Code of Practice for the Storage and Use of Special Gases in the Micro-electronics Industry

Acknowledgement

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INTRODUCTION

The purpose of this Code is to provide guidance on the application for a dangerous goods licence for the storage and use of special gases in micro-electronics industry. It sets out those requirements on the siting, design and construction of stores like mechanical ventilation system, gas detection system, fire suppression system, electrical installation and related provisions as required by the licensing authority. Furthermore, it gives a comprehensive guidance on the establishment of a safe working system.

The Code has incorporated the knowledge and opinion of members of the trade in micro-electronics industry, local universities and other government departments concerned. The application of this Code requires good engineering practices. This Code is a supplement to current legislation. Compliance with this Code will not exempt the users from complying with other relevant local legislation.

The Code will be reviewed regularly. Suggestion for improvement is welcome.

Fire Services Department

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Contents

Section	Topics	Page
1	Interpretation of Terminology	5
2	Application Procedures for Dangerous Goods Licence	6
3	Restrictions on Siting	7
4	Information Required for the Application of a Dangerous Goods Licence	8
5	Conditions for the Grant of a Dangerous Goods Licence	10
6	Conditions Licence Renewal	11
7	External Storage	12
8	Internal Storage General Service Corridor Mechanical Ventilating System	14
9	Wafer Fabrication Area (Cleanroom)	18
10	Compatibility of Storage	20
11	Gas Detection System	21
12	Fire Suppression System	23

13	Dispensing and Use of Gas	24
	Gas Cabinet	
	Distribution System	
14	Control Room	27
15	Electrical Installation and Equipment	28
16	Gas Cylinder	29
	Cylinder Standard	
	Cylinder Handling	
17	Safe Working System	31
	General	
	Health and Safety Precautions	
	Emergency Procedures	
	Training	
	Periodic Review and Auditing	
18	Fire Services Requirements	35
19	Hazardous Properties of Gases	36
	Health Hazard	
	Toxicity	
	Occupational Exposure Limit (OEL)	
	Fire Hazard	
20	**Enquiry**	41
	Appendix	
	Risk Assessment Report	I
	Recommended Minimum Safety Separation Distances	II
	List of Special Gases	III

1. Interpretation of Terminology

For ease of reference, the definitions of certain terms / abbreviations used in this Code are as follows:-

1.1 **Authorised person** means an engineer approved by the Authority to test, examine and certify gas cylinders and pipelines.

1.2 **Authority** means the Director of Fire Services.

1.3 **Competent person** means a professional chemist or an occupational hygienist with relevant qualification and experience, namely under certification programmes of the American Board of Industrial Hygiene, the Canadian Registration Board of Occupational Hygienists, the British Institute of Occupational Hygienists, the Australian Institute of Occupational Hygienists, the Hong Kong Institute of Occupational and Environmental Hygiene or other persons with equivalent qualification.

1.4 **FSD** means the Fire Services Department.

1.5 **Low rise building** means any building of which the floor of the uppermost storey does not exceed 30m above the point of staircase discharge at ground floor level.

1.6 **MSDS** means Material Safety Data Sheet.

2. Application Procedures for Dangerous Goods Licence

2.1 Applications for the storage and use of special gases used in micro-electronics industry should be forwarded to Dangerous Goods Division of the Hong Kong Fire Services Department, 3/F., 86 Hing Shing Road, Kwai Chung, New Territories.

2.2 On receipt of the application, FSD will refer the application to related government departments such as the Boilers and Pressure Vessels Authority of Labour Department, Environmental Protection Department and Government Laboratory for comments on the safety of compressed gases and pressurised systems, environmental protection and chemical compatibility. In formulating specific fire services requirement, Fire Services Department will consider the comment offered by the above Authority and Departments.

3. Restrictions on Siting

3.1 Only low-rise institutional or industrial buildings under single occupancy, from which evacuation can easily be effected, are considered suitable for the storage and use of these gases.

3.2 Locations for storage or inspection of gas cylinders shall be on street level and accessible by cart, trolley or other transport vehicle for easy conveyance or urgent removal in case of emergency. The storage area and fabrication area should also be accessible by major fire appliances for fire-fighting purpose.

3.3 Sites for storage and use should be provided with adequate means of escape leading to place of safety, which should be kept free from any obstruction at all times.

3.4 All locations for indoor and open storage shall be carefully selected so that the risks posed to nearby occupancies could be kept to minimal.

3.5 Applicant is advised to seek advice from the Planning Department and the Lands Department on the land use matter if applicable.

4. Information Required for the Application of a Dangerous Goods Licence

4.1 Pursuant to Regulation 62 of Dangerous Goods (General) Regulations, Cap 295B, any application for a licence to store special gases used in the micro-electronics industry shall be accompanied by 2 copies of plans as nearly as may be to scale of the store and every such plan shall include the following particulars:-

(a) the siting of the store;

(b) the material of which it is or is to be constructed;

(c) the means of ventilation and / or the ventilation plan if mechanical ventilation is provided or required in the store;

(d) the routing of and method of fixing any pipeline which is to be installed for the purpose of distributing gas from the store to any part of the premises which the store serves or is intended to serve, and the material of which it is to be constructed; and

(e) such other particulars like waste treatment system and drainage system, if any, as the Authority may require to be shown on the plan.

4.2 Every plan shall also be accompanied by the following documents:-

(a) a statement in writing declaring the nature of the gas or gases to be stored and the maximum quantities of storage thereof in respect of which the licence is required;

(b) a risk assessment report (The scope of Risk Assessment Report is at Appendix I);

(c) the specifications of electrical installation including the lighting fixture and gas detection system provided in the store;

(d) design and specifications to which it is intended that any distribution pipeline or other ancillary equipment is to be constructed;

(e) design and specifications of gas detection system, gas cabinet, and any other safety installations or hazard control measures; and

(f) a health and safety plan including emergency procedures.

4.3 Additional copies of plans, design and specifications of the distribution pipeline or other equipment may be required for comments by other government departments.

5. Conditions for the Grant of a Dangerous Goods Licence

5.1 No licence shall be granted by the FSD for the storage and use of special gases used in the micro-electronics industry unless the Authority is satisfied in relation to the store that:-

(a) the site of the store and the plan(s) referred to in Section 3 and Section 4 of this Code have been approved by the Authority and the construction of the store conforms with the plan;

(b) Fire Services Requirements issued are being complied with. The licence holder is obliged to ensure the continuous compliance with the Fire Services Requirements at all times; and

(c) other requirements in this Code are complied with.

5.2 The applicant shall also comply with regulations or requirements as prescribed by other government departments for the purpose of issuing a licence.

5.3 A licence shall only be granted by the Authority upon satisfactory compliance with the licensing requirements and the payment of fee, if any, as specified in the Dangerous Goods (General) Regulations.

5.4 The Authority reserves the right to amend licensing conditions to suit the situation as and when required.

6. Conditions of Licence Renewal

6.1 Licence will be subject to renewal upon expiry of the license (normally on annual basis).

6.2 On-site inspection will be carried out by an officer of the FSD before the expiry date of the licence. The layout of store will be checked to ensure the conformity with the latest accepted plans.

6.3 Continuous compliance with the issued Fire Services Requirements and this Code shall be a condition for licence renewal.

6.4 Renewal of licence shall only be granted by the Fire Services Department subject to a satisfactory result of the renewal inspection and payment of fee, if any, as specified in the Dangerous Goods (General) Regulations.

7. External Storage

7.1 If the special gases are to be stored in an external storage, the store shall be located in an open area of the premises or in a detached single-storey building on open ground. The design and construction for the detached single-storey building shall follow the requirements of an internal storage stipulated in section 8 of this code.

7.2 The siting for an external storage shall be so selected that maximum natural ventilation can be achieved to prevent accumulation of any leaked gas in an enclosed volume. The selected site shall be sufficiently open (at least open on two sides), so as to provide a high degree of natural ventilation. Vents in the roof shall be provided to avoid the accumulation of gas lighter than air in the roof-space. Sufficient headroom in the store structure is necessary to provide good cross ventilation.

7.3 Materials used for the construction of the external storage shall be non-combustible. External storage area for gas cylinders shall be provided with a non-combustible roof to keep the cylinders out from weather. A light-weight friable roof shall be provided to a flammable gas storage area. Wire-mesh fence shall be provided for security reason. Suitable crash barriers shall be provided to protect the store from mechanical damage by moving vehicles, forklifts etc.

7.4 Means shall be provided to secure the gas cylinders in an up-right position.

7.5 The storage area is to be kept away from source of ignition, building alley, building opening or ventilation intake. Various exposures shall be kept at a minimum separation distance from the storage area in accordance with the figures in Appendix II.

7.6 Gases shall be segregated in groups according to their hazardous characteristics. Gases incompatible to each other shall not be stored in the same store.

7.7 Nominally empty containers shall be segregated from full containers. They shall be clearly marked and stored in the same way as full container as the hazards remain. They should be returned to the gas supplier as soon as practicable.

7.8 An approved water spray system shall be provided.

7.9 An approved gas detection system shall be provided.

7.10 Proper drainage provision shall be provided in the storage area.

8. Internal Storage

8.1 General

8.1.1 If the special gases are to be stored in an internal storage, the store shall be located at street level. A minimum separation distance of 6 meters in all directions from any source of ignition, ventilation intake, building opening or building exit shall be provided.

8.1.2 The store shall be constructed of non-combustible materials from floor to ceiling having fire resisting period as required by the Buildings Department for special hazards. Good ventilation for such location of special hazard, either by mechanical ventilation or natural ventilation with opening facing at least two different directions should be adopted.

8.1.3 Mechanical ventilating system with cross flow effect shall be provided in the gas cylinder store and dispensing room. Extraction points shall be provided at suitable locations for the avoidance of accumulating and short-circuiting of the gases with make-up air.

8.1.4 An approved automatic sprinkler system shall be provided.

8.1.5 An approved gas detection system shall be provided to detect the presence of a hazardous condition.

8.2 Service Corridor

8.2.1 Service corridor shall be designed for the conveyance of hazardous materials on cart or trolley to and from the storage area. Means of escape shall not be used for the transportation of hazardous materials**.**

8.2.2 In existing building where service corridor is not provided, a designated route inside the premises shall be used for the conveyance of gas cylinders. Other persons should not use the route during the time of conveyance. If such designated route is not possible, additional protection of the gas cylinders by specially designed cylinder container should be used.

8.2.3 Gas detection system together with manually activated alarm buttons shall be strategically spaced in the service corridor. On activation, it shall produce a distinctive local audio and visual alarm. The signal shall also be transmitted to the designated control room in the premises.

8.2.4 The conveyance of cylinders in designated route shall be carried out by trained personnel and be supervised by a competent person.

8.2.5 An approved sprinkler system shall be provided in the corridor.

8.3 Mechanical Ventilating System

8.3.1 Forced ventilating system with a minimum air change rate of 10 air changes per hour shall be provided to the gas cylinder storage and dispensing room unless the gas cylinders are stored in gas cabinets.

8.3.2 The system shall have an emergency source of power. The mechanical ventilating systems of gas cylinder stores, dispensing rooms, air extraction systems of gas cabinets shall be working continuously at all times.

8.3.3 Local air extraction systems for equipment involving hazardous gases shall be kept working continuously during the operation process.

8.3.4 The duty ventilation fans and standby units shall be operated independently. If a duty fan fails to work, the standby fan shall start to operate automatically to maintain the minimum air change rate. An independent distinctive audio and visual alarm shall be actuated and the fan failure signal shall be transmitted to the designated control room in the premises to alert the management to effect immediate repair action.

8.3.5 No portions of the building structure such as service ducts shall be used as an integral part of the air transfer or air exhaust systems. Exhaust duct penetrating compartment wall or fire resistance construction shall be enclosed with the building materials equivalent to the fire resisting rating of the building structure in order to maintain a proper compartmentation.

8.3.6 All ductworks including air intake, exhaust air duct, distribution and return air systems shall be constructed of 'non-combustible' materials in compliance with BS476 Part 4 or another standard acceptable to the Authority. Unless there is justifiable reason, this requirement should be generally applied in line with the Building (Ventilating Systems) Regulations. Where the exhaust gas is flammable, fan component shall be constructed with both static and spark minimizing features. Fire dampers shall not be installed at exhaust air system. If the fan blade is driven by motor at a position outside air stream, special design shall be incorporated to avoid spilling out of exhaust air through the driving mechanism.

8.3.7 Exhaust air ducts from different gas cabinets or compartments shall not be connected together if mixing of the gases will create a fire or chemical reaction hazard. System pressure balance across the branches of ventilating system shall be so adjusted to ensure that exhaust air will not flow in reverse direction from one compartment or cabinet to another. Due consideration shall be given to the instant pressure change when cabinet door is open.

8.3.8 Fail-safe airflow detection device shall be installed at each ventilating system. Apart from the audio and visual alarm, total failure of the ventilating system shall automatically suspend the operation process inside the affected compartment and cabinet through an interlocking device. Automatic reset of alarm system and restart of operation process before resumption of ventilation are not permitted.

8.3.9 An automatic shut-off device in the gas supply system shall be actuated upon failure of the exhaust system.

8.3.10 Exhaust air discharged from cylinder stores, local air extraction system, inspection areas, purging equipment, gas cabinets or overpressure relief devices shall not be re-circulated.

8.3.11 The exhaust air shall be properly treated by appropriate equipment before discharged to the atmosphere. The discharge shall be at a suitable location to meet the EPD Requirement in respect of air pollution control.

9. Wafer Fabrication Area (Cleanroom)

9.1 Wafer Fabrication Area shall be constructed of non-combustible material from floor to ceiling of not less than 2-hour fire resisting period.

9.2 The ventilating system of wafer fabrication area shall be an independent system from other ventilating systems in the building. The air intakes shall be so selected as to avoid the draw-in of hazardous materials. The air ducts, connectors and fan equipment shall be constructed of non-combustible materials in compliance with BS476 Part 4 or another standard acceptable to the Authority. If a ventilation air duct passes through a compartment with fire resisting construction, it shall be wholly protected by an enclosure having equivalent fire resisting period.

9.3 An approved automatic sprinkler system and fire alarm system shall be installed in the cleanroom. Quick response sprinkler heads should be used within the down-flow air streams in cleanrooms.

9.4 The activation of fire detection and manual fire alarm systems shall raise a distinctive audio and visual alarm in the premises. The signal shall be transmitted to the designated control room in the premises and FSD.

9.5 Fire detection and gas detection systems shall not be designed to interfere with the shut down of local air exhaust system involving hazardous gases.

9.6 The actuation of the gas detection system shall automatically shut off the gas supply in the system.

9.7 A smoke detection system shall be provided in the fabrication area. The sensitivity of smoke detection system shall be at a minimum of 0.01% per metre obscuration. It shall be capable of monitoring particles to 10 microns or less.

9.8 Local air extraction system shall be provided to the workplace or cleanroom. The air extraction system shall be so designed to extract effectively any hazardous gas or vapor within the station enclosure. Exhaust air shall not be re-circulated into the workplace or cleanroom.

10. Compatibility of Storage

Different category of dangerous goods or class when referred to the IMDG Code shall not be placed in the same store. Gases incompatible to each other shall not be stored in the same storage area unless they are in separate gas cabinets. Notwithstanding, gases incompatible to each other shall not be stored in the same cabinet. In this regard, the advice of Government Chemist will be sought.

11. Gas Detection System

11.1 Areas for storage and use of special gases shall be provided with a gas detection system which should be acceptable to the Authority. It shall give a distinctive audio and visual alarm both inside and outside the affected areas when leakage of gas is detected. Sufficient gas detectors shall be positioned at strategic locations for effective detection.

11.2 A two-tiered alarm system may be adopted in the gas detection system. Level one shall be set at an air-borne concentration at or below the Occupational Exposure Limit-Time Weighted Average (OEL-TWA) of a hazardous gas or vapor (Examples of various operational exposure limits are discussed at section 19 of this code). The level should be as low as practicable for early warning. Actuation of the alarm shall give a distinctive audio and visual signal for immediate inspection and remedial action. Level two may be set at a higher concentration but under all circumstances it shall be well below the Short Term Exposure Limit (OEL-STEL), Ceiling value (OEL-C), or Immediately Dangerous to Life or Health (IDLH) value of a hazardous gas or vapor. Single-tiered alarm and level two alarm of a two-tiered system shall initiate evacuation and emergency procedures, and the gas supply shall be shut off automatically. There are circumstances that OEL or IDLH value for a gas is not available. In that case, advice from a competent person should be sought.

11.3 A flammable gas detection system shall give distinctive audio and visual alarm when a flammable gas is detected. It shall be set at a level well below the Lower Flammability Limit (LFL) of the flammable gases (for example 20-25% of LFL), and as low as practicable to allow a wide safety margin and early warning. For gases with both toxic and flammable nature, the lower of the two warning levels shall be adopted as the alarm levels.

11.4 Exhaust air enclosures in which flammable or toxic gases may evolve or any equipment with purposely built-in component for storing gases shall be provided with an approved gas detection system therein for continuous monitoring.

11.5 In an emergency situation, the gas detection system shall automatically shut off the gas supply and initiate a distinctive local audio and visual alarm inside and outside the affected rooms**.** It shall also transmit the signal to the designated control room in the premises for initiating the pre-determined emergency procedure and to the FSD.

12. Fire Suppression System

12.1 An approved sprinkler system shall be provided for all workplaces such as dispensing room, fabrication area and indoor storage of flammable gases, etc. A gaseous suppression system is not acceptable as substitute for a sprinkler system for areas under continuous ventilation.

12.2 An approved water spray system shall be provided to protect the open storage. The water spray system shall be actuated by a suitable fire detector such as an ultraviolet or infrared detector and also be provided with means for manual operation.

12.3 Gas cabinet containing pyrophoric/flammable gas shall be internally provided with a sprinkler system.

13. Dispensing and Use of Gas

13.1 Gas Cabinet

13.1.1 A gas cabinet is a purpose-built enclosure for the containment of gas cylinders to supply gas to the production equipment. It shall be constructed of non-combustible material and of robust design. It shall be provided with a view panel made of transparent wired glass for unobstructed viewing of its content and access to the cylinder valve groups. The doors shall be closely fitted and self-closing with a self-latching device. The specifications of cabinets shall be submitted to the FSD for examination and approval before put into use.

13.1.2 Exhaust air ducts from different gas cabinets shall not be connected together if the mixing of gases will create a fire or chemical reaction hazard. System pressure balance across the branches of ventilating system shall be so adjusted to ensure that the exhaust air will not flow in reverse direction from one cabinet to another. Due consideration shall be taken on the instant pressure change when cabinet door is open.

13.1.3 The cabinet shall be treated or coated to prevent chemical reaction with the stored gases.

13.1.4 Incompatible hazardous gases shall not be stored in the same cabinet. The gas supply system shall be located as close to the fabrication area as possible to minimize the length of supply pipeline.

13.1.5 An independent forced air extraction system capable of maintaining an adequate negative pressure inside a gas cabinet shall be provided. Minimum velocity of 1m/sec across the face of the view panel opening shall be provided. Cabinets may share the same extraction ducting system provided it will not create a reaction hazard in the ductwork.

13.1.6 An automatic inert gas pipeline purging system with manual backup shall be provided to the gas cabinet. Purging system shall be constructed of material compatible with the gas it serves. It shall be designed to prevent the cross contamination of purge gas. An isolation valve should be provided in the purge line in order to facilitate the maintenance of purging system.

13.1.7 Type of gas, purge gas and the process tool it serves shall be labelled prominently on the gas cabinet.

13.1.8 Names in Chinese and English, chemical formula and warning information of a gas serving a tool or workstation should be displayed at a prominent position thereon.

13.1.9 Within the cabinet there shall be facilities to secure the gas cylinder.

13.1.10 A gas detection system appropriate to the stored gas shall be provided inside a gas cabinet.

13.2 Distribution System

13.2.1 Materials for the pipeline, fitting, and ancillary equipment for distribution of substances including liquids and gases shall be compatible with the substances and be constructed to the standards acceptable to the Authority. The detailed schematic diagram shall be submitted for examination with the licence application package.

13.2.2 Gas cylinders, except with the approval of the Authority, should not be stored inside cleanroom. The supply pipeline shall not run in the means of escape. The pipeline shall be suitably secured and protected from mechanical damage.

13.2.3 Manual shut-off device shall be provided in the pipeline at an easily accessible location near a tool or workstation using toxic, flammable or corrosive gas and such device shall also be provided in a similar manner near its supply cylinder.

13.2.4 Over-pressure relief device shall be provided to the supply pipeline. Such device shall vent to an approved location or to a proper treatment system. The relieved gas shall be discharged to open air only when it will not jeopardize the safety of neighbouring life and property.

13.2.5 An automatic shut-off device to be actuated by a suitable detection system in the event of leakage shall be provided. The shut-off device shall be located as near as possible to the supply cylinder.

13.2.6 A by-pass valve, which is provided across the automatic shut-off device, shall be normally closed except in the course of purging.

13.2.7 A clearly labelled pipeline diagram showing the piping connection and gas route from a supply cylinder to a tool or workstation shall be provided in a conspicuous position near the gas supply point.

13.2.8 Stress from subsidence or heat may damage the pipeline and cause subsequent gas leakage. Risk level of subsidence in the site and pipeline expansion shall be assessed and suitable means to offset such stress shall be provided.

13.2.9 Gas leakage in the supply pipeline system shall actuate a distinctive audio and visual alarm and automatically shut off the gas supply.

13.2.10 Gas supply systems shall be designed, installed, tested, inspected, commissioned and maintained by an authorized person.

14. Control Room

A round-the-clock attended emergency control room shall be provided at a location on the premises for overall surveillance of the condition of storage area, cleanroom and service corridor. Emergency alarm, gas leakage, smoke and fire signals shall be relayed to this control room. Closed circuit television (CCTV) equipment and telephone communication system for the wafer fabrication area shall be provided.

15. Electrical Installation and Equipment

15.1 Uninterruptible power supply (UPS) capable of sustaining full load operation for not less than 6 hours shall be provided for the mechanical ventilating system, gas detection, fire suppression system, fire alarm system and waste treatment system. To ensure continuous running of the systems, a UPS can be a combination of static type inverter and diesel generator for reinforcing the power supply reliability.

15.2 In the fabrication area, electrical equipment within 1.5 metres of workstation or tool where flammable gas is used, and other electrical equipment, e.g. sensor, fan component and motor installed at air stream serving cylinder stores, workplaces, dispensing rooms, air grill and extraction points shall be selected and installed in accordance with the Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmosphere (BS EN 60079) or another standard acceptable to the Authority. Other than the explosive hazard mentioned above, all the equipment should be proved to be of appropriate type suitable for use inside the hazardous atmosphere.

15.3 Electrical installations inside cleanrooms, gas cylinder stores, dispensing rooms and workplaces shall follow requirements as stipulated in the Electricity (Wiring) Regulations, Chapter 406, Laws of Hong Kong.

15.4 All metallic parts of equipment and installations including exhaust fans, ductworks, gas pipelines, cabinets, tools and workstations shall be equipotentially bonded and earthed to protect against the effects of lightning and static electricity. An earthing system shall be provided in accordance with the Electricity (Wiring) Regulations, Chapter 406, Laws of Hong Kong.

16. Gas Cylinder

16.1 Cylinder Standard

Gas cylinders used for the storage of special gases are required to meet the following criteria and approved by FSD:

(a) Manufactured to BS5045, BS EN 1975, DOT specifications or any other specifications approved by FSD;

(b) Cylinder valves to be fitted with gas tight metal plugs capable of maintaining gas tightness at a pressure equal to the test pressure of cylinders;

(c) A flow limiting orifice to be provided to the gas cylinder valve to limit the maximum flow to 30 litre/min if the gas cylinder contains flammable, toxic, corrosive or oxidizing gas;

(d) Cylinder valve to be fitted with valve protection caps capable of protecting the valve from all directions in the event of the cylinder being dropped;

(e) Cylinders to be painted in colour codes as specified in Reg. 65 of Dangerous Goods (General) Regulations and to be clearly stenciled in paint or ink with the contents of cylinder;

(f) Labels stating the name, chemical formula and hazardous properties of the contents in both English and Chinese to be affixed on the cylinders; and

(g) Labels indicating the consumption status (i.e. full, in use, empty) of the cylinders to be affixed to the cylinders.

16.2 Cylinder Handling

16.2.1 Only persons having undergone training as per para. 17.4 will be permitted to handle gas cylinders.

16.2.2 Cylinder conveyed by metal cart or trolley should be carried in an upright position and properly secured from accidental falling.

16.2.3 Suppliers are required to provide suitable place and facilities within their licensed premises for cylinder inspection, emergency leakage repair or purging of residual gas in used cylinders with an inert gas. Suppliers are also required to provide suitable cylinder retrieval system for emergency removal of leaky cylinder from the premises of a user.

16.2.4 No gas decanting is allowed except by a gas supplier under separate licence as granted by the Authority.

16.2.5 Suppliers should inspect and certify gas cylinders being in safe working condition upon acceptance after importation.

16.2.6 An up-dated inventory record of full, consumed gas cylinders and movement of cylinders shall be maintained. Such record should be readily available for inspection by FSD.

16.2.7 Supplier should provide MSDS to the purchasers when delivering the gas cylinders.

17. Safe Working System

17.1 General

17.1.1 To reduce the chance of an accident, it is essential to establish a safe working system in consultation with a competent person. The general duties provisions of the Factories and Industrial Undertakings Ordinance and those of the Occupational Safety and Health Ordinance require employers to provide and maintain a safe system of work in their workplaces. It should include, as a minimum, health and safety precautions, emergency procedures, training and auditing. A written Health and Safety Plan documenting all pertinent elements of such a safe system of work shall be prepared and submitted with the licence application package.

17.1.2 The implementation of health and safety measures in a workplace or other premises storing or using special gases shall follow, for the sake of consistency, one single set of health-based standard as far as practicable. Its implementation and monitoring shall be carried out by a competent person.

17.2 Health and Safety Precautions

17.2.1 A risk assessment should be carried out to identify the health and fire hazards and to recommend appropriate safety precautions. Subsequent safe working procedures, in-house safety rules, safety precautions or appropriate safety measures by engineering control shall be established.

17.2.2 MSDS, site plans of hazardous materials and installations shall be readily available in the emergency control room and outside the dangerous goods store.

17.2.3 A requirement of a minimum of two persons to carry out duty in the storage room, cleanroom and handling of gas cylinders should be adopted.

17.2.4 Unauthorized entry into the premises shall be prohibited.

17.3 Emergency Procedures

17.3.1 A designated competent person, in consultation with the emergency services shall work out an emergency response plan and arrange regular joint exercises with the local fire station. As condition requires, he may initiate an on-site emergency procedure and render appropriate assistance to the responding emergency services. The designated competent person should have appropriate backup to take up his duty in case he is not available on the occurrence of any accidents.

17.3.2 On the occurrence of an accident, the emergency response team shall, according to the emergency response plan:

(a) put on personal protective gears including breathing apparatus;

(b) evacuate people in the premises;

(c) cut off the hazardous chemical supplies, shut down plants and installations;

(d) stop leaks, control spills and check fires if condition permits;

(e) obtain plans of hazardous materials storage area, fabrication area, gas distribution system and other installations or facilities in connection with the hazardous event;

(f) make available the hazardous material inventory and respective Material Safety Data Sheet (MSDS);

(g) conduct on-site hazard assessment; and

(h) inform the responding emergency services the prevailing situation and actions taken and advise them on the nature of risks involved and possible hazards.

17.4 Training

17.4.1 An employer shall provide such information, instruction and training to his employees including the nature and risk in connection with their work, monitoring procedures, control measures, use of protective clothing and equipment. Induction course to new employees and regular refresher training should be conducted. Periodic training must be provided to ensure employees can apply and use its principles and equipment. Both lecture and practical sessions should be well planned, recorded and regularly up-dated. A requisite examination commensurate with nature of duties should be conducted before assumption of a post. Employer shall ensure the employees possess sufficient knowledge, skill and experience to a level appropriate to their involvement in handling of special gases.

17.4.2 Training shall include, but not limited to:

(a) marking and labeling of cylinders;

(b) proper procedures for cylinder changeover and pipeline purging;

(c) maintenance of equipment or other systems in such places where storage or use of special gases is involved;

(d) principle and operation of gas supply, monitoring and treatment systems;

(e) hazardous properties of the special gases involved in the operations and the precautionary measures;

(f) safe disposal of the hazardous substances;

(g) donning, use and removal of personal protective equipment and clothing;

(h) first-aid and casualty handling;

(i) principles of fire protection systems and basic fire-fighting techniques;

(j) emergency procedures; and

(k) other pertinent contents of the Health and Safety Plan.

17.4.3 The extent of training should be commensurate with the job nature and responsibility of an employee. For example, a cylinder handler may only require basic training on hazards, safety operation of cylinders and associated emergency procedure whereas a member of emergency response team may require extensive training on all aspects.

17.5 Periodic Review and Auditing

A periodic audit by a competent person should be adopted to ensure the objectives of the safe working system are achieved. The Health and Safety Plan should be periodically reviewed and revised. Additional risk assessment should be conducted to formulate strategies and procedures to mitigate any new or altered risk arising from changes in equipment, facilities, installation, work processes, or storage and use of hazardous substances.

18. Fire Services Requirements

Fire Services Requirements would be formulated upon receipt of application for dangerous goods store licence and following an on-site inspection for the approval of siting by the Authority. A set of standard requirements could be obtained from the Dangerous Goods Division or the FSD website at http://www.hkfsd.gov.hk for general reference. However, the Authority may, in view of any particular risk associated with the storage and use of special gases, vary any provision of the standard requirements.

19. Hazardous Properties of Gases

(a) This section gives the principal hazardous properties of gases. It is not attempted to cover all possible hazards. Details of the hazards should be extracted from the suppliers' MSDS, literature, or publication from professional institutions or organizations. (The list of Special Gases is at Appendix III)

(b) These special gases may pose health, flammable or other hazards. They can be toxicants, carcinogens, irritants, sensitizers, corrosives, asphyxiants or materials with other health hazard properties. Some of them may carry multiple hazards. Gas mixtures should be assumed to have the same hazards as the individual gases. The potential of synergistic, i.e. more than additive, effects must also be considered. The actual hazards depend on the mixture components and their concentration. Gas mixtures are not discussed in detail in this section.

(c) The physical properties of gases such as vapor density and saturated vapor pressure should be taken into consideration when the application is being under processed.

19.1 Health Hazard

19.1.1 Corrosive gases such as boron trichloride, boron trifluoride, chlorine, dichlorosilane, hydrogen chloride and hydrogen fluoride are harmful and can cause irreversible damage to animal tissue when in direct contact. It may react with the materials of construction and ventilation system causing material damage and possible failure.

19.1.2 Toxic gases such as arsine, diborane and phosphine may cause acute or chronic damage to health when inhaled, swallowed or absorbed through skin.

19.1.3 Asphyxiation hazard exists with any gas or gas mixture that does not contain sufficient oxygen to support life. Such gas or gas mixtures can dilute the oxygen content in the atmosphere to a level causing health hazard. The generally accepted minimum level of oxygen is about 18 % for physically fit persons.

19.2 Toxicity

19.2.1 Toxic level is usually indicated by median lethal concentration in parts per million, volume by volume (ppm, v/v) for a gas or vapor in air, or in milligram per litre (mg/L) for an aerosol or particulate, in a period of 1 hour or 4 hours' exposure (LC50/1hr or LC50/4hr). LC50 are experimental data on animals for establishing dose-relationship and may not be directly translated into acute toxicity for human. One of its uses is the classification of toxic level for hazard warning. Lethal concentration for a liquid substance means the toxicity level of the liquid when it becomes a vapour.

19.2.2 In terms of LC50/4hr, the Notification of New Substances Regulations UK, 1993 classifies a gas or vapor as very toxic (LC50/4hr at or less than 0.5 mg/L), toxic (LC50/4hr between 0.5 mg/L and 2 mg/L) and harmful (LC50/4hr between 2 mg/L and 10 mg/L). Occupational Safety and Health Administration (OSHA) of USA classifies a hazardous gas as highly toxic if its LC50/4hr is less than 200 ppm or toxic if it is between 200 and 2000 ppm. There is no worldwide consensus on the classification of toxicity in terms of toxic concentrations. Accordingly, manufacturers may provide different toxic classifications for the same substance in their respective MSDSs.

19.3 Occupational Exposure Limit (OEL)

19.3.1 In the evaluation of health hazards, references should be made to the Occupational Exposure Limits (OELs) published by the Labour Department (LD) of the HKSAR. These limits are intended to provide guidance for designing control measures to ensure workplace safety. There are three categories of OELs, i.e. TWA (8 hours time-weighted average), STEL (short-term exposure limit) and C value (ceiling). TWA value refers to the recommended limit of exposure for an 8-hour day and a 5-day workweek without causing adverse effects to nearly all the workers. STEL refers to the exposure limit for 15-minutes and C value refers to the maximum concentration which should not be exceeded during any period of the work day.

19.3.2 The "immediately dangerous to life or health (IDLH) value", established by the National Institute of Occupational Safety and Health (NIOSH) of USA, is defined as a level that is likely to cause death, immediate or delayed adverse health effects, or inhibition of escape from such an environment. They are given in ppm or mg/m^3 for a 30-minute exposure. The 30 minutes is the maximum time for escape under an IDLH environment. Even before the IDLH has attained, people shall make every effort to escape from the incident site.

19.3.3 When chemical substances are not listed in the publication of the Labour Department (LD), reference may be made to the published Threshold Limit Values (TLVs) developed by the American Conference of Governmental Industrial Hygienists (ACGIH), the Workplace Environmental Exposure Level (WEEL) developed by the American Industrial Hygiene Association (AIHA), Maximum Exposure Limit (MEL) and Occupational Exposure Standard (OES) approved by the Health and Safety Commission (HSC) in United Kingdom, or other standards published by reputable international organizations.

19.3.4 The OELs are only intended to be reference levels for ensuring occupational hygiene, and therefore should not be used for any other purpose whatsoever, such as indication of relative toxicity. All health-based exposure limits are approximate with considerable variability from different reputable sources owing to the difference in sampling and adopted methodology to obtain the toxicity data. It is recommended to be conservative in using those figures. From time to time, the exposure limits may be reviewed and revised. Reference should be made to the latest publication of the local Authority or a reputable organization, e.g. LD of the HKSAR, ACGIH, AIHA, NIOSH or HSC.

19.4 Fire Hazard

19.4.1 Three conditions are needed simultaneously in order to ignite a flammable gas: a concentration within the flammable limits of that gas; an oxidizer, and a source of ignition. The flammability limits of a gas or vapour define the range of concentrations in mixtures with air that will propagate flame. Flammable range of a gas or vapour is the concentrations in air between the lower flammable limit (LFL) and the upper flammable limit (UFL).

19.4.2 Mixtures of flammable gas with air or other oxidants within the flammable range have the potential to explode. The severity of an explosion caused by the ignition of a flammable gas/air or other oxidant mixture depends on several factors like the quantity and extent of enclosure or confinement of the gas mixture.

19.4.3 Another special hazard is pyrophoric gases. Gases such as silane, phosphine, and diborane under suitable chemical kinetics condition, will ignite spontaneously in contact with air without the application of external heat. Under some conditions, spontaneous ignition may not occur, resulting in the formation of an unstable volume of pyrophoric gas or a mixture with oxidant which may explode subsequently.

20. Enquiry

Enquiries on the contents of this Code of Practice should be directed to the Dangerous Goods Division of FSD at the following address, telephone, facsimile or e-mail address:-

Dangerous Goods Division
3/F., 86 Hing Shing Road, Kwai Chung,
New Territories.
Telephone no : 2417 5757
Fax no : 2413 0873
E-mail address : fsdgd@hkfsd.gov.hk

Risk Assessment Report (RAR)

The objective of the RAR is to provide detailed information of the proposed project with a view to facilitating the Authority in making a decision on whether or not a licence under section 6 of Dangerous Goods Ordinance should be granted for the storage of special gases used in the micro-electronics industry. The contents of RAR should include the following information, where appropriate. However, should there be any vital information that the Authority may require, the applicant /project proponent would be advised accordingly.

1. Executive Summary

   Summary of main issues, finding, conclusions and recommendations

2. Introduction

2.1 Purpose of the Risk Assessment Report

2.2 The approach

3. Description of the Project

3.1 Site location, means of access and evacuation routes

3.2 Key project requirements including information on storage and use of gas cylinders, method of transportation of gas cylinders from suppliers to the store, routing of supply pipeline and material used for the construction of the store and the gas supply piping

3.3 Size or scale and design of the project

3.4 Description of scenarios with the project, existing occupancies and planned development within 100m radius of the proposed store

3.5 The nature of activities to be carried out in the premises where gases are stored or used

4. Description of Assessment Methodologies

Assessment methodologies, assumptions and criteria, including calculations and inputs and outputs files of a typical model run for all mathematical modeling

5. Identification of On-site Risk to Life and Properties Impacts

5.1 Potential on-site risks to life and properties impacts including the types, characteristics and estimated quantities of leakage / emissions, discharges, potential disturbances or displacement associated with the activities relating to the project during operation

5.2 Potential risk due to exposure situation / hazard

5.3 Specific hazardous areas within the project premises

6. Mitigation of Risks due to Adverse Situations

6.1 Measures to eliminate or reduce the potential risks to life and properties due to adverse situations

7. Conclusions and Recommendations

8. Appendix

Any other information relevant to the project, such as details of past accidents involving special gases

Recommended Minimum Safety Separation Distances

Typical type of exposure	Features to be separated	Minimum separation distance (metre)
Smoking, Naked Flames	Storage Area	6
Bulk Storage of Flammable Gases and Liquids	Storage Area	6
Unprotected Electrical Equipment	Flammable	6
Site Boundaries Air Compressors & Ventilator Intakes Roadways (other than those required for access) Bulk Storage of Cryogenic Liquids Building Openings	Toxic, Flammable and other Gases	6
Pyrophoric Gases in Store	Other Gas Containers	2
Pyrophoric Gases Connected for use	Other Gas Containers	2

Source: British Compressed Gases Association (1995), Code of Practice – CP18 : The Safe Storage, Handling and Use of Special Gases In the Micro-electronics Industry (Revision 1)

Table 1 (a) - Gases

List of Special Gases

Appendix III

GAS	CLASSIFICATION		LC50/1 hr ISO/DIS 10298 (ppm by vol)	FLAMMABLE LIMITS (% IN AIR)	RELATIVE DENSITY GAS (AIR=1)	RELATIVE DENSITY LIQUID (WATER = 1)	VAPOUR PRESSURE AT 20 °C (bar abs)
	CHIP	IGC					
* Ammonia	T	T,C	7,338	15-30	0.6	0.7	8.6
Arsenic pentafluoride	-	T+,C	20		5.9		16.7
Arsine	-	F+, T+	20	3.9-77.8	2.7	1.6	15
Boron trichloride	T+,C	T,C	2,541		4	1.3	1.6
Boron trifluoride	T+,C	T,C	387		2.4	1.6	2.2
Bromomethane (R40B1)	T, Xi	F+, T	850	8.6-20.0	3.1	1.7	1.9
1,3-Butadiene	F+	F+, T	no acute toxicity	1.4-16.3	1.9	0.65	2.4
Carbon monoixde	F, T	F+, T	3,760	12.5-74	1	0.79	
Carbonyl fluoride	-	T, C	360		2.2	0.7	
Carbonyl sulphide	-	F+, T	1,700	12-28.5	2	1.2	11
* Chlorine	T	O, T, C	293		2.5	1.6	6.8
Chlorine pentafluoride	-	O, T+, C	122		4.5	1.9	3.4
Chlorine trifluroide	-	O, T, C	299		2.8	1.9	1.5
Chlorotrifluoroethylene (R1113)	-	F+, T	2,000	4.6-64.3	4	1.5	5.1
Cyanogen	F, T	F+, T	350	3.9-36.6	1.8	0.95	4.8
Cyanogen chloride	-	T+, C	80		2.1	1.2	1.3
Diborane	-	F+, T+	80	0.8-98P	1	0.42	
Dichlorosilane	-	F+, T, C	314	2.5-80	3.5	1.3	1.6
Ethylene oxide	F+, T	F+, T	2,900	3-100	1.5	0.89	1.4
Fluorine	T+,C	O, T+, C	185		1.3	1.5	
Germane	-	F+, T+	20	not known	2.6		
Hexafluoroacetone	-	T, C	470		5.8	1.5	5.9
Hydrogen bromide	C, Xi	T, C	2,860		2.8	2.2	21
Hydrogen chloride	C, Xi	T, C	3,120		1.3	1.2	21
Hydrogen iodide	C, Xi	T, C	2,860		4.5	2.8	7.5
Hydrogen selenide	-	F+, T+	2	not known	2.8	2	9.5
Hydrogen sulphide	F+, T+	F+, T	712	4.3-45.5	1.2	0.92	18.8
Hydrogen telluride	-	F+, T+	2	not known	4.5		
Methylmercaptan	F, Xn	F+, T	1,350	3.9-21.8	1.6	0.89	1.7
Nitric oxide	-	O, T+, C	115		1	1.3	
Nitrogen dioxide	T+, Xi	O, T+, C	115		2.8	1.4	1
Nitrosyl chloride	-	T+, C	35		2.3	1.4	2.7
Phosgene	T+	T+, C	5		3.5	1.4	1.6
Phosphine	-	F+, T+	20	not established / P	1.2	0.74	34.6
Phosphorus pentafluoride	-	T+, C	190		4.5		
Phosphorus trifluoride	-	T, C	320		3	1.6	
Selenium hexafluoride	-	T+, C	50		6.7		

Table 1 (a) Cont'd- Gases

Appendix III

GAS	CLASSIFICATION		LC50/1 hr ISO/DIS 10298 (ppm by vol)	FLAMMABLE LIMITS (% IN AIR)	RELATIVE DENSITY GAS (AIR=1)	RELATIVE DENSITY LIQUID (WATER = 1)	VAPOUR PRESSURE AT 20 °C (bar abs)
	CHIP	IGC					
Silane	-	F+	no acute toxicity	not established / P	1.1	0.55	
Silicon tetrafluoride	-	T, C	450		3.6		
Stibine	-	F+, T+	20	not known	4.3	2.2	
Sulphur tetrafluoride	-	T+, C	40		3.7		
Sulphuryl fluoride	-	T	3,020		3.7	1.7	16
Sulphur dioxide	T, Xi	T, C	2,520		2.3	1.5	3.3
Vinyl chloride (R1140)	F, T	F+, T	no acute toxicity	3.8-31	2.2	0.97	3.4

Table 1 (b) – Liquids

LIQUID	CLASSIFICATION		LC50/1 hr ISO/DIS 10298 (ppm by vol)	FLAMMABLE LIMITS (% IN AIR)	RELATIVE DENSITY GAS (AIR=1)	RELATIVE DENSITY LIQUID (WATER = 1)	VAPOUR PRESSURE AT 20 °C (bar abs)
	CHIP	IGC					
Hydrogen fluoride	T+, C	T+, C	1,276		0.7	0.97	1
Tungsten hexafluoride	-	T+, C	160	-	10.3	3.4	1.1
Trichlorosilane	F	-	1,040	1.2-90.5	5	1	1

Legend

O - Oxidant
F+ - Extremely flammable
F - Highly flammable
T+ - Very toxic
T - Toxic
Xn - Harmful
C - Corrosive
Xi - Irritant
P - Pyrophoric

CHIP - Chemicals (Hazard Information Packaging for Supply) Regulation
IGC - Industrial Gases Council
ISO/DIS 10298 - Determination of the toxicity of a gas or gas mixture

Source : British Compressed Gases Association (1995), Code of Practice-CP 18 : The Safe Storage, Handling and Use of Special Gases in the Micro-electronics Industry (Revision 1).

Legend* - In the event of storage and use of only one type of special gas (e.g. ammonia or chlorine), merit consideration for relaxation of the safety requirement may be given.