

## FIRE SAFETY REQUIREMENTS FOR CHEMICAL/HAZMAT WAREHOUSES

### 1 SCOPE

Chemicals or hazardous materials (hazmat) have a wide range of properties and hazards which must be identified and understood in order to fulfill the requirements of safe warehousing. A complete understanding of the hazards requires an assessment of the container and packaging systems and storage arrangements. In addition, the requirements of general warehouse shall be complied with.

Note: The fire safety requirements for laboratory storing and using chemicals/hazmat shall be in accordance with NFPA 45 [except for the Maximum Allowable Quantity (MAQ) which shall be as stipulated in Table 2 & 3 of this Guideline]. Refer to SCDF's Web-site for more comprehensive details.

### 2 IDENTIFICATION OF HAZARDOUS MATERIALS (HAZMAT)

2.1 Substances listed as hazardous materials are classified as follows:

Class	Type of Hazmat
1	Explosives (1.1 to 1.6)
2.1	Flammable gas
2.2	Non-flammable compressed gas
2.3	Poisonous gas
3	Flammable and combustible liquid
4.1	Flammable solid
4.2	Substance liable to spontaneous combustion
4.3	Substance which, dangerous when contact with water
5.1	Oxidizer
5.2	Organic peroxide
6.1	Poisonous substance
6.2	Infectious substance (etiologic agent)
7	Radioactive material Category I
	Radioactive material Category II
	Radioactive material Category III
8	Corrosive material
9	Miscellaneous hazardous material (dangerous sub-substance)

Note: Consultation with FSSD shall be sought at the initial stage (Quantitative Risk Assessment study may be required by the Hazmat Dept of SCDF) and, at the stage of finalising for further comment and concurrence before the formal plan submission under the Self-Regulation Scheme. QP shall obtain the technical requirements from other relevant agencies first before consulting FSSD especially for the followings classes of hazardous materials:

- **SPF** for Class 1
- **NEA** for Class 2.3, 3, 6.1, 6.2, 7 & 8
- **MOH** for Class 6.2 (Health Sciences Authority, HSA) & Class 7 (Centre for Radiation Protection under HSA);

### 3 SIZE LIMITATION

3.1 For chemical/hazmat warehouses storing Class 3, 4 & 5 hazardous materials, the maximum floor area per compartment and type of fire protection system shall as follows:

Hazard Grade	Maximum Fire Compartment Size (m <sup>2</sup> )			
	K1	K2	K3	K4
3 & 4	≤ 50 m <sup>2</sup>	≤ 200 m <sup>2</sup>	≤ 600 m <sup>2</sup>	≤ 900 m <sup>2</sup>
2	≤100 m <sup>2</sup>	≤ 400 m <sup>2</sup>	≤2,400 m <sup>2</sup>	≤3,600 m <sup>2</sup>
1	≤400 m <sup>2</sup>	≤2,000 m <sup>2</sup>	**	**

Type	Provision of Fire Protection System	
K1	Relatively small structure & low fire risk	Manual fire alarm with DECAMS system
K2	Automatic surveillance	Automatic fire detection with DECAMS system
K3	Automatic fire suppression system	Automatic sprinkler (CP52) with DECAMS system
K4	Automatic extinguishing system (foam system)	Automatic foam sprinkler with DECAMS system

Note:

- (i) Refer to **Table 1** for hazard grade classification;
  - (ii) The required fire protection system is only restricted to the chemical/hazmat warehouse fire compartment. However, automatic fire detectors (linked to DECAMS) shall also be provided along the perimeter of the fire compartment wall if the building housing the hazmat warehouse is not protected with the automatic or the sprinkler system (it is only applicable where the warehouse is directly connected to other occupied area within the building through access opening);
  - (iii) The fire rating of the fire compartment wall shall be minimum 2 hours regardless of the type of fire protection system. For Class 3 hazmat storage, it shall be masonry construction except the ceiling (all floor element above such hazmat storage shall be masonry construction with minimum of 2 hours rating) may use fire rated board but to comply fully with the M&E riser shaft requirements;
  - (iv) Different classes and incompatible hazmat shall be stored in separate fire compartment with minimum 2 hours fire rating;
  - (v) No basement floor is allow to store Hazardous materials;
  - (vi) The compartment size limit and type of fire protection system for Class 2 Hazmat shall follow Hazard Grade 1 requirements;
  - (vii) Fire rated roller shutter is not allowed for the purpose to limit the compartment size control; any fire rated roller shutter at the access opening shall be activated by either local automatic smoke detection system or/and the general building automatic fire alarm system;
- \*\* No specific limit but to comply with the fire safety requirements for general warehouse.

- 3.2 Storage of compressed gases (Class 2), flammable liquid (Class 3), flammable solid (Class 4.2 & 4.3), oxidizing agent (Class 5.1) and organic peroxide (Class 5.2) shall be located only at the ground floor with at least one external wall facing directly to a exterior open safe space unless otherwise stipulated;
- 3.3 Solid materials (Class 4.1) is allowed to be stored at aboveground floors of habitable height not more than 24m and the storage quantity shall be limited to 1,200kg/m<sup>2</sup> of floor area.
- 3.4 Compressed gas cylinders (Class 2) are allowed to be stored at aboveground floors of habitable height not more than 24m provided that a vehicular ramp (with turning facility) suitable for 24 ton fire engine is erected for direct access to the storage area.
- 3.5 For Class 2 hazardous materials, no stacking is allowed. The hazardous materials shall be laid directly on the floor.
- 3.6 Storage, use and handling of compressed gases (Class 2) shall be in compliance with NFPA 55 and it may allow be located at aboveground floor.
- 3.7 For sprinkler protected warehouse, the storage height shall be limited to 18m for single-storey warehouse and 15m for warehouse that is located at 1<sup>st</sup> storey of a multiple-storey building. For non-sprinkler protected warehouse storing Class 3 hazardous materials, the storage height shall be in compliance with NFPA 30 (basing on the flashpoints of the hazardous materials), subject to a maximum height of 3.6m.
- 3.8 Storage of oxidizers (Class 5.1, solid or liquid) shall be in compliance with NFPA 430 or AS 4326.
- 3.9 Storage of organic peroxide (Class 5.2) shall be in compliance with NFPA 432 or AS 2714.
- 3.10 No compartment in the chemical/hazmat warehouse shall comprise more than one storey.
- 3.11 Recommendations made within the individual Material Safety Data Sheet (MSDS) shall be complied with.
- 3.12 An approved layout plan (with the relevant TFP/FSC) with such hazmat warehouse/storage clearly highlighted shall be kept within the premises to facilitate the inspection and emergency operation procedures.

## 4 PROVISION OF ACCESSWAY

Fire engine accessway shall be provided for fire fighting appliances. The length of the accessway, based on the gross cubical extent of the entire warehouse space, shall be as follows:

### Non-Sprinkler Protected

Cubicle Extent	Length of Accessway
<7,100m <sup>3</sup>	$\frac{1}{6}$ perimeter (min 15m)
<14,200m <sup>3</sup>	$\frac{1}{4}$ perimeter
<28,400m <sup>3</sup>	$\frac{1}{2}$ perimeter
<42,400m <sup>3</sup>	$\frac{3}{4}$ perimeter
>42,400m <sup>3</sup>	island site access

### Sprinkler Protected

Cubicle Extent	Length of Accessway
<14,200 m <sup>3</sup>	$\frac{1}{6}$ perimeter (min 15m)
<28,400m <sup>3</sup>	$\frac{1}{4}$ perimeter
<42,400m <sup>3</sup>	$\frac{1}{2}$ perimeter
<56,800m <sup>3</sup>	$\frac{3}{4}$ perimeter
>56,800m <sup>3</sup>	island site access

- 4.2 At least one external wall of the warehouse shall be directly fronting an empty space (such as turf area) of minimum width 2m. One of the access doors provided along this external wall shall be placed not more than 30m (for type K1) or 15m (for type K2) from the fire engine access road or accessway for ease of fire-fighting.
- 4.3 For K3 and K4 compartment, at least one external wall shall be directly fronting an engine access road or accessway. At least two exit access doors (minimum 15m apart) shall be provided along this external wall for ease of fire-fighting.
- 4.4 The loading and unloading (the area may be roofed over) shall be carried out directly from the exterior open space for type K2, K3 and K4 compartments.
- 4.5 For type K1 compartment, the distance from the external loading/unloading area (may be roofed over) to the access door of the compartment shall not be more than 10m for non-sprinkler protection building and 15m for sprinkler protection building. For Class 3 hazardous materials, the maximum volume of hazardous liquid shall be limited to 3,000L or 5,000L for non-sprinkler and sprinkler protected compartment respectively;
- 4.6 For storage of Class 4.1 hazardous materials aboveground level, fire engine accessway and the associated FAPs shall be provided for the full stretch of the external wall of the storage area.

## **5 WATER SUPPLY FOR PRIVATE HYDRANT**

- 5.1 Water supply for hydrant system shall comply with the following requirements:
- (a) Hydrant fed by PUB mains is allowed for type K1 and K2 compartments. The water supply requirement shall comply with the clause 4.4.2(a) of the Fire Code.
  - (b) Hydrant with dedicated pumping & storage facilities shall be provided for type K3 and K4 compartment. The water supply requirement shall comply with the Table 4.4.2(a) of the Fire Code with minimum running pressure of 3.5 bars (it shall be designed accordingly to individual emergency respond plan and respective SOP).
- 5.2 The spillage control and retention basin for fire fighting water for warehouse storage hazardous substances shall be in accordance with SS 532 , NEA requirements and NFPA 30. Gate valve(s) shall be provided from the second containment (such as bund wall) at a safe location to allow the fire-fighters to operate during emergency and, the outlet shall be directly drained to a safe area or storm drain.

## **6 MECHANICAL VENTILATION SYSTEMS**

- 6.1 The ventilation systems for warehouse storing Class 3 hazardous materials shall comply with SS 532 and the smoke control system shall comply with the requirements for general warehouse.
- 6.2 The ventilation system for Class 2 shall comply with NFPA 55;
- 6.3 Mechanical ventilation system for removal of vapour shall be interlocked with the smoke control system to ensure that both systems will not be affecting one another.
- 6.4 The ventilation system shall be designed to provide air-movement across all portions of the room to prevent the accumulation of vapours. Short-circuiting of the mechanical ventilation system shall be avoided.
- 6.5 Fresh air inlets and exhaust outlets shall be properly located according to the type of gases or vapours to be exhausted.

Note: The air-conditioning system and M/V system for the storage area of hazmat shall not be shared with other occupied area.

## **7 FIRE EXTINGUISHER**

- 7.1 Fire extinguisher shall be provided complying with CP 55, SS532 and other related standards. Please also refer to the relevant MSDS and consult the manufacturer or supplier for the details.
- 7.2 Additional mobile type 50kg ABC (foam or chemical powder) fire extinguishers having minimum 6m throw and the discharge hose length of minimum 6m shall be provided to cover the loading and unloading area for K2, K3 and K4 compartment under hazard grade 2, 3 & 4. The access from any remote point of the loading / unloading area (including the parking lots area) to the 50kg fire extinguishers shall not be more than 15m.
- 7.3 For K1 compartment size, mobile type 50kg fire extinguisher shall only be required when the overall Hazmat storage area is more than 100m<sup>2</sup>.

## **8 DETERMINATION OF EXIT REQUIREMENT**

- 8.1 The determination of travel distance in chemical/hazmat warehouse shall be in compliance with Table 2.2 A of the Fire Code for high hazard occupancy, 10m/20m for non-sprinkler building and 20m/35m for sprinkler protected building.
- 8.2 All exit and access doors shall be provided with the proper hazard and warning sign on both sides of these doors.

## **9 OTHER FIRE SAFTY REQUIREMENTS**

- 9.1 The following standards and codes of practices (may not be exhaustively listed) shall be complied with for the proposed chemical/hazmat warehouse:
- a) CP 10 : Code of Practice for the Installation and Servicing of Electrical Fire Alarm System
  - b) CP 29 : Code of Practice for Fire Hydrant Systems and Hose Reels
  - c) CP 52 : Code of Practice for Automatic Fire Sprinkler System
  - d) CP 55 : Code of Practice for Use and Maintenance of Portable Fire Extinguishers
  - e) SS 98 : Preparation and use of Material Safety Data Sheets (MSDS)
  - f) SS 254: Electrical Apparatus for explosive Gas Atmosphere
  - g) SS 286 :Classification and class labels for hazardous substances
  - h) SS 532 : Storage of Flammable and Combustible Liquids
  - i) NFPA 16A : Foam-Water Sprinkler and Spray Systems
  - j) NFPA 45 : Fire Protection for Laboratories Using Chemicals  
(refer to Table 2 & 3 for the MAQ)
  - k) NFPA 55 : Compressed Gases & Cryogenic Fluids
  - l) NFPA 70 : National Electrical Code
  - m) NFPA 430 : Liquid and Solid Oxidizers
  - n) NFPA 432 : Storage of Organic Peroxide
  - o) NFPA 495 : Explosive Materials Code
  - p) NFPA 704 : Identification of the Hazards of Materials
  - q) AS 2714 : The storage and handling of hazardous chemical materials –  
Class 5.2 substances (organic peroxides)
  - r) AS 4326 : The storage and handling of oxidizing agents

**Table1: Hazard Grade Classification**

Hazard Classification		Hazard Grade				
		4	3	2	1	0
Liquids	Class 3	category I & 2 Flash point < 23° C	category 3 Flash point 23 - 60° C	category 4 Flash point between 60 - 150° C	Flash point > 150° C	Only burns with supporting fire
Solid Materials	Class 4	Ignites very easily and burns rapidly	Ignites and burns rapidly	Readily combustible	Moderately combustible	Combustible only with supporting fire
Oxidizing Agent	Class 5.1	class 4 Vary strong oxidizing agent (may classified under explosive substance)	class 3 Strong oxidizing agent	class 2 Weak oxidizing agent	-	-
Oxidizing Peroxide	Class 5.2	class I	class II	class III	class IV	class V

Note:

- i) For flammable gases (Class 2), the LFL (or LEL) is less than 13% or the flammability range is greater than 12
- ii) Classification and the respective hazard grades may subject to change in accordance with the international standards such as ISO, UN or GHS (Globally Harmonized System of Classification & Labelling of chemicals).

**Table 2: Maximum Allowable Quantities (MAQ) in Laboratory for Liquid**

Lab Unit	Excluding Qty in Cabinet	Including Qty in Cabinet
	Max Qty (L, litres per Lab Unit floor area)	Max Qty (L, litres per Lab Unit floor area)
Laboratory	(i) 50L or (ii) 1.6L/m <sup>2</sup> and not more than 350L {500L}  should portion of liquid stored/used is cat 1 & 2, it shall be limited to  (i) 20L or (ii) 0.8L/m <sup>2</sup> and not more than 250L {350L}	(i) - (ii) 3.2L/m <sup>2</sup> and not more than 750L {1000L}  should portion of liquid stored/used is cat 1 & 2, it shall be limited to  (i) - (ii) 1.6L/m <sup>2</sup> and not more than 500L {750L}
Laboratory (in hospital and health care occupancy)	(i) 10L or (ii) 0.4 L/m <sup>2</sup> and not more than 150L (250L)  should portion of liquid stored/used is cat 1 & 2, it shall be limited to  (i) 5L or (ii) 0.4 L/m <sup>2</sup> and not more than 150L (250L)	(i) - (ii) 0.8L/m <sup>2</sup> and not more than 250L {500L}  should portion of liquid stored/used is cat 1 & 2,it shall be limited to  (i) - (ii) 0.8L/m <sup>2</sup> and not more than 250L {500L}

Note:

- i) Individual lab unit shall be a fire compartment;
- ii) Each safety cabinet is still restricted to max of 250L (to comply with SS 532);
- iii) { } is referring to the maximum allowable quantities for sprinkler protected building;
- iv) Laboratory operators are strongly advised and encouraged to minimize their amount of flammable liquids on benches by returning them to chemical store or safety cabinets (UL, FM or PSB listed product) when the liquid are not needed for the day. The quantity of these liquid placed on benches and fume cupboards shall not exceed 10% of the total allowable storage capacity within the lab unit. Liquids used for running and operating laboratory instruments or other work-in-progress which may require some quantities of solvents to operate are exempted from the 10% limit.



**Table 3: Maximum Allowable Quantities (MAQ) in Laboratory for Gases**

Item	Types of Gases	MAQ (L, litres per Lab Work Floor Area with sprinkler protection)
1	Flammable gasses	(i) 170 L or (ii) 3.4 L/m <sup>2</sup> per cluster
2	Oxidizing gasses	(i) 170 L or (ii) 3.4 L/m <sup>2</sup> per cluster
3	Liquefied flammable gasses*	(i) 30 L or (ii) 0.6 L/m <sup>2</sup> per cluster
4	Toxic gasses	(i) 8L or (ii) 0.16 L/m <sup>2</sup> per cluster

Note:

- i) The capacity in litres (L) is referred to the internal volume (water capacity) of the gas cylinder;
  - ii) Lab Work Area is not necessary be individual fire compartment but shall be housed within a lab unit;
  - iii) For item 1 to 3, the MAQ shall be halved for those building which is not protected with sprinkler system;
  - iv) Item 1 to 4 may be accommodated in a single cluster and be spaced at least 3 m apart from each cluster (6 m for building without sprinkler protection);
  - v) To comply with NFPA 45 for others requirements such as the ventilation (4 & 8 A/C), hazard identification and "No Smoking" signs etc;
  - vi) The provision of sprinkler system shall be designed under the Ordinary Hazard Group 3 Special (CP52);
  - vii) No combustible materials shall be placed within 3m buffer range of the gas cylinder;
  - viii) No flammable or combustible liquid shall be placed within 6m buffer range of the gas cylinder;
  - ix) For storage and handling of Class 2 hazmat in enclosed space (including the concealed space of raised floor and ceiling), metal pipe sleeve and gas leak detection system shall be provided to reduce the accumulation of gases and vapours that may cause danger to occupant, building and emergency response team. Oxygen-level monitoring system shall be provided to prevent the possibility of oxygen-deletion (Asphyxiation) within the room;
  - x) The air-conditioning system and M/V system for laboratory unit shall not be shared with other occupied area.
- \* For LPG cylinders, only 2 x 4.5kg cylinders are allow for each lab unit.