# A Guide to Application for Storage and Use Licence of Special Gases in the Microelectronics Industry

Fire Services Department
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## Preamble

In 2022, the Government promulgated the Hong Kong Innovation & Technology (I&T) Development Blueprint for developing Hong Kong into an international I&T centre. To further implement the Blueprint, the Government is committed to facilitating the research and development of microelectronics as stated in the Chief Executive's 2023 Policy Address.

Special gases are crucial components in the microelectronics industries, where their versatility and unique properties make them ideal for being used to produce electronic devices. In support of the Government's plan to facilitate the research and development of microelectronics in Hong Kong, the Fire Services Department (FSD) has revisited the existing regulatory standard governing the storage and use of special gases and formulated a new safety guide. The guide aims to enhance the safety for storage and use of special gases to align with the prevailing global industry best practice at time of issue while facilitating safe and smooth operations of the microelectronics industry.

"A Guide to Application for Storage and Use Licence of Special Gases in the Microelectronics Industry" (this Guide) will supersede Chapter 2.4 Application for Store and Use Licence of Special Gases in the Microelectronics Industry of "A Guide to Application for Dangerous Goods Licence and Approval" ("DG Application Guide"), while the remainder Chapters of the DG Application Guide are still valid and applicable to special gases DG store and use licence application. This Guide should also be read in conjunction with the Code of Practice for Fire Safety in Buildings (FS Code) issued by the Buildings Department. The fire safety requirements relating to means of escape, fire resisting construction and means of access stipulated in the FS Code should be complied with.

This Guide is to provide guidance on the application for a store and use licence of special gases in the microelectronics industry. As microelectronics industry is rapidly growing with emerging new technologies, FSD will keep reviewing technological developments of the microelectronics industry and review this Guide accordingly, if the situation so requires.

It is important to notice that the grant of licence by FSD under the Dangerous Goods Ordinance (Cap. 295) does not waive the obligation of the applicant to obtain any prior consent, approval, permission or licence from other government departments or agencies pursuant to other legal and regulatory requirements in relation to the proposed storage and use of special gases. These departments or agencies may include, but are not limited to, the Buildings Department, Customs and Excise Department, Electrical and Mechanical Services Department, Environmental Protection Department, Hospital Authority, Invest Hong Kong (InvestHK), Lands Department, Planning Department, Transport Department and Labour Department. Besides, the processing of an application or the granting / renewal of a licence / approval shall not be taken as a waiver of any terms in any leases or licences granted by the Government or any public officers. Nor will they in any way affect or modify any agreements or covenants relating to any premises or building to which the licence / approval relates.

## Abbreviations

| | | |
|---|---|---|
| Cap. 295 | - | Dangerous Goods Ordinance, Chapter 295, Laws of Hong Kong |
| Cap. 295E | - | Dangerous Goods (Application and Exemption) Regulation 2012, Chapter 295E, Laws of Hong Kong |
| Cap. 295G | - | Dangerous Goods (Control) Regulation, Chapter 295G, Laws of Hong Kong |
| DFS | - | Director of Fire Services |
| DG | - | Dangerous Goods |
| EPD | - | Environmental Protection Department |
| EQ | - | Exempt Quantity |
| FRR | - | Fire Resistance Rating |
| FSD | - | Fire Services Department |
| FSI | - | Fire Service Installation and Equipment |
| IDLH | - | Immediately Dangerous to Life or Health |
| $LC_{50}$ | - | Lethal Concentration 50 |
| LFL | - | Lower Flammable Limit |
| NTP | - | Normal Temperature and Pressure |
| OEL | - | Occupational Exposure Limit |
| OEL-C | - | Occupational Exposure Limit – Ceiling |
| OEL-STEL | - | Occupational Exposure Limit – Short-Term Exposure Limit |
| OEL-TWA | - | Occupational Exposure Limit – Time-Weighted Average |
| PML | - | Packing, Marking and Labelling |
| QRA | - | Quantitative Risk Assessment |
| SDS | - | Safety Data Sheet |
| UPS | - | Uninterruptible Power Supply |
| VMB | - | Valve Manifold Box |

# Table of Contents

# Part 1 General Information

## 1.1 Title

This document shall be titled “A Guide to Application for Storage and Use Licence of Special Gases in the Microelectronics Industry” hereinafter referred to as “the Guide” or “this Guide”.

## 1.2 Definitions

1.2.1 “Cleanroom” means a room in which the concentration of airborne particles is controlled to specified limits, including area below the raised floor and above the ceiling grid if these areas are part of the air path and within the rated construction.

1.2.2 “Compressed gas” means a gas which is under pressure when packaged.

1.2.3 “Continuous gas detection system” means a gas detection system where the analytical instrument is maintained in continuous operation and sampling is performed without interruption. Analysis is allowed to be performed on a cyclical basis at intervals of not more than 30 minutes.

1.2.4 “Corrosive gas” means a gas that causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact.

1.2.5 “Detached special gas station” means a separate single-storey building used for storage of special gases and associated equipment.

1.2.6 “Emergency alarm system” means a system to provide visual indication and audio warning of emergency situations involving dangerous goods.

1.2.7 “Emergency control room” means a room at the premises used for overall monitoring of the condition of the storage area, cleanroom, service corridor, etc., signals received from emergency equipment, and manned by adequate trained personnel round-the-clock.

1.2.8 “Exhausted enclosure” means an appliance or piece of equipment that consists of a top, a back, and at least two sides providing a means of local exhaust for capturing gases and vapours.

1.2.9 “Fabrication area” means an area within a semiconductor fabrication facility and related research and development areas in which there are processes using dangerous goods.

1.2.10 “Flammable gas” means a gas which at 20°C and a standard pressure of 101.3 kPa:

(a) is ignitable when in a mixture of 13% or less by volume with air; or

(b) has a flammable range with air of at least 12 percentage points regardless of the lower flammability limit.

1.2.11 “Gas cabinet” means a fully enclosed, non-combustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use.

1.2.12 “Highly-toxic gas” means a gas with an $LC_{50}$ (one-hour) value of equal to or less than 200 $ml/m^3$.

1.2.13 “Immediately dangerous to life or health (IDLH)”, established by the National Institute for Occupational Safety and Health (NIOSH) of the US, is defined as a situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The IDLH value refers to a maximum (airborne concentration) level above which only a highly reliable breathing apparatus providing maximum worker protection is permitted. IDLH values are based on a 30-minute exposure duration.

1.2.14 “Incompatible materials” mean materials that, when mixed, have the potential to react in a manner that generates heat, fumes, gases or byproducts which are hazardous to life or property.

1.2.15 “Indoor storage” means a location that does not meet the definition of outdoor storage. Indoor storage includes special gas room and detached special gas station.

1.2.16 “Inert gas” means a non-reactive, non-flammable, non-corrosive gas such as argon, helium, krypton, neon, nitrogen and xenon.

1.2.17 “Lethal concentration 50” is the concentration in air which, administered by continuous inhalation to both male and female young adult albino rats for one hour, is most likely to cause death within 14 days in one half of the rats.

1.2.18 “Low vapor pressure gas" is a gas with saturated vapor pressure less than 0.2 MPa (2 bar) at room temperature.

1.2.19 “Lower flammable limit” is the minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. The LFL is sometimes referred to as “LEL” or “lower explosive limit.”

1.2.20 “Normal temperature and pressure” means a temperature of 21°C and a pressure of 1 atmosphere (101 kPa).

1.2.21 “Occupational exposure limit” is the airborne concentration(s) of individual chemical agents that represent levels which are regarded to impose no adverse health effects to nearly all workers on exposures by the route of inhalation.

1.2.22 “Occupational exposure limit – ceiling” is the airborne concentrations of a chemical substance that should not be exceeded during any part of a working day.

1.2.23 “Occupational exposure limit – short-term exposure limit” is the 15-minute time-weighted average of the airborne concentration of a chemical substance.

1.2.24 “Occupational exposure limit – time-weighted average” is the time-weighted average concentration of a chemical substance over an eight-hour working day for a five-day workweek, to which nearly all workers can be exposed day after day without adverse health effects.

1.2.25 “Outdoor storage” means a location that is in an open area and sufficiently open (at least open on two sides) to provide a high degree of natural ventilation.

1.2.26 “Oxidizing gas” means a gas that can support and accelerate combustion of other materials more than air does.

1.2.27 “Pressure receptacle” means a receptacle used for containing Class 2 Schedule 2 dangerous goods under pressure, other than a boiler or a pressure vessel as defined by section 2(1) of the Boilers and Pressure Vessels Ordinance (Cap. 56).

1.2.28 “Purging” means a method used to free the internal volume of a piping system of unwanted contents that results in the existing contents being removed or replaced.

1.2.29 “Pyrophoric Gas” means a gas with an autoignition temperature in air at or below 54°C.

1.2.30 “Restricted flow orifice” means a device installed in the gas cylinder valve body that restricts the flow rate to 30 litre/min at maximum.

1.2.31 “Scrubber” means an equipment to treat exhaust air before discharged to atmosphere.

1.2.32 “Service corridor” means a fully enclosed passage used for carriage of dangerous goods to and from the storage area, and purposes other than those required for means of escape.

1.2.33 “Silane station” means an unconfined space where silane bulk source, associated equipment and supplies are stored and used.

1.2.34 “Special gas room” means a separately ventilated, fully enclosed room in which only compressed gases, associated equipment and supplies are stored or used. Examples of special gas room are DG Store where pressure receptables are stored and dispensing room.

1.2.35 “Tool” means any device, storage container, workstation or process machine used in a fabrication area.

1.2.36 “Toxic gas” means a gas with an $LC_{50}$ (one-hour) value of more than 200 ml/$m^3$, but not more than 5000 ml/$m^3$.

1.2.37 “Valve manifold box” means a fully enclosed, ventilated enclosure of limited size used to house valves, fittings, pressure regulating, monitoring, and flow-control

system suitable for the distribution of gases in closed piping systems to one or more tools or workstations.

1.2.38 “Workstation” means a defined space or an independent principal piece of equipment using hazardous chemical within a fabrication area where a specific function, laboratory procedure or research activity is performed.

## 1.3 List of Special Gases

A non-exhaustive list of special gases is provided in Appendix A of this Guide. The list of special gases enumerates the special gases commonly used in the microelectronics industry. The microelectronics industry shall comply with this Guide when storing and using any special gases.

## 1.4 Miscellaneous

The provisions of this Guide are not intended to inhibit technological advances that are not specifically prescribed by this Guide. If the applicant considers that there are significant difficulties with the design in compliance with the requirements prescribed in this Guide, the design proposed by the applicant can be submitted to FSD for review on a case-by-case basis. In such case, the applicant shall provide evidence in support of how the proposed design may satisfy the minimum intended health and safety requirements as prescribed by this Guide.

# Part 2 Siting, Construction and Separation

## 2.1 General

2.1.1 Buildings are prohibited for storage and use of special gases if sleeping accommodation exists therein.

2.1.2 DG Store shall be located at street level and accessible by cart, trolley or other transport vehicle for easy carriage or urgent removal in case of emergency. The storage area and fabrication area shall also be accessible by major fire appliances for fire-fighting purpose. If the applicant proposes locating the DG Store on an upper floor, the proposed location of the DG Store could be reviewed by FSD on a case-by-case basis, and, in any event, it shall not exceed 30 metres above the ground floor level. The applicant shall provide a justifiable reason and submit a risk assessment along with the licence application package.

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

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

2.1.5 Applicant is advised to seek advice from Planning Department (PD) and Lands Department (LandsD) on the land use matter, if applicable.

## 2.2 DG Store

2.2.1 General

(a) Multiple types of DG shall not be stored together in a licensed store if they are incompatible. To determine the compatibility of multiple types of DG, the provisions of Cap. 295G and Code of Practice for Control of Dangerous Goods on Land shall be observed.

(b) Normally empty containers shall be segregated from full containers. They shall be clearly marked and stored in the same way as the marking and storage of full container while some hazards may still remain. They should be returned to the gas supplier as soon as practicable.

(c) DG Store containing highly toxic, toxic and corrosive gases shall be provided with emergency shower and eyewash station. The emergency shower and eyewash station shall be located in a safe area nearby.

2.2.2 Security

(a) DG Store shall be secured against unauthorized entry. For outdoor storage, barriers against entry shall allow free circulation of air throughout the area of storage or use.

(b) Entrance of DG Store containing highly toxic, toxic, pyrophoric or flammable gases shall be provided with Closed Circuit Television (CCTV) and linked to emergency control room for monitoring conditions at the entry.

2.2.3 Outdoor Storage

(a) Outdoor storage area for pressure receptacles shall be provided with a non-combustible roof to avoid the pressure receptacles being disrupted by the weather. Vents shall be provided in the roof to avoid the accumulation of gas lighter than air in the roof-space.

(b) Sufficient headroom in the store structure shall be maintained to provide good cross ventilation.

(c) Materials used for the construction of the outdoor storage shall be non-combustible. 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.

(d) Means shall be provided to secure the gas cylinders in an upright position.

(e) The storage area is to be kept away from sources of ignition, building alleys, building openings or ventilation intakes. Various exposures shall be kept at a minimum separation distance from the storage area in accordance with Table 2.2.3(e) below:

Table 2.2.3(e)

| Typical Type of Exposure | Features to be Separated | Minimum Separation Distance (Metre) |
|---|---|---|
| Smoking, Naked Flames | Storage Area | 3 |
| Bulk Storage of Flammable Gases and Liquids | Storage Area | 3 |
| Unprotected Electrical Equipment | Flammable | 3 |
| (a) Site Boundaries<br>(b) Air Compressors & Ventilator Intakes<br>(c) Roadways (other than those required for access)<br>(d) Bulk Storage of Cryogenic Liquids<br>(e) Building Openings | Toxic, Flammable and other Gases | 3 |
| Pyrophoric Gases in Store | Other Gas Containers | 2 |
| Pyrophoric Gases Connected for use | Other Gas Containers | 2 |

Note: These distances are recommendations only. The risk assessment may suggest other distances.

(f) An automatic flame detection system (if applicable) shall be provided in accordance with Section 4.1.

(g) A automatic suppression system shall be provided in accordance with Section 4.2.

(h) A gas detection system shall be provided in accordance with Section 4.4.

(i) Proper drainage provision shall be provided in the storage area.

### 2.2.4 Silane Station

Silane and silane mixtures exceeding 57 $m^3$ at normal temperature and pressure (NTP) and the related delivery systems shall be located in a silane station. Section 2.2.3 and the following salient points shall be observed when planning a silane station.

(a) Silane Station shall be sheltered from the elements by non-combustible roof and protected from weather exposure by not more than three detached walls so the roof and walls are separated from one another with adequate space between the walls and between the walls and the roof structure, thereby reducing the possibility of confinement or accumulation of silane if there is a leak. (NOTE - The open space can be constructed of chain link fencing or a similar open structure that does not restrict airflow.)

(b) Objects that are not part of the silane system or its supporting structures or fire barriers but would interfere with free air movement through the silane system, shall be located at a minimum distance from the silane containing equipment of twice the objects height. If the minimum distance cannot be achieved, mechanical ventilation shall be provided.

(c) There shall be a 2-hour fire barrier wall provided between the pressure receptacle of silane and control panels or process gas panels. Alternatively, a minimum 9m separation distance shall be maintained between the pressure receptacles and the control panels or process gas panels.

(d) A minimum of two exits shall be provided to silane station. An exception is that one exit is allowed when the areas of silane station are less than 19 $m^2$ and the equipment installed therein would not obstruct the exit route.

### 2.2.5 Special Gas Room

If special gases are to be stored or dispensed indoors, a special gas room shall be provided. The following salient points shall be observed when siting a special gas room.

(a) Not be located at basement level;

(b) Be provided with minimum separation distance of 6m in all directions from any source of ignition, ventilation intake, building opening or building exit;

(c) Be constructed of non-combustible materials;

(d) Be separated from the remainder of the building having a fire resistance rating of not less than two hours carried from floor to ceiling;

(e) Be provided with a flame detection (if applicable) in accordance with Section 4.1;

(f) Be provided with an automatic suppression system in accordance with Section 4.2;

(g) Be provided with a gas detection system in accordance with Section 4.4;

(h) Be provided with mechanical ventilation system operating at a negative pressure in accordance with Section 4.5 or natural ventilation in accordance with Section 4.6;

(i) Be provided with an emergency alarm system in accordance with Section 4.7.

### 2.2.6 Detached Special Gas Station

When the storage capacity of pyrophoric gases (other than silane and silane mixtures, where Section 2.2.5 and Section 3.6 are applicable) exceeds 57 $m^3$ at NTP, the pyrophoric gases shall be stored in a detached special gas station or an outdoor storage area. The following salient points shall be observed when siting a detached special gas station.

(a) Not be located at basement level;

(b) Be located at street level;

(c) Be a single-storey separated building;

(d) Be provided with minimum separation distance as specified in Table 2.2.3(e).

(e) Be constructed of non-combustible materials;

(f) Be enclosed having a fire resistance rating of not less than two hours carried from floor to ceiling;

(g) Be provided with a flame detection (if applicable) in accordance with Section 4.1;

(h) Be provided with an automatic suppression system in accordance with Section 4.2;

(i) Be provided with a gas detection system in accordance with Section 4.4;

(j) Be provided with a mechanical ventilation system operating at a negative pressure in accordance with Section 4.5 or natural ventilation in accordance with Section 4.6;

(k) Be provided with an emergency alarm system in accordance with Section 4.7.

2.2.7 DG Store Containing Highly-toxic Gases

The following salient points shall be observed when planning a DG Store containing highly-toxic gases.

(a) Be provided with cylinder containment vessels or cylinder containment system to enclose the gas cylinders when leaking;

(b) Be provided with double-lock security door, security window and other appropriate measures to avoid unauthorized entry when highly-toxic gas is stored or dispensed.

## 2.3 Fabrication Area

The following salient points shall be observed when planning a fabrication area.

(a) Not be located at basement level;

(b) Be constructed of non-combustible materials;

(c) Be separated from the remainder of the building having a fire resistance rating of not less than two hours carried from floor to ceiling;

(d) Be provided with a smoke detection system in accordance with Section 4.1;

(e) Be provided with an automatic suppression system in accordance with Section 4.2;

(f) Be provided with a gas detection system in accordance with Section 4.4.

## 2.4 Service Corridor

The following salient points shall be observed when planning a service corridor.

(a) Be designed for the carriage of special gases on cart or trolley to and from the storage area; means of escape shall not be used as a service corridor;

(b) Doors from service corridor shall swing in the direction of exit and shall be self-closing;

(c) Be provided with an automatic suppression system in accordance with Section 4.2;

(d) Be provided with a gas detection system in accordance with Section 4.4;

(e) Be provided with a mechanical ventilation system in accordance with Section 4.5 or natural ventilation in accordance with Section 4.6;

(f) Be provided with an emergency alarm system in accordance with Section 4.7.

# Part 3 Storage, Dispensing and Use of Special Gases

## 3.1 Pressure Receptacle

### 3.1.1 Pressure Receptacles Standard

Pressure receptacles used for the storage of special gases are required to meet the following criteria and shall be approved by FSD:

(a) Manufactured according to BS 5045, DOT specifications or any other specifications approved by FSD;

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

(c) If the pressure receptacle contains a special gas other than an inert gas, a restricted flow orifice shall be provided to the pressure receptacle valve to limit the maximum flow to 30 litre/min;

(d) If the pressure receptacle contains silane, a restricted flow orifice shall be provided to the pressure receptacle valve in accordance with Section 3.6;

(e) The valve to be fitted with valve protection caps shall be capable of protecting the valve from all directions in the event of the pressure receptacle being dropped;

(f) PML requirements of pressure receptacle shall refer to Cap. 295G and Code of Practice for Control of Dangerous Goods on Land;

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

### 3.1.2 Pressure Receptacles Handling

(a) Only persons having undergone training as per Section 5.4 shall be permitted to handle pressure receptacles.

(b) Pressure receptacles carried by metal cart or trolley should be in an upright position and properly secured from accidental falling.

(c) Suppliers are required to provide suitable place and facilities within their licensed premises for pressure receptacle inspection, emergency leakage

repair or purging of residual gas in used pressure receptacles with an inert gas. Suppliers are also required to provide suitable pressure receptacles retrieval system for emergency removal of leaky pressure receptacles from the premises of a user.

(d) No gas decanting is allowed except by a gas supplier under a separate licence as granted by FSD.

(e) Suppliers should inspect and certify pressure receptacles being in safe working condition upon acceptance after importation.

(f) An updated inventory record of full and consumed pressure receptacles and movement of pressure receptacles shall be maintained. Such record should be readily available for inspection by FSD.

(g) Supplier should provide SDS to the purchasers when delivering the pressure receptacles.

(h) The carriage of pressure receptacles in the designated route shall be carried out by trained personnel and be supervised.

3.1.3 Pressure receptacles, except with the approval of FSD, should not be stored inside cleanroom.

## 3.2 Gas Cabinet

3.2.1 Gas cabinet shall be constructed in accordance with the following:

(a) Constructed of steel with thickness not less than 2.5 mm;

(b) Be provided with a view panel made of transparent wired glass for unobstructed viewing of its content and access to the cylinder valve groups;

(c) The door shall be closely fitted and self-closing with a self-latching device;

(d) Gas cabinet interiors shall be treated, coated or constructed of materials that are compatible with the stored gases. Such treatment, coating or construction shall include the entire interior of the cabinet.

The specifications of cabinets shall be submitted to FSD for examination before being put into use.

3.2.2 Only gases with same hazardous properties and inert gas shall be stored in the same cabinet with due consideration of subsidiary hazard and their reactivity. The gas supply system shall be located as close to the fabrication area as possible to minimize the length of supply pipeline.

3.2.3 An independent mechanical ventilation system capable of maintaining an adequate negative pressure inside a gas cabinet shall be provided in accordance with Section 4.5.

3.2.4 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 opened.

3.2.5 An automatic inert gas line purging system with manual backup shall be provided to the gas cabinet. Purging system shall be constructed of material compatible with the gas that 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.

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

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

3.2.8 Within the cabinet there shall be facilities to secure the pressure receptacle.

3.2.9 A gas detection system appropriate to the stored gas, which meets the requirements of Section 4.4, shall be provided inside a gas cabinet.

3.2.10 Automatic sprinklers shall not be installed in gas cabinet containing water-reactive gases.

3.2.11 To reduce the likelihood of gas cylinder misloading, barcode scanner should be provided in the gas cabinet. When gas cylinders are being replaced, the barcode scanner should be used to scan the barcode belonging to the gas cylinder. If the type of gas does not match the intended usage for the gas cabinet, the system shall raise an alert signal to the operator. Suitable alternatives other than barcode scanners may be used as long as they support comprehensive gas exchange protocols.

3.2.12 Gas supply source containing low vapor pressure gas may be allowed to situate close to production equipment or inside the fabrication area if necessary. However, unless the special gases have unique properties (like low vapor pressure gases) or specific processes demand so, the quantity of special gases within the fabrication area should be kept to a minimum (reference could be made to Guobiao GB 50646) under normal circumstances.

3.2.13 A visual warning device should be prominently installed on the cabinet to alert emergency personnel in case of any gas leakage incidents, effectively pinpointing the affected cabinet such that it can be readily located.

## 3.3 Distribution System

3.3.1 Austenitic stainless steel seamless pipe shall be used for process piping. The inner surface should be cleaned and passivated.

3.3.2 Process piping shall be welded by orbital welding, except for connection to the tools and equipment.

3.3.3 The connection of process pipes serving pyrophoric, flammable, highly-toxic, toxic and corrosive gases to the tools and equipment shall be located within a ventilated enclosure, if the connection is not welded.

3.3.4 Gaskets used for mechanical seals shall be made of stainless steel or nickel, which shall be compatible with the gas. Non-metallic gaskets, scratched gaskets, or

previously used gaskets shall not be used. Only one gasket shall be used on the same sealing surface.

3.3.5 All penetration points in the fire barriers of the fabrication area made by process pipes shall be equipped with pipe sleeves. The welded sections of the process pipes shall not be located within the sleeves. Gaps between the process pipes and pipe sleeves shall be filled with fire-rated material having a fire-resistance rating that is not less than that of the fire barrier it penetrates.

3.3.6 Coaxial (double containment) piping shall be used for highly toxic, corrosive, and pyrophoric gases, unless there is a justifiable reason not to use so.

3.3.7 Piping shall not be located within means of escape, including protected corridors, protected lobbies, required staircases, etc. The pipeline shall be suitably secured and protected from mechanical damage.

3.3.8 Pneumatic leak test shall be conducted in accordance with the requirements of ASME B31.3 – Process Piping Guide or other standards acceptable to DFS. The test pressure shall not be less than 1.1 times the design pressure. The gas used as test fluid shall be non-flammable and non-toxic.

3.3.9 Markings used for piping systems shall consist of the content's name and include a direction-of-flow arrow. Markings shall be provided at each valve; at wall, floor or ceiling penetrations; at each change of direction; and at not less than every 6.1m or fraction thereof throughout the piping run.

3.3.10 Materials for the piping, fittings, 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 DFS. The detailed schematic diagram shall be submitted for examination with the licence application package.

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

3.3.12 Over-pressure relief device shall be provided to the process piping. 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 jeopardise the safety of neighbouring life and property.

3.3.13 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 the supply pressure receptacle as possible.

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

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

3.3.16 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.

3.3.17 Gas supply systems shall be designed, installed, tested, inspected, commissioned and maintained by an Approved Person (Piped Gas Installation).

3.3.18 All process pipes serving pyrophoric, flammable, highly-toxic and toxic gases installed within fabrication areas shall be exposed.

3.3.19 Process pipes and associated fittings, valves serving oxidizing gas shall be free from oil and grease. The materials shall undergo degreasing treatment.

## 3.4 Carriage of Pressure Receptacles

3.4.1 In new building, a service corridor shall be provided, when necessary, to transport pressure receptacles indoors.

3.4.2 In existing building where no service corridor is provided, a designated route inside the premises shall be used for the carriage of pressure receptacles. Other persons shall not be allowed to use the route during the time of carriage. If such designated

route is not feasible, additional protection of the pressure receptacles by specially designed pressure receptacle container should be provided.

3.4.3 Means of escape shall not be used for the carriage of pressure receptacles.

3.4.4 Receiving, transporting, unpacking, and dispensing of pressure receptacles and any hazardous materials shall be carried out by trained personnel.

## 3.5 Purging

3.5.1 Pyrophoric, flammable, highly-toxic, toxic and corrosive gas sources shall be provided with dedicated inert gas supply source.

3.5.2 Only compatible gases shall be permitted to share an inert gas supply source.

3.5.3 Purge line shall be provided with check valve to prevent backflow and cross-contamination of purge gas or other process gases.

3.5.4 Prior to the commencement of any work involving process pipelines, the gas inside the pipeline should be completely replaced with inert gas before and during the work. The replaced gases should undergo treatment by a scrubber before being discharged.

## 3.6 Silane System

3.6.1 Silane and silane mixtures shall be stored, used and handled in accordance with the requirements of this section.

3.6.2 To prevent flames from affecting adjacent silane cylinders in the event of a fire in a gas cylinder, silane cylinders shall be secured and separated from other silane cylinders. Each silane cylinder shall be separated by steel plate of thickness not less than 6 mm with the plate extended a minimum of 460 mm below the centreline of a cylinder valve and a minimum 150 mm above the centreline of the cylinder valve.

3.6.3 Silane delivery system shall be equipped with restricted flow orifice.

(a) Non-bulk silane system: the restricted flow orifice shall not exceed 0.25 mm in diameter.

(b) Bulk silane system: the restricted flow orifice shall not exceed 3.175 mm in diameter.

A bulk silane system refers to a pressure receptacle or interconnected group of pressure receptacles with a water volume exceeding 250 L. A non-bulk silane system refers to a pressure receptacle or interconnected group of pressure receptacles with a water volume equal to or not exceeding 250 L.

3.6.4 Purge gas used for the purging of silane delivery system piping and components at the source location shall be supplied from dedicated inert gas supply source. The minimum velocity of purge gas in the vent line system shall be 0.3 m/s.

3.6.5 A mechanical ventilation system shall be provided to gas cabinet containing silane and silane mixtures, and the ventilation rate shall be determined in accordance with one of the followings:

(a) When cylinder is equipped with restricted flow orifice of 0.25 mm in diameter, ventilation rate in gas cabinet shall not be less than 1200 air changes per hour;

(b) When cylinder is equipped with restricted flow orifice of 0.15 mm in diameter, ventilation rate in gas cabinet shall not be less than 400 air changes per hour; or

(c) The volumetric flow rate is determined by the size of the restricted flow orifice in the discharge line or cylinder valve at the maximum silane source pressure. Regardless of whether an orifice is used, the minimum ventilation rate of gas cabinet shall not be less than the maximum volumetric flow rate of silane multiplied by 250.

3.6.6 Flame detection system shall be provided in accordance with Section 4.1.

3.6.7 A gas detection system shall be provided in accordance with Section 4.4 and the following:

(a) Within gas cabinets, VMBs and exhausted enclosures: When a concentration of silane higher than 50 ppm is detected, a distinctive audio and visual alarm shall be activated in the premises, and the gas supply shall be shut off automatically;

(b) Outside gas cabinets, VMBs and exhausted enclosures: When a concentration of silane higher than 5 ppm is detected, a distinctive audio and visual alarm shall be activated in the premises. Shut-off of gas supply will not be required if the detected concentration of silane is lower than 50 ppm.

3.6.8 An automatic shutoff system shall be provided to automatically shut off the gas flow when gas or flame is detected by gas detection or flame detection system.

3.6.9 At least one remote manual shut-off device shall be provided at each exit door of silane station and such shut-off device shall be installed not less than 4.6m from the source of supply and the process gas panel.

3.6.10 When a silane fire occurs, the gas source of silane shall be shut off. No person should attempt to extinguish the silane flame without shutting off the gas supply.

# Part 4 Fire Safety Protection

# Fire Service Installations and Equipment

Fire service installations and equipment shall comply with the requirements of prevailing version of Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment, and the requirements outlined in this Section.

## 4.1 Automatic Fire Detection and Alarm System

4.1.1 A smoke detection system shall be provided in the following locations in accordance with the requirements of this Section:

(a) In the return airstream of fabrication area;

(b) In the air supply plenum above the fabrication area.

4.1.2 Where smoke detection system is installed at the entry to the return air path, area coverage of a spot-type detector or sampling port spacing shall be limited to 0.4$m^2$.

4.1.3 The minimum fire alert sensitivity for a single sampling point or spot-type detector shall be a maximum value of 0.65% per metre. On activation of alert, the alert signal shall be transmitted to the emergency control room and an investigation into the activation shall be carried out immediately by the site emergency team.

4.1.4 The minimum fire alarm sensitivity for a single sampling point or spot-type detector shall be a maximum value of 3.2% per metre. On activation of alarm, the alarm signal shall raise a distinctive audio and visual alarm in the premises and the signal shall be transmitted to the emergency control room and FSD.

4.1.5 Smoke detection shall operate in the airflow velocities anticipated within the fabrication area.

4.1.6 Flame detection system shall be provided to detect a fire at potential leak points on the pyrophoric gas delivery system when such delivery system is used in the following locations:

(a) In special gas room;

(b) In detached special gas station;

(c) In gas cabinet;

(d) In VMB;

(e) Outdoor storage area.

4.1.7 When flame detection system is activated, the nearest isolation valve of the gas source shall be closed automatically. The activation of the detection system shall raise a distinctive audio and visual alarm in the premises, and the alarm signal shall be transmitted to the emergency control room and FSD.

## 4.2 Automatic Suppression System

4.2.1 An approved automatic sprinkler system shall be provided throughout the building containing semiconductor fabrication facilities, with the exception of dispensing room and special gas room where water-reactive gases are present.

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

4.2.3 Gas cabinet containing pyrophoric, flammable gases shall be internally provided with a sprinkler system, except for gas cabinet containing water-reactive gases. Quick response sprinkler heads should be used within the gas cabinet.

4.2.4 Quick response sprinkler heads should be used within the down-flow air streams in cleanrooms.

## 4.3 Manual Fire Alarm System

4.3.1 Activation of manual fire alarm system shall raise a distinctive audio and visual alarm in the premises. The alarm signal shall be transmitted to the designated control room in the premises and FSD.

## 4.4 Gas Detection System

4.4.1 A gas detection system shall be provided in the following areas where special gases are stored and used in accordance with the requirements of this Section.

(a) Fabrication Areas;

(b) Special Gas Rooms;

(c) Detached Special Gas Stations;

(d) Outdoor Storage;

(e) Gas Cabinets;

(f) VMBs;

(g) Service Corridors;

(h) Exhausted Enclosures.

4.4.2 The gas detection system shall be capable of monitoring the room, area or equipment in which the gas is located at or below the gas concentrations in accordance with Table 4.4.2.

Table 4.4.2

| Classification of Gas [1] | Location | Threshold Limit [2] | Alarm level |
|---|---|---|---|
| Toxic gas and highly toxic gas | Within gas cabinets, VMBs and exhausted enclosures | Immediately dangerous to life and health (IDLH) | Level two alarm |
| | At space outside gas cabinets, VMBs and exhausted enclosures | Occupational Exposure Limit – Time Weighted Average (OEL-TWA) | Level one alarm |
| | | • Immediately dangerous to life and health (IDLH); or<br>• Occupational exposure limit – ceiling value (OEL – C); or<br>• Occupational exposure limit – short term exposure limit (OEL – STEL) | Level two alarm |
| Pyrophoric gas and flammable gas | Within or outside gas cabinets, VMBs and exhausted enclosures | 25% of the lower flammable limit (LFL) | Level one alarm |
| | | 50% of the lower flammable limit (LFL) | Level two alarm |
| Inert gas | Within or outside gas cabinets, VMBs and exhausted enclosures | 19.5% of oxygen level | Level one alarm |
| | | 18% of oxygen level | Level two alarm |

Note [1]: For gases with both toxic and flammable nature, the thresholder limit of toxic gas or flammable gas, whichever is lower, shall be adopted as the alarm level.

Note [2]: When OEL or IDLH value for a gas is not available, reference may be made to the published Threshold Limit Values (TLVs) developed by the American Conference of Governmental Industrial Hygienists (ACGIH), Workplace Exposure Limits (WELs) approved by the Health and Safety Executive (HSE) in the United Kingdom, or other standards established by the reputable international organisations.

4.4.3 Actuation of level one alarm shall give a distinctive local audio and visual alarm in the affected area to alert the personnel within the area.

4.4.4 Actuation of level two alarm shall give a distinctive audio and visual alarm in the premises to initiate evacuation and emergency procedure, and the gas supply shall be shut off automatically. Signal of level two alarm shall be transmitted to FSD.

4.4.5 For both level one alarm and level two alarm, alarm signal shall be transmitted to emergency control room to alert emergency response team for immediate inspection and remedial action.

4.4.6 A level two alarm of the gas detection system shall automatically close the shutoff valve at the source on gas supply piping related to the system being monitored for which gas is detected. Automatic closure of shutoff valves shall comply with the following:

(a) Where the gas detection sampling point initiating the gas detection system alarm is within a gas cabinet or exhausted enclosure, the shutoff valve in the gas cabinet or exhausted enclosure for the specific gas detected shall automatically close;

(b) Where the gas detection sampling point initiating the gas detection system alarm is within a room of storage, dispensing or use of gases, the shutoff valves on all gas lines for the specific gas detected shall automatically close;

(c) Where the gas detection sampling point initiating the gas detection system alarm is within a VMB, the shutoff valve at the VMB shall automatically close.

## 4.5 Mechanical Ventilation System

4.5.1 A mechanical ventilation system shall be provided in the following locations in accordance with the requirements of this Section.

(a) Special Gas Rooms: Mechanical ventilation with a minimum air change rate of 10 air changes per hour shall be provided to special gas rooms;

(b) Detached Special Gas Stations: Mechanical ventilation with a minimum air change rate of 10 air changes per hour shall be provided to detached special gas stations;

(c) Gas Cabinets: Mechanical ventilation capable of maintaining not less than 100 Pa negative pressure inside a gas cabinet shall be provided to gas cabinets. Minimum air change rate of 300 air changes per hour shall be provided;

(d) VMBs: Mechanical ventilation capable of maintaining an adequate negative pressure inside a gas cabinet shall be provided to VMBs. Minimum velocity of 1 m/s across the face of the view panel opening shall be provided;

(e) Service Corridors: Mechanical ventilation with a minimum air change rate of 10 air changes per hour shall be provided to service corridors;

(f) Workstations: Mechanical ventilation system shall be provided to capture and exhaust gases, fumes and vapours at workstations.

4.5.2 The mechanical ventilation system shall have an emergency source of power. The mechanical ventilation systems shall be working continuously at all times.

4.5.3 Mechanical ventilation system for workstations involving hazardous gases shall be kept working continuously during the operation process. Workstations shall not be energized without adequate exhaust ventilation.

4.5.4 A mechanical ventilation system shall consist of duty ventilation fan and standby fan. The duty ventilation fan and standby fan shall operate 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 also be actuated and the duty fan failure signal shall be transmitted to the designated control room in the premises to alert the management to effect immediate repair action.

4.5.5 No portion of the building structure such as service ducts shall be used as an integral part of the air transfer or mechanical ventilation systems. If the ductwork of mechanical ventilation system passes through compartments, any part of the ductwork outside the serviced compartment shall be totally enclosed by fire resisting construction to BS 476: Part 20, to the same fire resistance rating (FRR) as the serviced compartment or the containing compartment, whichever is higher.

4.5.6 All ductworks including air intake, exhaust air duct, distribution and return air systems shall be constructed of “non-combustible” materials in compliance with BS 476 Part 4 or another standard acceptable to DFS. Unless there is a justifiable reason, this requirement should be generally applied in line with the Building (Ventilating Systems) Regulations (Cap. 123J). Ductwork handling corrosive gas shall be made of corrosion-resistant materials. 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 mechanical ventilation system for gas cabinets and VMBs. If the fan blade is driven by a motor at a position outside air stream, special design shall be incorporated to avoid spilling out of exhaust air through the driving mechanism.

4.5.7 The mechanical ventilation system specified in this Section shall be a system independent of other ventilation systems in the building.

4.5.8 The air intakes shall be so selected as to avoid the draw-in of hazardous materials.

4.5.9 Exhaust air discharged from fabrication areas, special gas rooms, gas cabinets, VMBs, service corridors and workstations shall not be re-circulated.

4.5.10 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 a reverse direction from one compartment or cabinet to another. Due consideration shall be given to the instant pressure change when cabinet door is opened.

4.5.11 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 shall not be permitted.

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

4.5.13 Pyrophoric, flammable, toxic, highly-toxic and corrosive gases should be treated by scrubber before discharged to the atmosphere. The scrubber shall be selected based on the hazard property of the exhaust air. Incompatible gases should be arranged in separate scrubbers. The discharge shall be at a suitable location to meet the EPD's requirement in respect of air pollution control.

4.5.14 Mechanical ventilation system with cross flow effect shall be provided. Extraction points shall be provided at suitable locations for avoidance of accumulating and short-circuiting of the gases with make-up air.

4.5.15 Mechanical ventilation system serving special gas rooms shall not be shut down when fire detection and alarm system or gas detection system is activated.

## 4.6 Natural Ventilation

4.6.1 When natural ventilation is provided in lieu of mechanical ventilation, the following salient points shall be observed.

(a) Natural ventilation shall be achieved by providing fixed and permanent ventilation openings (such as louvres) at high and low levels on external walls of the DG Store to outside open space. The ventilation openings shall have a minimum total effective louvre area equivalent to 1% and not exceeding 3% of the total area of the walls and roof / ceiling of the DG premises;

(b) The low-level ventilation openings shall be situated immediately above the level of door sill;

(c) The ventilation openings shall not be obstructed on either side of any building structures by container stacks, dirt or articles in order to maintain effectiveness of natural ventilation.

## 4.7 Emergency Alarm System

4.7.1 An emergency alarm system shall be provided in the following locations where hazardous materials and special gases are transported and stored in accordance with the requirements of this Section.

(a) Special Gas Room: Manually activated alarm button shall be installed in the vicinity of the special gas room containing highly toxic, toxic pyrophoric, flammable gases;

(b) Service Corridor: Manually activated alarm buttons shall be installed at not more than 45m intervals throughout the transport route.

4.7.2 Activation of the emergency alarm system shall raise a distinctive local audio and visual alarm in the incident room and the area outside of the incident room to alert occupants of an emergency situation involving hazardous materials. The alarm signal shall also be transmitted to the emergency control room in the premises.

## 4.8 Emergency Power System

4.8.1 UPS capable of sustaining full load operation for not less than 6 hours shall be provided for the following systems:

(a) Mechanical Ventilation System;

(b) Fire Suppression System;

(c) Gas Detection System;

(d) Fire Detection System;

(e) Fire Alarm System;

(f) Emergency Alarm System;

(g) Waste Treatment System.

To ensure continuous running of the systems, the UPS can be a combination of static type inverter and diesel generator for reinforcing the power supply reliability.

## 4.9 Electrical Installation and Equipment

4.9.1 Electrical installations inside cleanrooms, pressure receptacle stores, dispensing rooms and workplaces shall follow requirements as stipulated in the Electricity (Wiring) Regulations (Cap. 406E).

4.9.2 All metallic parts of equipment and installations including ventilation 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 Cap. 406E.

4.9.3 An electrostatic discharge device shall be provided at the entrance of the DG Store. While a person's body can become electrostatically charged by friction and natural environmental conditions, the electrostatic discharge device shall be used to prevent the accumulation and accidental discharge of static electricity from the body before such person enters the DG Store.

## 4.10 Emergency Control Room

4.10.1 An emergency control room should be established to facilitate effective monitoring of alarms and signals by personnel. The room should be located to provide FSD quick access to it during emergency responses.

4.10.2 Emergency control room shall be continuously attended by the trained personnel to respond to the various alarms and signals in case of emergency situation.

4.10.3 The alarms and signals of all fire and safety protection systems such as emergency alarm, gas detection, mechanical ventilation systems and emergency power system shall be transmitted to the emergency control room.

4.10.4 Closed circuit television (CCTV) equipment and telephone communication system for the fabrication area shall be provided.

# Part 5 Health and Safety Precautions

## 5.1 General

5.1.1 To reduce the chances of accident incidence, it is essential to establish a safe working system. The system should include, as a minimum, health and safety precautions, emergency procedure, training and auditing. A written operation manual documenting all pertinent elements of such a safe system of work shall be prepared and submitted with the licence application package. Besides, when health and safety precautions are being taken and built into the system, it is advisable to take into account the provisions as stipulated in the Factories and Industrial Undertakings Ordinance (Cap. 59) and Occupational Safety and Health Ordinance (Cap. 509).

5.1.2 The operation manual shall include, but not limited to the following:

(a) Emergency Plan;

(b) Arrangement of Emergency Drill;

(c) Personnel Training;

(d) Emergency Response Team.

5.1.3 Periodic audit shall be carried out to ensure that the objectives of the safe working system are achieved. The operation manual should be periodically reviewed and revised. Additional risk assessment should be conducted to formulate strategies and procedure to mitigate any new or altered risk arising from changes in equipment, facilities, installation, work processes, or storage and use of hazardous substances.

## 5.2 Emergency Plan

5.2.1 Emergency plan shall be prepared to respond fires and other emergencies, and should include the following as minimum:

(a) <u>List of Information</u>

(i) The types of all pieces of emergency equipment available and their locations;

(ii) A brief description of any testing or maintenance programs for the available pieces of emergency equipment;

(iii) An indication that hazard identification labelling is provided for each storage area;

(iv) The location of posted emergency procedures;

(v) A SDS or equivalent for each special gas stored or used on the site;

(vi) A list of personnel who are designated as emergency team;

(vii) A list of the types and quantities of special gases found within the facility;

(viii) Means to prohibit unauthorised entry into the premises;

(ix) The minimum number of staff required to perform duty in the storage areas, fabrication areas and handling of pressure receptacles.

(b) Procedures Required

(i) Procedures to be followed in case of fire or release of gases, such as sounding the alarm, notifying the FSD, evacuating personnel, controlling and extinguishing the fire;

(ii) Procedures and schedules for conducting emergency drills of these procedures;

(iii) Procedures for maintenance and operation of fire protection equipment and systems, drainage and emergency power system and ventilation equipment and systems;

(iv) Procedures for safe shutdown or isolating equipment under emergency conditions and start-up following cessation of emergencies;

(v) Procedures for effective communication between the occupants and estate management of the building in case of emergency.

(c) Written copies of the laid down emergency procedures shall be kept readily available in the emergency control room, fabrication areas and outside the DG stores and shall be updated when conditions change.

## 5.3 Emergency Drills

5.3.1 Emergency drills shall be conducted at least annually.

5.3.2 Records of drills conducted shall be maintained at the emergency control room for a period of not less than one year.

## 5.4 Personnel Training

5.4.1 An employer shall provide training to his employees who are in areas where hazardous materials are stored, dispensed, handled or used.

5.4.2 Training shall be provided to enable personnel to recognize and identify the nature and risk in connection with their work, monitoring procedure, control measures, use of protective clothing and equipment, hazards of the materials employed, actions required by emergency plan, etc. General training shall include, but not limited to:

(a) the marking and labelling of pressure receptacles;

(b) proper procedure for pressure receptacles 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 procedure;

(k) other related contents of the operation manual.

5.4.3 Well planned lecture and practical sessions should be regularly delivered and properly recorded. The content of both sessions should also be updated on a regular basis.

5.4.4 Induction course shall be completed prior to beginning work in the workplace.

5.4.5 Refresher training shall be conducted at least annually.

5.4.6 Training record shall be maintained properly.

5.4.7 When a new hazardous material is introduced into the workplace that presents a new hazard, or new information is obtained pertaining to hazard created by the hazardous material that has not been included in the previous training, and when there are changes in equipment, operation and hazardous materials, additional training shall be provided accordingly.

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

## 5.5 Emergency Response Team

5.5.1 An employer shall designate an emergency response team with appropriate number of personnel round-the-clock to properly implement the actions required under the emergency plan.

5.5.2 The roles of members and the division of labour within the emergency response team must be clearly defined and outlined to ensure the emergency procedures as specified in Section 5.5.4 will be fully and properly implemented by the members on the occurrence of an accident.

5.5.3 For the emergency response team designated in facilities or sites that store and use considerable quantities of special gases, including those used for pilot or mass production of microelectronic products, a person with solid experience and knowledge in emergency management (such as firefighting or chemical leakage handling) shall be responsible for overseeing the administration of the team. This requirement may be waived for small-scale operations involving special gases, such as those performed in university laboratories solely for research purposes.

5.5.4 Emergency procedures shall be recorded in emergency plan. Emergency procedures implemented by members of emergency response team on the occurrence of an accident shall include, but not be limited to:

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

(b) Evacuate people in the premises;

(c) Cut off the hazardous chemical supplies;

(d) Shut down plants and installations;

(e) Stop leaks, control spills and check fires if condition permits;

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

(g) Make available the hazardous substance inventory and respective SDS;

(h) Conduct on-site hazard assessment;

Inform the FSD the prevailing situation and actions taken and advise them on the nature of risks involved and possible hazards.

# Part 6 Quantitative Risk Assessment

## 6.1 General

6.1.1 When the quantity of the dangerous goods stored and used in the microelectronics facility exceeds the exempt quantity (EQ) under Cap. 295, application for a DG store and use licence is required. When properties of special gases are pyrophoric, flammable, corrosive and/or toxic, QRA will be required to ascertain that the risk level posed by the facility concerned would be within acceptable level. Subject to the risk assessment, DFS may, in view of any particular risk associating with the storage and use of special gases, vary any of the provision of standard requirements.

6.1.2 QRA shall be prepared, checked and signed by qualified personnel with professional knowledge and skill in conducting QRA.

6.1.3 A QRA report shall be submitted to FSD. The objective of the QRA report is to provide detailed information of the proposed project with a view to facilitating DFS in deciding on whether or not a licence under Section 6 of Cap. 295 should be granted for the storage and use of special gases used in the microelectronics industry and facility.

6.1.4 The contents of QRA report should include the following information, where appropriate:

(a) Executive Summary – Summary of main issues, findings, conclusions and recommendations;

(b) Introduction – Purpose of the QRA report and the approach;

(c) Description of the Project –

(i) Site location, means of access and evacuation routes;

(ii) Key project requirements including information on types of special gases in storage and use, pressure receptacle adopted, method of conveyance of pressure receptacle from suppliers to the store, routing of supply pipelines and material used for the construction of the store and the gas supply piping;

(iii) Size or scale and design of the project;

(iv) Description of scenarios with the project, existing occupancies and planned development within 100m radius of the proposed facility;

(v) The nature of activities to be carried out in the premises where gases are stored or used.

(d) Description of QRA Methodologies – QRA methodologies, assumptions and criteria, including calculations and inputs and outputs files of a typical model run for all mathematical modelling. QRA methodologies should include contents that cover, but are not limited to, those mentioned in Sections 6.2 to 6.11;

(e) Identification of On-site and Off-site Risk to Life and Properties Impacts;

(f) Mitigation of Risks due to Adverse Situations – Measures to eliminate or reduce the potential risks of life and properties due to adverse situations;

(g) Conclusions and Recommendations;

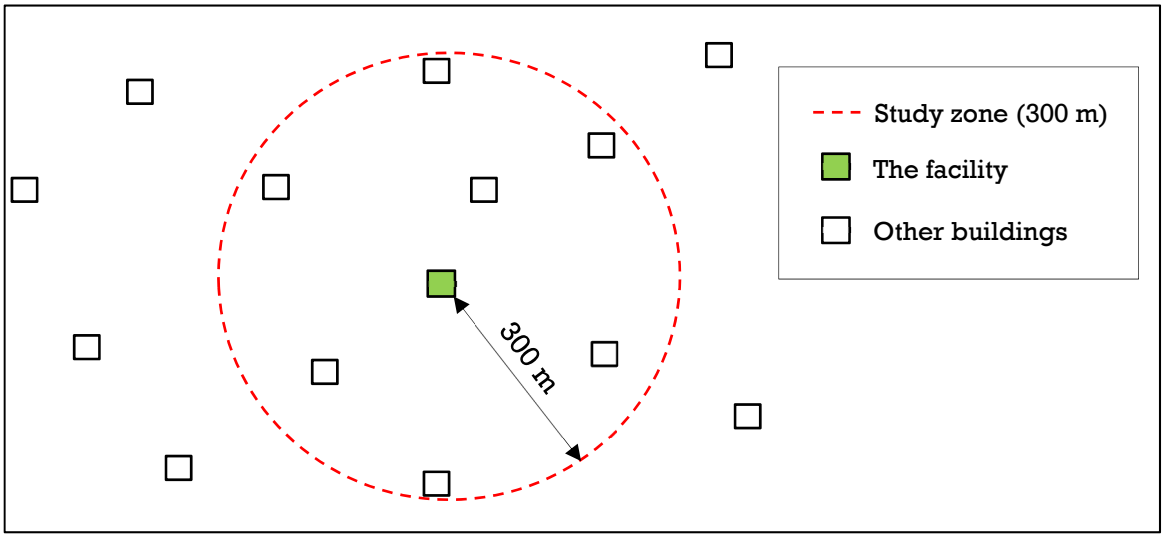
(h) Appendix – Any other information relevant to the project, such as details of past accidents involving special gases.

6.1.5 However, should DFS require any vital or further information other than those included in QRA report, the applicant / project proponent would be requested to submit so for FSD's consideration.

## 6.2 Study Zone for QRA

A study zone should be considered, covering the maximum distance for fatal effects from catastrophic release of the largest section inventory using the consequence models, and a minimum of 300 metres from the facility boundary. An example is illustrated in Figure 6.2. There should be a check at the end of the study that the $1\times10^{-9}$ risk contours lies within the study zone.

Figure 6.2




## 6.3 Meteorological Data

6.3.1 At least six representative weather classes should be considered, covering the stability conditions of stable, neutral and unstable, and wind speeds of low, medium and high. An example of six representative weather classes is provided in Table 6.3.

Table 6.3

| Wind Speed | A | B | B/C | C | C/D | D | E | F |
|---|---|---|---|---|---|---|---|---|
| < 2.5 ms-1 | B medium | | | D low | | | F low | |
| 2.5 - 6 ms-1 | | | | D medium | | | E medium | |
| > 6 ms-1 | | | | D high | | | | |

Note: Low wind speed corresponding to < 2.5 $ms^{-1}$

Medium wind speed corresponding to 2.5 $ms^{-1}$ – 6 $ms^{-1}$

High wind speed corresponding to > 6 $ms^{-1}$

At least six representative weather classes should be

6.3.2 Wind speeds are in unit of metres per second ($ms^{-1}$) while the atmospheric stability classes are referred to the following definition:

A - Very Unstable

B - Moderately Unstable

C - Slightly Unstable

D - Neutral

E - Slightly Stable

F - Stable

## 6.4 Population

At least the following two major types of population within the study area should be considered.

(a) Building population

Building population includes the subject building, adjacent residential, commercial, industrial buildings, etc.

(b) Transient population

Transient population includes road traffic population and pedestrian population.

Since population varies in different time periods, the assessment should consider at least two categories of days (weekdays and weekends), and four time periods of each day (morning peak traffic hours, daytime, afternoon traffic hours and night time).

## 6.5 Hazard Identification

All potential failure scenarios and hazard outcomes related to the facility concerned should be identified and considered. Some examples are provided below, without being exhaustive.

Failure Scenarios

- Rupture of piping, containers, etc.
- Leakage of piping, instruction connections, etc.
- Failure of ventilation and exhaust treatment systems, etc.

Hazard Outcomes

- Fireball
- Jet fire
- Flash fire
- Toxic gas dispersion

## 6.6 Failure Frequency

Failure frequency should be reviewed and considered with reference to internationally recognised sources of information including research papers, statistics, guidelines, etc.

## 6.7 Consequence Analysis

Consequence analysis should be performed to explain the development of hazard outcome from initial release to various events depending on whether there is an immediate or delayed ignition. It can be presented by an event tree to show possible outcomes following immediate and delayed ignition.

(a) Ignition Probability

Both immediate and delayed ignitions should be considered. The ignition probability should be made reference to internationally recognised sources of information including research papers, statistics, guidelines, etc.

(b) Consequence Modelling

Consequence modelling should be conducted by industrially recognised and validated software. The consequence results of all identified hazard outcomes should be determined. Hazardous impact distance caused by the hazard outcomes and the associated impacts should be evaluated.

## 6.8 Risk Summation

Risk summation should be conducted by industrially recognised and validated software to generate the risk levels associated with the facility in terms of Individual Risk and Societal Risk.

## 6.9 Risk Criteria

6.9.1 The acceptability of the risks is evaluated in terms of Individual Risk and Societal Risk. Reference could be made to Section 4.4, Chapter 12 of Hong Kong Planning Standards and Guidelines.

(a) Individual Risk

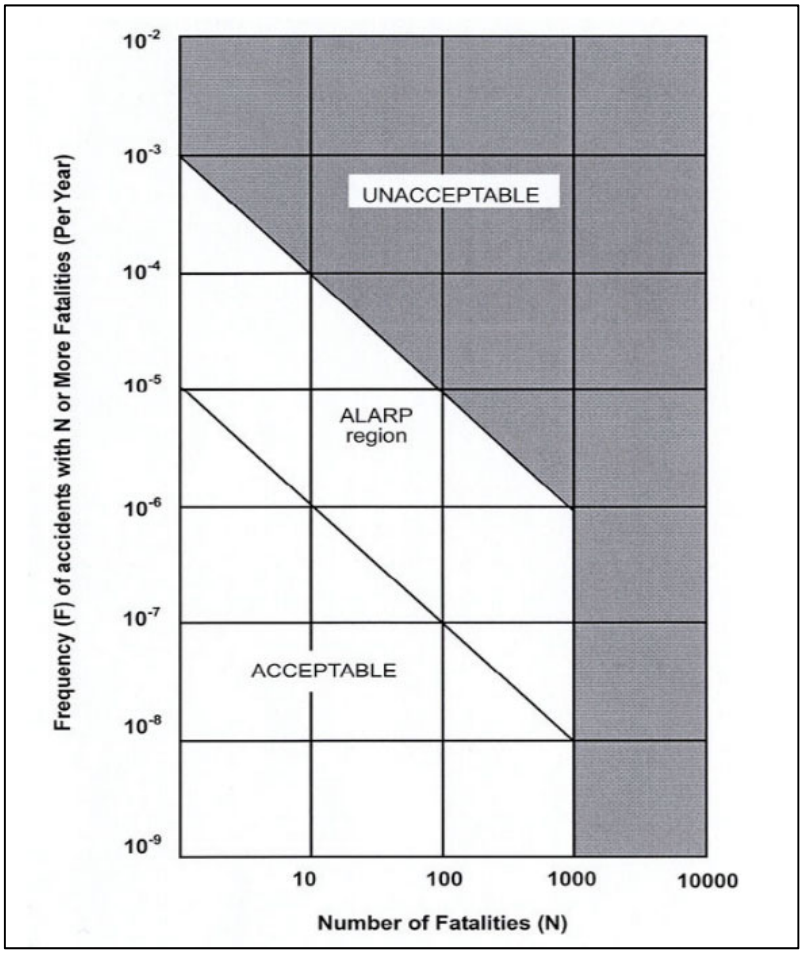
Individual Risk is the predicted increase in the chance of death per year to an individual who lives or works near to the facility. Individual Risk is often shown on a map of the area surrounding the facility as contours of equal risk which decrease according to distance from the facility. Maximum level of off-site individual risk associated with the facility should not exceed 1 in 100,000 per year i.e. $1x10^{-5}$/year.

(b) Societal Risk

Societal Risk expresses the risks to the whole population living near the facility. It is expressed in terms of lines plotting the cumulative frequency (F) of N or more deaths in the population from incidents at the installation. The societal RG is presented graphically in Figure 6.9.

Two F-N risk lines are used in the RG that mark “acceptable” or “unacceptable” societal risks. The intermediate region indicates the acceptability of societal risk is borderline and should be reduced to a level which is “as low as is reasonably practicable” (ALARP). It seeks to ensure that due consideration will be given to adopting all practicable and cost effective measures that can reduce risk.

Figure 6.9




## 6.10 Study Findings

The risks in terms of Individual Risk and Societal Risk should be summarised. Apart from Individual Risk and Societal Risk, value of Potential Loss of Life should also be presented to identify the highest risk special gases. Mitigation measures should be proposed, where necessary.

## 6.11 Mitigation Measures

If Societal Risk falls into ALARP region, mitigation measures should be considered and proposed, and mitigated risk should be evaluated.

# Appendix A -
# List of Special Gases (Non-exhaustive)

List of Special Gases (Non-exhaustive)

| Chemical Formula | Product Name (GAS) | UN Number | Proper Shipping Name/ Packing Group (if any) | Class | Subsidiary Hazard | General Exempt Quantity | Industrial Exempt Quantity | Special Exempt Quantity | Specification | Supplementary Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| $NH_3$ | Ammonia | 1005 | AMMONIA, ANHYDROUS | 2.3 | 8 | 25 | 50 | None | - | None |
| $AsF_5$ | Arsenic pentafluoride | 1955 | COMPRESSED GAS, TOXIC, N.O.S. | 2.3 | None | None | None | None | - | The proper shipping name can be supplemented with the technical name. |
| $AsH_3$ | Arsine | 2188 | ARSINE | 2.3 | 2.1 | None | None | None | - | None |
| $AsH_3$ | Arsine (adsorbed) | 3522 | ARSINE, ADSORBED | 2.3 | 2.1 | None | None | None | - | None |
| $BCl_3$ | Boron trichloride | 1741 | BORON TRICHLORIDE | 2.3 | 8 | None | None | None | - | None |
| $BF_3$ | Boron trifluoride | 1008 | BORON TRIFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $BF_3$ | Boron trifluoride (adsorbed) | 3519 | BORON TRIFLUORIDE, ADSORBED | 2.3 | 8 | None | None | None | - | None |
| $CH_3Br$ | Bromomethane (R40B1)/ Methyl Bromide | 1062 | METHYL BROMIDE | 2.3 | None | 25 | 50 | None | With not more than 2% chloropicrin | None |
| $C_4H_6$ | 1,3-Butadiene | 1010 | BUTADIENES, STABILIZED or BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED | 2.1 | None | 75 | 150 | None | Containing more than 40% butadienes | None |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CO | Carbon monoxide | 1016 | CARBON MONOXIDE, COMPRESSED | 2.3 | 2.1 | None | None | None | - | None |
| $COF_2$ | Carbonyl fluoride | 2417 | CARBONYL FLUORIDE | 2.3 | 8 | None | None | None | - | None |
| COS | Carbonyl sulphide | 2204 | CARBONYL SULPHIDE | 2.3 | 2.1 | None | None | None | - | None |
| $Cl_2$ | Chlorine | 1017 | CHLORINE | 2.3 | 5.1, 8 | None | None | None | - | None |
| $Cl_2$ | Chlorine (adsorbed) | 3520 | CHLORINE, ADSORBED | 2.3 | 5.1, 8 | None | None | None | - | None |
| $ClF_5$ | Chlorine pentafluoride | 2548 | CHLORINE PENTAFLUORIDE | 2.3 | 5.1, 8 | None | None | None | - | None |
| $ClF_3$ | Chlorine trifluoride | 1749 | CHLORINE TRIFLUORIDE | 2.3 | 5.1, 8 | None | None | None | - | None |
| $C_2ClF_3$ | Chlorotrifluoroethylene (R1113) | 1082 | TRIFLUOROCHLOROETHYLENE, STABILIZED (also known as REFRIGERANT GAS R1113) | 2.3 | 2.1 | None | None | None | - | None |
| $C_2N_2$ | Cyanogen | 1026 | CYANOGEN | 2.3 | 2.1 | None | None | None | - | None |
| CNCl | Cyanogen chloride | 1589 | CYANOGEN CHLORIDE, STABILIZED | 2.3 | 8 | None | None | None | - | None |
| $B_2H_6$ | Diborane | 1911 | DIBORANE | 2.3 | 2.1 | None | None | None | - | None |
| $SiH_2Cl_2$ | Dichlorosilane | 2189 | DICHLOROSILANE | 2.3 | 2.1, 8 | None | None | None | - | None |
| $Si_2H_6$ | Disilane | 1954 | COMPRESSED GAS, FLAMMABLE, N.O.S. | 2.1 | None | 75 | 150 | None | - | The proper shipping name can be supplemented with the technical name. |
| $C_2H_4O$ | Ethylene oxide | 1040 | ETHYLENE OXIDE, or ETHYLENE OXIDE WITH NITROGEN | 2.3 | 2.1 | 25 | 50 | None | Up to a total pressure of 1 MPa (10 bar) at 50°C | None |

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|---|---|---|---|---|---|---|---|---|---|---|
| $F_2$ | Fluorine | 1045 | FLUORINE, COMPRESSED | 2.3 | 5.1, 8 | None | None | None | - | None |
| $GeH_4$ | Germane | 2192 | GERMANE | 2.3 | 2.1 | None | None | None | - | None |
| $GeH_4$ | Germane (adsorbed) | 3523 | GERMANE, ADSORBED | 2.3 | 2.1 | None | None | None | - | None |
| $C_3F_6O$ | Hexafluoroacetone | 2420 | HEXAFLUOROACETONE | 2.3 | 8 | None | None | None | - | None |
| $H_2$ | Hydrogen | 1049 | HYDROGEN, COMPRESSED | 2.1 | None | 75 | 150 | None | | None |
| HBr | Hydrogen bromide | 1048 | HYDROGEN BROMIDE, ANHYDROUS | 2.3 | 8 | None | None | None | - | None |
| HCl | Hydrogen chloride | 1050 | HYDROGEN CHLORIDE, ANHYDROUS | 2.3 | 8 | None | None | None | - | None |
| HI | Hydrogen iodide | 2197 | HYDROGEN IODIDE, ANHYDROUS | 2.3 | 8 | None | None | None | - | None |
| $H_2Se$ | Hydrogen selenide, adsorbed | 3526 | HYDROGEN SELENIDE, ADSORBED | 2.3 | 2.1 | None | None | None | - | None |
| $H_2Se$ | Hydrogen selenide, anhydrous | 2202 | HYDROGEN SELENIDE, ANHYDROUS | 2.3 | 2.1 | None | None | None | - | None |
| $H_2S$ | Hydrogen sulphide | 1053 | HYDROGEN SULPHIDE | 2.3 | 2.1 | None | None | None | - | None |
| $H_2Te$ | Hydrogen telluride | 3160 | LIQUEFIED GAS, TOXIC, FLAMMABLE, N.O.S. | 2.3 | 2.1 | None | None | None | - | The proper shipping name can be supplemented with the technical name. |
| $CH_4S$ | Methyl mercaptan | 1064 | METHYL MERCAPTAN | 2.3 | 2.1 | None | None | None | - | None |
| NO | Nitric oxide | 1660 | NITRIC OXIDE, COMPRESSED | 2.3 | 5.1, 8 | None | None | None | - | None |

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|---|---|---|---|---|---|---|---|---|---|---|
| $NO_2$ | Nitrogen dioxide | 1067 | DINITROGEN TETROXIDE (also known as NITROGEN DIOXIDE) | 2.3 | 5.1, 8 | None | None | None | - | None |
| NOCl | Nitrosyl chloride | 1069 | NITROSYL CHLORIDE | 2.3 | 8 | None | None | None | - | None |
| $COCl_2$ | Phosgene | 1076 | PHOSGENE | 2.3 | 8 | None | None | None | - | None |
| $PH_3$ | Phosphine | 2199 | PHOSPHINE | 2.3 | 2.1 | None | None | None | - | None |
| $PH_3$ | Phosphine (adsorbed) | 3525 | PHOSPHINE, ADSORBED | 2.3 | 2.1 | None | None | None | - | None |
| $PF_5$ | Phosphorus pentafluoride | 2198 | PHOSPHORUS PENTAFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $PF_5$ | Phosphorus pentafluoride (adsorbed) | 3524 | PHOSPHORUS PENTAFLUORIDE, ADSORBED | 2.3 | 8 | None | None | None | - | None |
| $PF_3$ | Phosphorus trifluoride | 1955 | COMPRESSED GAS, TOXIC, N.O.S. | 2.3 | None | None | None | None | - | The proper shipping name can be supplemented with the technical name. |
| $SeF_6$ | Selenium hexafluoride | 2194 | SELENIUM HEXAFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $SiH_4$ | Silane | 2203 | SILANE | 2.1 | None | 75 | 150 | None | - | None |
| $SiF_4$ | Silicon tetrafluoride | 1859 | SILICON TETRAFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $SiF_4$ | Silicon tetrafluoride (adsorbed) | 3521 | SILICON TETRAFLUORIDE, ADSORBED | 2.3 | 8 | None | None | None | - | None |
| $SbH_3$ | Stibine | 2676 | STIBINE | 2.3 | 2.1 | None | None | None | - | None |
| $SF_4$ | Sulphur tetrafluoride | 2418 | SULPHUR TETRAFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $SO_2F_2$ | Sulphuryl fluoride | 2191 | SULPHURYL FLUORIDE | 2.3 | None | None | None | None | - | None |
| $SO_2$ | Sulphur dioxide | 1079 | SULPHUR DIOXIDE | 2.3 | 8 | 25 | 50 | None | - | None |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $WF_6$ | Tungsten hexafluoride | 2196 | TUNGSTEN HEXAFLUORIDE | 2.3 | 8 | None | None | None | - | None |
| $C_2H_3Cl$ | Vinyl chloride (R1140) | 1086 | VINYL CHLORIDE, STABILIZED | 2.1 | None | 75 | 150 | None | - | None |