
6. Purge line gases should be replaced with an inert gas such as nitrogen, or vacuums should be induced in the lines. Measures should be taken to prevent reverse flows where purge lines are connected from a single purge line to multiple devices.
7. If there is any risk of accidents due to the mixing of the gases being handled, the supply of inert purge gas and the purge pipes must be separate.
8. Toxic gas purge lines should open inside abatement systems, which should eliminate the toxicity before the gases are released. Flammable gases should be released in safe places after being diluted to not more than the minimum explosive level.
9. Electromagnetic valves connected to pipes should as far as possible be normally closed types.
10. Valves and cocks should provide proper means for operation by users.
11. Pressure regulators should be located as close as possible to vessel valves; suitable filters should be provided at pressure regulator intakes to prevent valve seat leaks due to foreign objects.
12. Pressure and flow gauges and other metering instruments should be located at suitable positions.
13. Devices to prevent reverse flows should be provided at locations where there is a risk of reverse flows, such as in the pipes between gas supply and using equipment and so on.
14. Steps should be taken to seal etc any valves that have important effects on safety and that are not in regular use.
15. Valves connected to pipes shall indicate the open and shut directions, and whether they are open or shut.

**Exhaust ducts**

Para. 13 The exhaust ducts from gas using equipment must meet the following requirements.

1. Ducts should be as simple as possible, wherever possible without bends or converging flows.
2. The materials used for ducts should be non-flammable if the gases conducted are flammable, and corrosion-resistant if they are corrosive.
3. The ducts from the special gas materials using equipment and abatement system should be airtight.
4. Fine differential pressure gages to quickly detect abnormal situations should be placed in the exhaust ducts from gas materials using equipment.
5. The structures of exhaust ducts for disilane, phosphene and monosilane should prevent and allow the quick removal of build-up of products in the ducts.
6. Separate exhaust duct systems from each gas using device and abatement system should be provided where there is a risk of accident due to the mixing of exhaust gases from different sets of special gas materials using equipment.

**CVD apparatus etc**
Para. 14 CVD apparatus etc must meet the following requirements.
1. Gas using equipment such as CVD apparatus etc should be enclosed in a cabinet or should have a hood through which gases are exhausted. However, this does not apply to the use of gases at low pressure in reaction apparatus such as low pressure CVD apparatus etc.
2. Gas leak detector and alarm systems appropriate to the nature of the gas used should be provided around gas using equipment such as CVD apparatus.
3. Gases exhausted from gas using equipment should be diluted with inert gases where necessary and should be released into the atmosphere after being rendered harmless in an abatement system. Pipes and ducts leading from multiple CVD devices should be airtight, and if there is any risk of accident from the mixing of the exhaust gases, individual pipe and duct systems should be provided from the CVD devices to the abatement system.
4. Measures should be provided to prevent air flowing back into the device in case of emergency such as power failure or failure of the exhaust equipment.

Abatement system

Para. 15 The abatement system must meet the following requirements.
1. The system should be capable of treating the special gas materials and solids generated by their use.
2. The abatement system should be able to treat the special gas materials so that they are at no higher than the permissible concentration at the outlet from the system.
3. In an emergency, the abatement system should be capable of treating the full contents of the largest special gas materials storage container as regards gas storage, while as regards gas usage, the system should be capable of treating the full contents of the largest special gas materials vessel or 2 minutes of flow from the largest diameter pipe in case of rupture, at normal temperatures and pressures.
4. It should be possible to check the operational status of the system from outside the system or from a remote location, and the system should automatically issue an alarm according to any abnormal condition arising during operation.
5. Non-inflammable or corrosion-resistant materials should be used for the system according to the nature of the gases treated, and the system should be airtight to prevent any escape of special gas materials except from the outlet.
6. The structure of the system should prevent the escape of any chemicals used in treatment.
7. The electrical system of the abatement system should be protected against explosion if flammable gases are generated or there is a risk of this.

Chapter 3 Handling

Storage

Para. 16 Special gas materials should be stored in the following way.
1. The minimum necessary volume of gas should be stored, and empty and half-full containers that are no longer required should be returned as promptly as possible to the supplier.
2. The openings of filled gas cylinders should be closed with safety caps.
3. Filled gas cylinders should be marked as and divided into highly inflammable, inflammable and toxic etc.
4. Filled gas cylinders should be stored inside cylinder cabinets.
5. Gases that could cause accidents if mixed together should be stored in separate cylinder cabinets.
6. Storage facilities should be provided with pressure gages and with safety devices to immediately return pressure to not more than the permissible pressure if pressure exceeds that level. If the safety device includes a safety valve or rupture disk, it should be provided with a discharge tube, with the outlet of the discharge tube being located in the abatement system.

7. Storage devices should be fixed to floors or walls to prevent them from overturning or sliding in earthquakes etc, and filled containers should be fixed at at least top and bottom with chains or belts etc.

Gas usage

Para. 17 Special gas materials should be used in the following ways.
1. Before purchasing gases, estimate the frequency of use and amounts used, and order the minimum amount necessary.
2. Handle filled gas containers with care, seal openings with caps and attach protective caps when moving them, and try to prevent them from overturning or suffering impact.
3. Take note of the remaining level of gas in containers, and never allow the residual pressure to fall to 0.1 MPa or less.
4. Handle gas containers properly and securely, and never apply excessive force to the valves etc attached to the pipes. To prevent misunderstandings about whether valves are open or shut, do not turn the valve full on.
5. If there is any risk of accident from special gas materials mixing with other types of gases, displace any gas inside the apparatus using the gas with inert gas or apply a vacuum, with the special gas container valve closed, after the special gas material container has been connected to the apparatus and before the container is removed.
6. After replacing a special gas material container, check that there are no gas leaks from the connection to the container.
7. Take measures to eliminate static electricity from equipment using inflammable gas.
8. Exhaust gases from the safety and treatment systems should always be exhausted through the abatement system for treatment.
9. The exhaust devices from cylinder cabinets should maintain suitable replacement frequencies having regard to the specific gravity of the gas in order to prevent gas leaks accumulating.
10. Facilities should be provided to fix gas using equipment in place, to prevent it from overturning or sliding in earthquakes etc.

Chapter 4 Maintenance and management of equipment

Checking for leaks

Para. 18 Daily airtightness tests using purge gas must be performed on equipment using special gas materials, by means of the pressure gauges on the pipes etc. Every effort should be made to find any leaks due to loose joints etc.

Daily inspections

Para. 19
19.1 Users should prepare checklists for their daily inspections of equipment using special gas materials, and base their inspections on the checklists. Daily inspections should include checks for any abnormalities at the beginning and end of use of the equipment, and checks of the operation of the equipment using the gas at least once a day, or more often according to the type of gas and equipment. If any abnormality is found, the equipment should be repaired or other action should be taken to make it safe.
19.2 The following inspection items are suggestions only; each laboratory should prepare its own list.
   1. Operation of fans in exhaust ducts
   2. Operation of exhaust devices for cylinder cabinets and check of pressure differentials
   3. Check visually or by gages attached to pipes or pressure reduction valves for leaks in gas containers, pipes and CVD apparatus
   4. Check for levels of purge and emergency isolation gas
   5. Condition of the abatement system
   6. Operation of gas leak detector and alarm systems
   7. Unusual noise or vibration when equipment is started up
   8. Any other necessary matters
19.3 Chief maintenance engineers for the usage of special high-pressure gas should retain these inspection records.

Regular inspections

Para. 20
20.1 Chief maintenance engineers for the usage of special high-pressure gas should prepare checklists for regular detailed inspections of all parts of equipment using special gas materials as distinct from the daily inspections. Such regular inspections should be conducted at least once a year, regardless of how often the equipment is used.
20.2 The following items should be inspected and the results should be recorded.
   1. Corrosion and/or damage to pipes and loose joints
   2. Suction in exhaust pipes and unusual noises and/or vibration in mechanical parts
   3. Corrosion, damage and/or loose joints in the abatement system, deposits in the exhaust duct and level and effectiveness of treatment chemicals
   4. Check of operation of gas leak detector and alarm system
   5. Check of operation of emergency isolation system
   6. Calibration of pressure gages by a licensed operator under Article 144-1 of the Measurement Law
   7. Check on maintenance of safety power supply
   8. Check for fire extinguishers
   9. Check for protective apparatus such as respirators etc
   10. Availability of means of communication in emergency
20.3 Chief maintenance engineers for the usage of special high-pressure gas should retain records of these inspection items.

Method of repair

Para. 21
21.1 When equipment that uses special gas materials is to be repaired, first study the scope of work and methods to be used, and take expert advice to place the equipment in a state in which will not endanger safety.
21.2 When carrying out the repairs, first draw up a plan of the work and appoint someone to be in charge of it, then implement the repairs according to the plan and under the supervision of the person in charge. Ensure that anything unusual is immediately reported to the person in charge.
21.3 Wherever possible, at least two people should be involved in repairs, with the person in charge monitoring safety and the condition of the equipment. The gas inside devices and pipes related to the repairs should be displaced by inert gas at the beginning, and valves should be closed to prevent gas leaks, and so forth to avert any danger.
21.4 If the gas using equipment is open or the work is to be performed inside it, avoid danger by preventing any gas leaks in the open part.
21.5 If repairs on the gas using equipment or abatement system allow for the gas to be absorbed or dissolved, repeatedly purge the system with inert gas etc and wear gloves and breathing apparatus, and other protective clothing, if necessary.

21.6 Once repairs are finished and the equipment is ready for use, check for leaks and that the equipment is functioning correctly.

21.7 The chief maintenance engineer for the usage of special high-pressure gas should record the details of the repairs and store them in an equipment file.

Cleaning

Para. 22

22.1 Laboratories which use special gas materials must be clean and tidy. In particular, evacuation routes must be clear of obstructions.

22.2 Any build-ups of products in exhaust ducts should be promptly removed as necessary.

Chapter 5 Education and training

Education and training

Para. 23

23.1 In order to prevent accidents in the handling of special gas materials, chief maintenance engineers for the usage of special high-pressure gas will organize regular education and training at least once a year conducted by chief maintenance engineers for the usage of special high-pressure gas or experts with experience in the handling of these gases. This will be in addition to the education and training conducted by the Center. Education and training will also be provided in the following circumstances:

1. When new equipment is installed or equipment is modified
2. When methods of use change
3. When the relevant legislation is amended
4. When any unusual conditions occur
5. When anyone has breached the relevant legislation or safety management standards

23.2 This training and education will cover the following items:

1. Physical and chemical properties and toxicity of, danger from and handling of the special gas materials
2. Functions, performance and use of laboratory equipment
3. Laboratory work procedures
4. Contents and methods of daily inspections
5. Contents and methods of regular inspections
6. Emergency measures and evacuation routes in case of accidents etc
7. Performance and use of protective equipment such as breathing apparatus for use in emergencies
8. This manual and relevant legislation
9. Other matters necessary to safety management and the prevention of accidents

23.3 Notwithstanding the provisions in Item 1, chief maintenance engineers for the usage of special high-pressure gas may omit all or part of education and training for persons recognized as having sufficient knowledge and skills in relation to the matters in Item 2.

23.4 When conducting the training specified in Item 1, chief maintenance engineers for the usage of special high-pressure gas will record and file the following points:

1. Date training held and areas covered
2. Names of persons receiving education and training

Chapter 6 Safety measures and responses in emergencies
Safety measures for equipment

Para. 24 Chief maintenance engineers for the usage of special high-pressure gas should conduct studies of emergency situations in which the power fails, there are accidents with the equipment or gas leaks occur etc to develop prompt and appropriate responses, and should prepare manuals on measures to deal with such emergency situations.

Responses to emergency situations

Para. 25 Chief maintenance engineers for the usage of special high-pressure gas should make users aware of the following in order to prevent accidents and maintain safety when emergencies occur:
1. Provision of means of rapid communication and systems of communication
2. Manuals and necessary measures to prevent physical harm
3. Appropriate first aid procedures according to the condition of the injured and the addresses and contact details for hospitals able to deal with accident victims
4. Other matters necessary for preventing accidents and ensuring safety

Chapter 7 Miscellaneous provisions

Revision of manual

Para. 26 The Center will revise this manual.

Handling of gases other than special gas materials

Para. 27 Gases other than those designated as special gas materials in the Appendix should be treated on the basis of this manual according to their flammability or toxicity or other dangerous or polluting properties, having regard to the dangers posed by these gases.

Other matters

Para. 28 Other matters regarding the safe handling of special gas materials that are not specified in this Manual are left to the discretion and instruction of chief maintenance engineers for the usage of special high-pressure gas.

Supplementary provision

This Manual shall come into force from April 1, 2004.

Supplementary provision (April 1 2007)

This Manual shall come into force from April 1, 2007.
### Appendix

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* indicates a special high pressure gas specified in Article 7 of the Enforcement Ordinance.