

SINGAPORE CIVIL DEFENCE FORCE

Technical Guidelines & Fire Safety Requirements For Laboratories Handling Chemicals



Scope

- **Introduction**
- **General fire safety requirements for Laboratory handling chemicals**
- **Specific fire safety provisions of BSL 3 or 4**
- **Conclusion**

Classification of Hazard

Class	Description
1	Explosives
2	Flammable Gases [LPG, Hydrogen]
3	Flammable Liquids [Acetone, Benzene]
4	Flammable Solids [Phosphorus, Magnesium]
5	Oxidizing Substances [Benzoyl peroxide, Ether peroxide]
6	Poisonous Material
7	Radioactive Material
8	Corrosive Material
9	Miscellaneous

Class 2 Flammable Gases

Clause 2.1 – Flammable gases

Clause 2.2 – Non-flammable gases

Clause 2.3 – Poisonous (toxic) gases

Class 3 Flammable Liquids

Class 4 Flammable Solids

Clause 4.1 – Flammable solids

Clause 4.2 – Substances liable to spontaneous combustion

Clause 4.3 – Substances which, on contact with water, emit flammable gases

Class 5 Organic Peroxides

Clause 5.1 – Oxidizing agents

Clause 5.2 – Organic peroxides

Class 6 Poisonous Material

Class 6.1 – Poisonous substances

Class 6.2 – Infectious substances

Relevant Base Standards

➤ **CP40**

The storage of Flammable and Combustible Liquids

➤ **NFPA 55**

Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks



NFPA 45
Fire Protection for Laboratories
Using Chemicals

NFPA 45 as the Base Design for Laboratory

**NFPA 45
Fire Protection for Laboratories
Using Chemicals**

Objective and Terminology

- Fire is contained to the room of origin, within a single Laboratory Unit
- **Lab Units** shall be fire compartmented from each other and non-lab areas

NFPA 45 – Some Definitions & Requirements

(Standard on “Fire Protection for Laboratories Using Chemicals”)

➤ **Laboratory Unit** – An enclosed space used for experiments or tests

- ❖ A Lab Unit can include ancillary offices, toilet, etc and contain one or more separate Lab Work Areas
- ❖ 2 hrs fire rated enclosure in Non-Sprinkler protected premises or
- ❖ 1 hr fire rated enclosure in Sprinkler protected premises

➤ **Laboratory Work Area** – a space within the Lab Unit for testing, analysis, research or similar activities that involve the use of Chemicals.

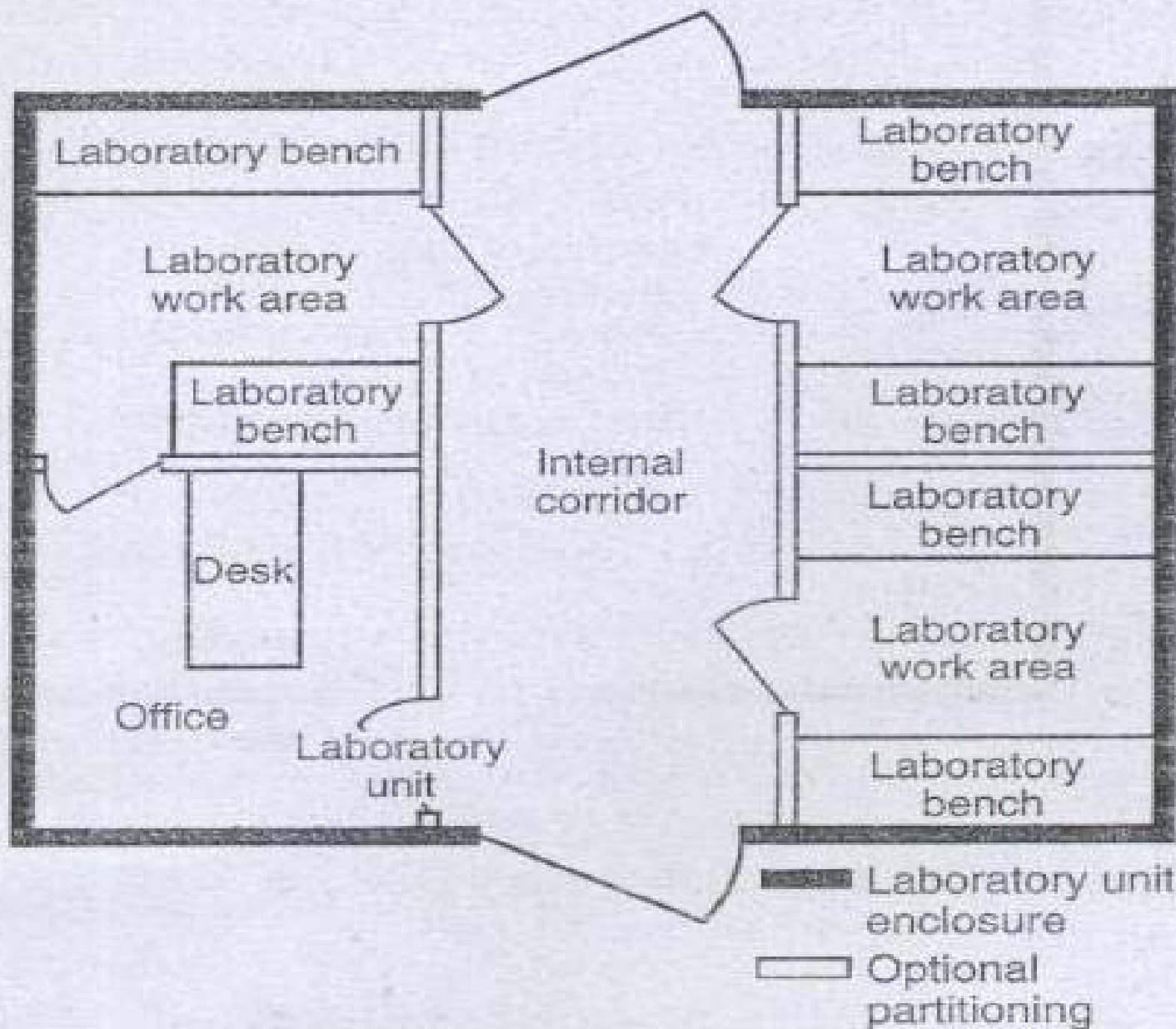


FIGURE D.2.4(c) Laboratory Unit with Optional Partitioning.

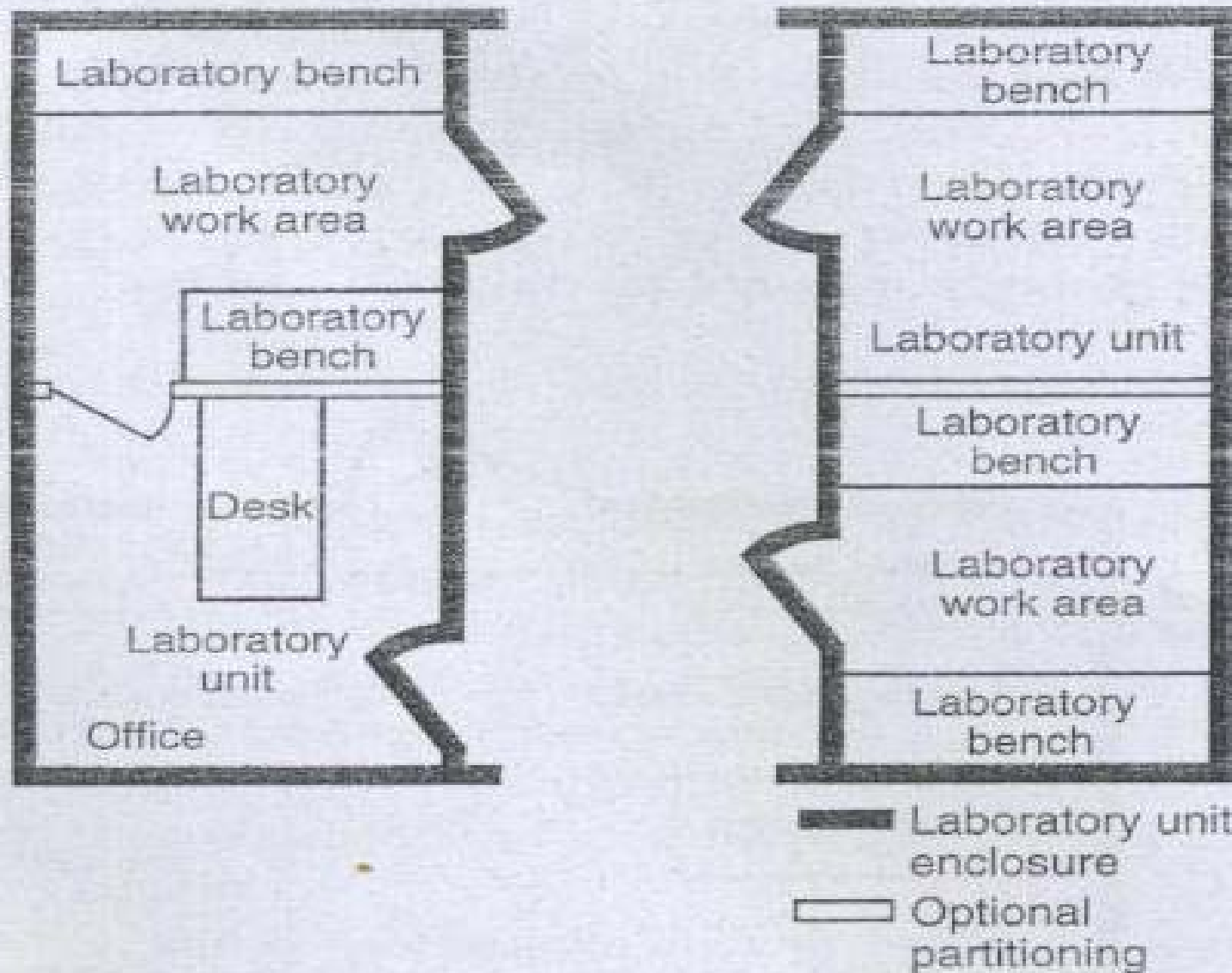


FIGURE D.2.4(d) Laboratory Units Separated by an Exit Passageway.

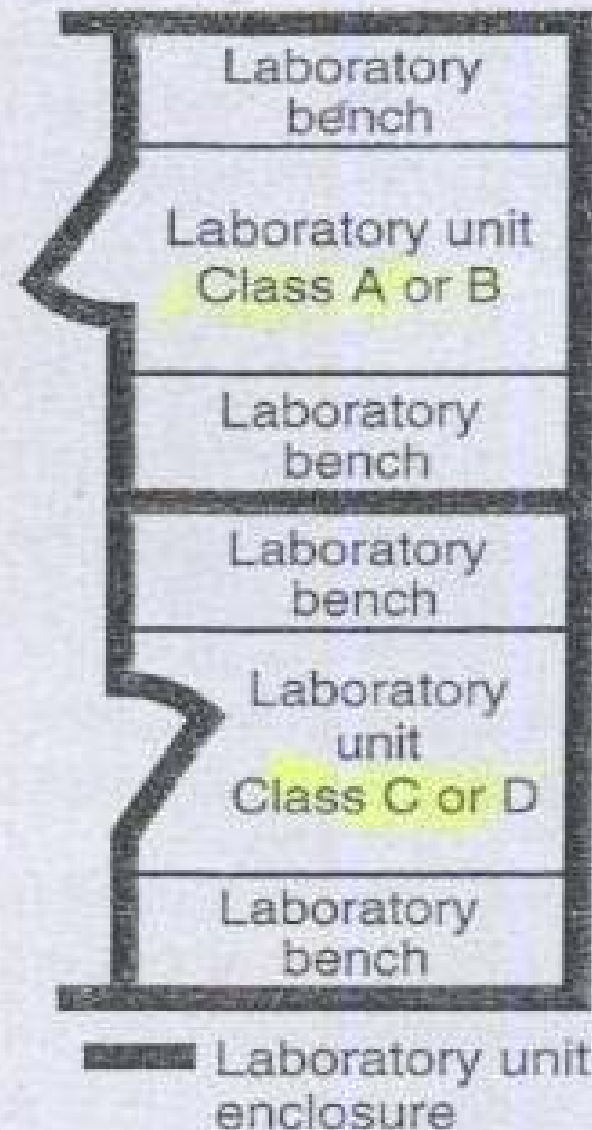
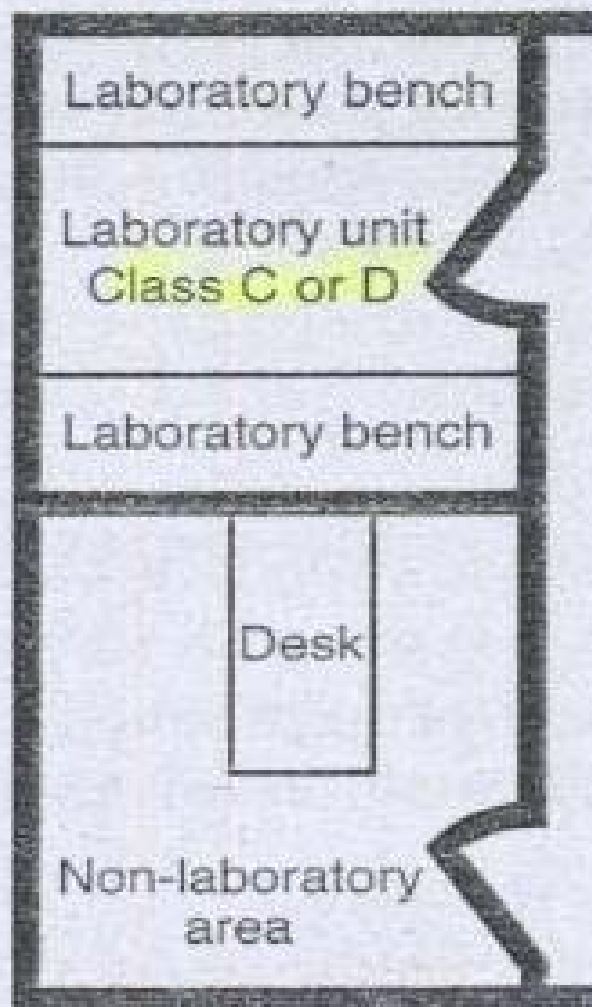


FIGURE D.2.4(e) Separation of Laboratory Units and Non-Laboratory Areas.

Some Basic Fire Safety Requirements in Laboratory

- 1. Chemical fume Hood Exhausted system**
- 2. Lab Unit and Lab Work Area** shall be continuously maintained at a negative pressure
- 3. All new Lab shall be sprinkler protected**
- 4. Hazardous chemicals shall be stored in such a manner as to limit a spill scenario to less than 20 L**

NFPA 45: Laboratory **With Sprinkler** System for Liquid – For only new building

(up to 93°C)

Lab Unit Hazard Class	Liquid Class	Excluding Qty in Cabinet		Including Qty in Cabinet	
		Max Qty (L) Per 9.3 m ²	Max Qty (L) Per Lab Unit	Max Qty (L) Per 9.3 m ²	Max Qty (L) Per Lab Unit
A (floor area to be less than 10,000 ft ² with 2 hrs rating)	I	38 (4.08 l/m ²)	2270	76	4540
	I, II & IIIA	76 (8.16 l/m ²)	3028	150	6060
B (floor area to be less than 10,000 ft ² with 1 hrs rating)	I	20 (2.15 l/m ²)	1136	38	2270
	I, II & IIIA	38 (4.08 l/m ²)	1515	76	3028
C	I	7.5 (0.81 l/m ²)	570	15	1136
	I, II & IIIA	15 (1.62 l/m ²)	757	30	1515
D	I	4 (0.43 l/m ²)	284	7.5	570
	I, II & IIIA	4 (0.43 l/m ²)	284	7.5	570

Note: 1 L/m² means 1mm depth of liquid spread over 1 m²

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	I, II & IIIA	4 (0.43 l/m ²)	284	7.5	570

All Not Permitted

Note: 1 L/m² means 1mm depth of liquid spread over 1 m²

NFPA 45: Laboratory Without Sprinkler System for Liquid – For only existing old building

(up to 93°C)

		Excluding Qty in cabinet		Including Qty in cabinet		
Lab Unit Hazard Class	Liquid Class	Max Qty (L) <u>per 9.3 m²</u>	Max Qty (L) <u>per Lab unit</u>	Max Qty (L) <u>per 9.3 m²</u>	Max Qty (L) <u>per Lab unit</u>	
A (floor area to be less than 10,000 ft ² with 2 hrs rating)	I	Not permitted	Not permitted	Not permitted	Not permitted	
	I, II & IIIA	Not permitted	Not permitted	Not permitted	Not permitted	
B (floor area to be less than 10,000 ft ² with 1 hrs rating)	I	Not permitted	Not permitted	Not permitted	Not permitted	
	I, II & IIIA	Not permitted	Not permitted	Not permitted	Not permitted	
C	I	7.5 (0.81 l/m ²)	284 {570}	15	570 {1136}	
	I, II & IIIA	15 (1.62 l/m ²)	380 {757}	30	760 {1515}	
D	I	4 (0.43 l/m ²)	140 {284}	7.5	284 {570}	
	I, II & IIIA	4 (0.43 l/m ²)	140 {284}	7.5	284 {570}	

Note: 1 l/m² means 1mm depth of liquid spread over 1 m²

NFPA 45: Laboratory Without Sprinkler System for Liquid – For only existing old building

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All Not Permitted

Note: 1 l/m² means 1mm depth of liquid spread over 1 m²

Modification for Maximum Allowable Quantities (MAQ)

Flammable Liquid in Laboratory

	Liquid Class (CP40 Classification)	Excluding Qty in Cabinet	Including Qty in Cabinet
		Max Qty (Liters per Lab Unit)	Max Qty (Liters per Lab Unit)
Laboratory	I	(i) 15L or (ii) 0.8L/m ² and not more than 250L {350L}	(i) - (ii) 1.6L/m ² and not more than 500L {750L}
	Mixed (the MAQ for Class I within mixture shall also be restricted to Class I category)	(i) 30L or (ii) 1.6L/m ² and not more than 350L {500L}	(i) - (ii) 3.2L/m ² and not more than 750L {1000L}
Laboratory (in hospital and health care occupancy)	I	(i) 5L or (ii) 0.4 L/m ² and not more than 120L {250L}	(i) - (ii) 0.8L/m ² and not more than 250L {500L}
	Mixed (the MAQ for Class I within mixture shall also be restricted to Class I category)	(i) 10L or (ii) 0.4 L/m ² and not more than 120L {250L}	(i) - (ii) 0.8L/m ² and not more than 250L {500L}

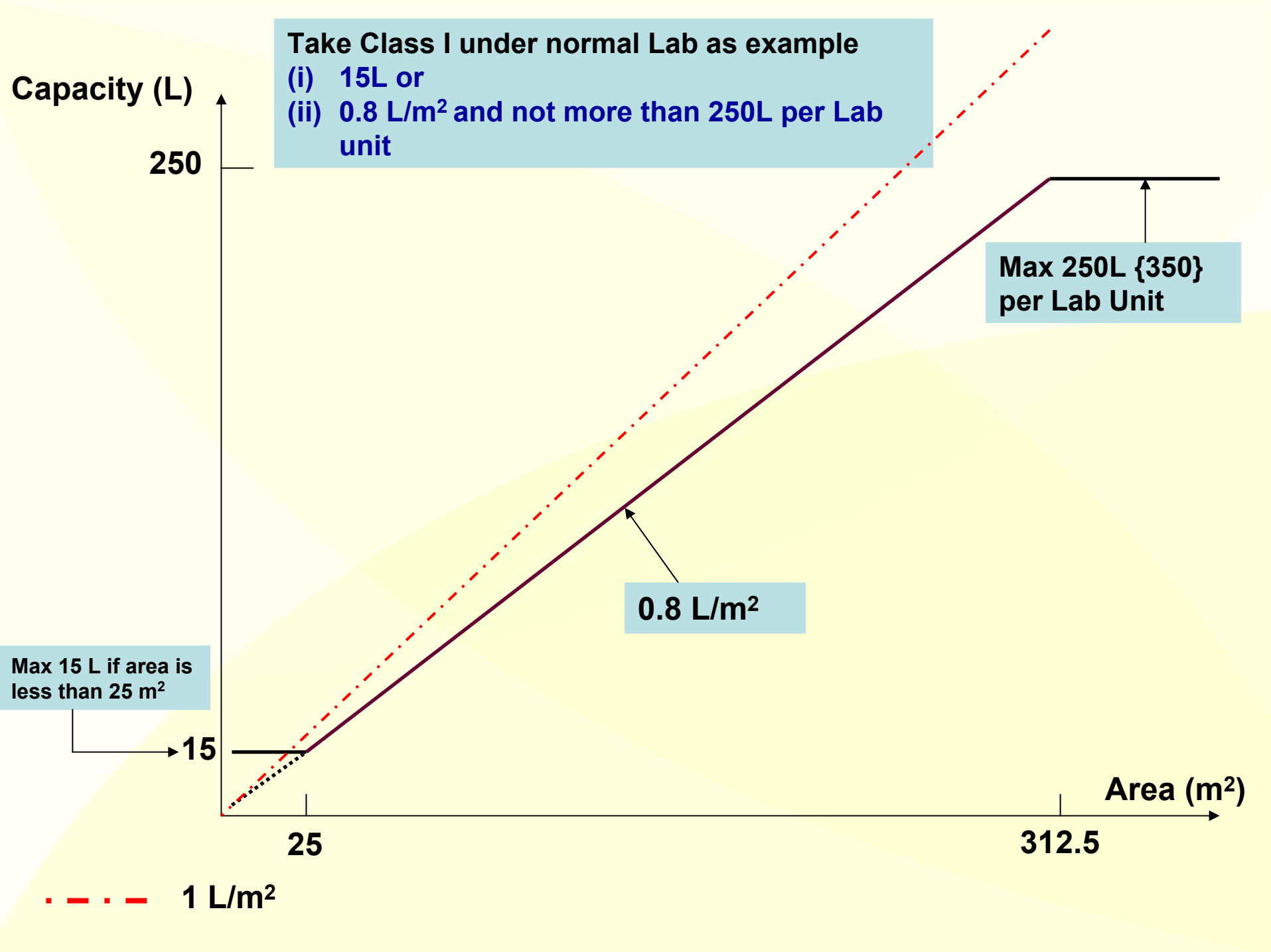
{ } = Maximum Quantity allowed (MAQ) for sprinkler protected lab

Modification for Maximum Allowable Quantities (MAQ)

Flammable Liquid in Laboratory

	Liquid Class (CP40 Classification)	Excluding Qty in Cabinet	Including Qty in Cabinet
		Max Qty (Liters per Lab Unit)	Max Qty (Liters per Lab Unit)
Laboratory	I	(i) 15L or (ii) 0.8L/m ² and not more than 250L {350L}	(i) - (ii) 1.6L/m ² and not more than 500L {750L}
	Mixed	(i) 30L or	(i) -
Each safety cabinet is restricted to 250L			
Laboratory (in hospital and health care occupancy)		(ii) 0.4 L/m ² and not more than 150L {250L}	(ii) 0.8L/m ² and not more than 250L {500L}
	Mixed (the MAQ for Class I within mixture shall also be restricted to Class I category)	(i) 10L or (ii) 0.4 L/m ² and not more than 150L {250L}	(i) - (ii) 0.8L/m ² and not more than 250L {500L}

{ } = Maximum Quantity allowed (MAQ) for sprinkler protected lab



- 1. Not more than 10% of the allowable qty is allow on the working bench**
- 2. The remaining allowable qty that allow not to be kept in the safety cabinet shall be stored within cupboard with metal tray for spillage control**
 - ❖ FSSD may impose these qty to be kept in the safety cabinet after NFPA has provided with the justification**

Maximum Allowable Quantity For Gases

Per **Lab Work Area** (With Sprinkler System)

A. Flammable gasses

170 L for 50 sq meters and less

$Y (L) = 3.4 \times \text{Lab work area for } > 50 \text{ sq meters}$

B. Oxidizing gasses

170 L for 50 sq meters and less

$Y (L) = 3.4 \times \text{Lab work area for } > 50 \text{ sq meters}$

C. Liquefied flammable gasses

30 L for 50 sq meters and less

$Y (L) = 0.6 \times \text{Lab work area for } > 50 \text{ sq meters}$

D. Toxic gasses

8 L for 50 sq meters and less

$Y (L) = 0.16 \times \text{Lab work area for } > 50 \text{ sq meters}$

Maximum Allowable Quantity For Gases Per **Lab Work Area** (With Sprinkler System)

A. Flammable gasses

170 L for 50 sq meters and less

Y (L) = 3.4 x Lab work area for > 50 sq meters

B. Oxidizing gasses

170 L for 50 sq me

Y (L) = 3.4 x Lab w

C. Liquefied flammab

30 L for 50 sq met

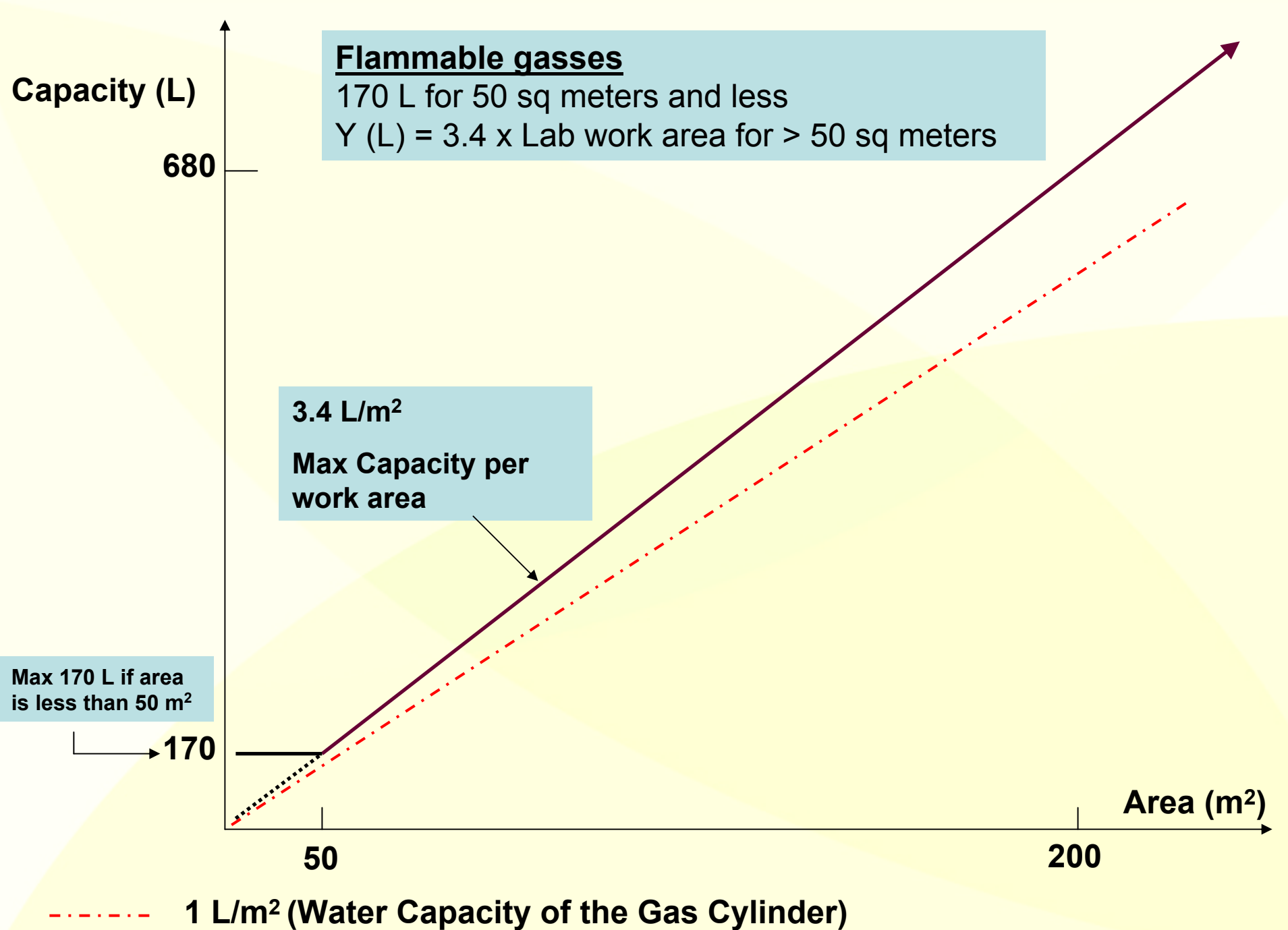
Y (L) = 0.6 x Lab w

D. Toxic gasses

8 L for 50 sq meters and less

Y (L) = 0.16 x Lab work area for > 50 sq meters

the capacity in liters (L) is
refer to the internal volume
(water capacity)
of all cylinders in each of the
listed classifications



- 1. For item A to C, the MAQ shall be halved if the lab is without sprinkler system;**
- 2. Item A to D is considered as one cluster and be spaced 3 m apart from each others (6 m for lab without sprinkler system);**
- 3. To comply with NFPA 45 for other requirements such as the ventilation (4 & 8 A/C), hazard identification and "No Smoking" signs etc;**

- 4. The provision of sprinkler system shall be designed to Ordinary Hazard Group 3 Special (CP52);**
- 5. No combustible materials shall be placed within the 3m buffer range of the gas cylinder**
- 6. No Flammable liquid shall be placed within 6m buffer range of the gas cylinder;**

Ventilation

- 1. Min. 4 A/C at night and weekends**
- 2. Min 8 A/C when lab is occupied**
- 3. Lab units or lab work areas shall be continuously maintained at a negative pressure**

Ventilation

- 4. Risk assessment shall be carried out to ensure such ventilation system serves the intended design.**
- 5. Engineered calculation shall be carried out by the Professional Engineer**

Ventilation & Detection System

- 6. For toxic gases, gas leak detection system shall be provided and shut off the gas supply automatically**
- 7. Gas leak detection system may also be extended to flammable gases**
- 8. Oxygen-level monitoring system to reduce the possibility of Oxygen-depletion (Asphyxiation) for other gases**

Ventilation & Detection System

9. The automatic detection or monitoring interlocking system is to

- **detect the leak,**
- **sound the alarm to alert occupant**
- **shut-off gas supply**
- **activate designated extraction system**

10. For piping system passing through other non-lab space, metal pipe sleeves shall be provided if such space is not natural ventilated or mechanically ventilated

Guidelines on Fire Safety Requirements for Bio-Containment Facilities

Purpose of the guidelines

To stipulate the fire safety requirements for biomedical facilities (Bio-Safety Level 3 and above) handling biological agents or toxins.

Some Definitions

➤ **“Biological Agent”** refers to the biological agents stipulated in the First Schedule, Second Schedule and Third Schedule of the Biological Agents and Toxins Act.

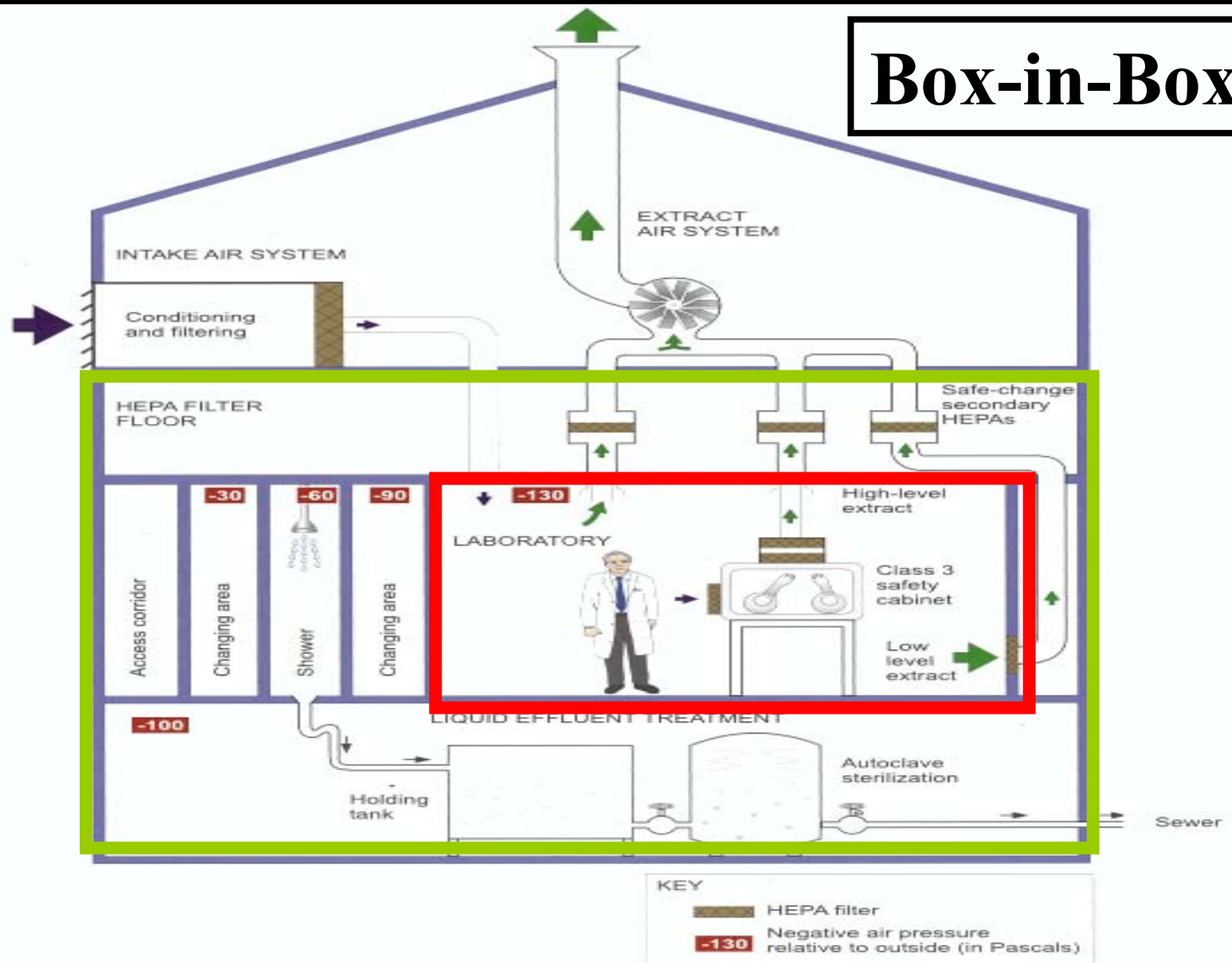
➤ **“Toxin”** refers to the toxins stipulated in the Fifth Schedule of the Biological Agents and Toxins Act.

Some Definitions

- **BSL-3 or BSL-4** is defined as any enclosed room or space which is designed to comply with the WHO, (World Health Organization) and MOH's requirements for storing or handling of biological agents or toxins.
- **“Anteroom”** is defined as the room leading into the BSL-3 or BSL-4. This room would commonly be used to house shower and changing facilities.

A Typical BSL 3/4 Containment lab

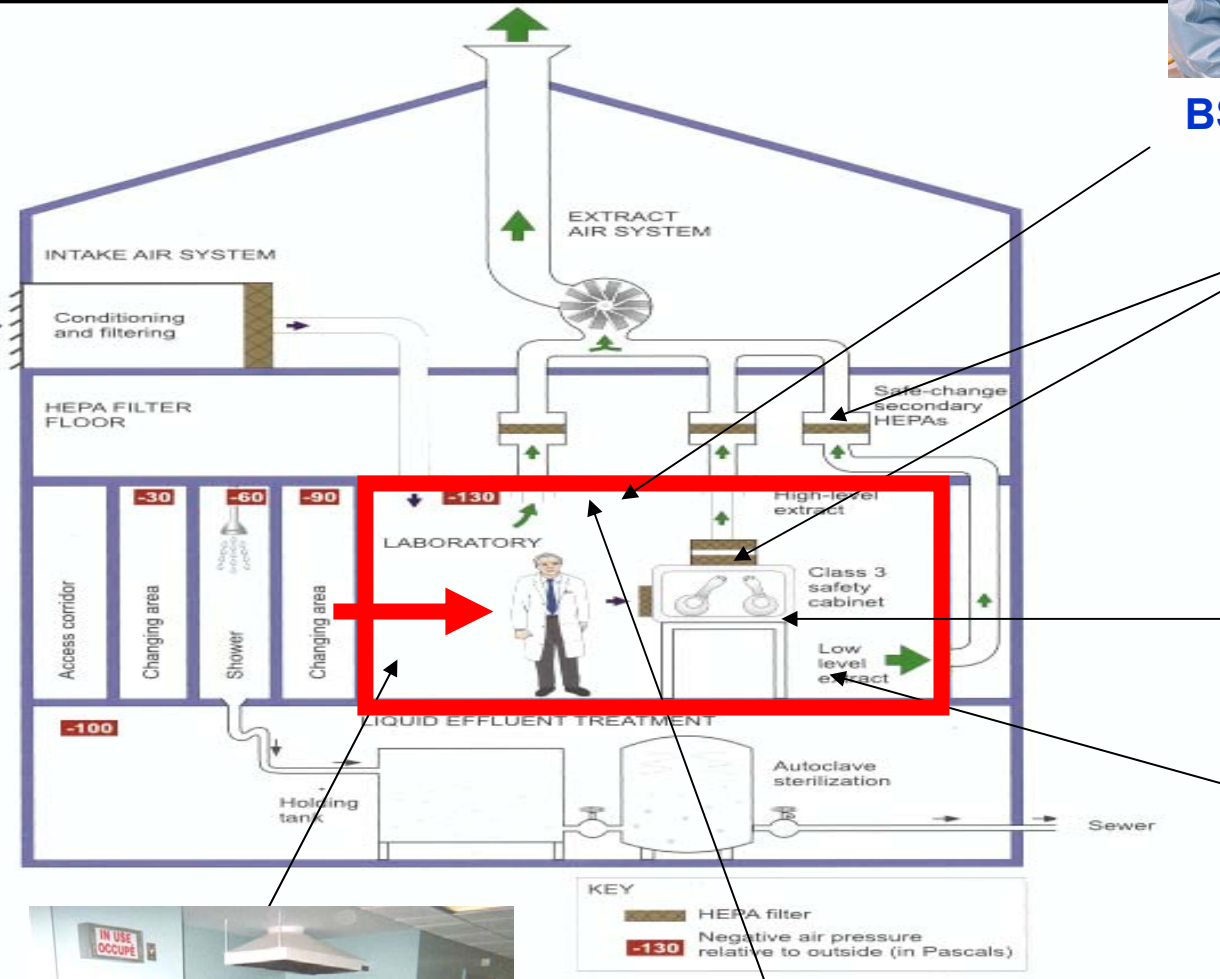
Box-in-Box



BSL 3/4 Work Space

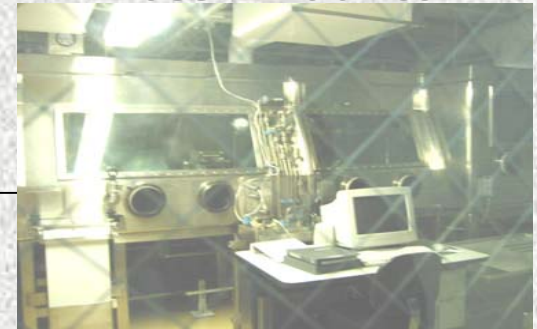


BSL 3/4 work space



HEPA
Filters

Class III Cabinet



Other Lab
Equipment



Pass through Autoclave



CCTV

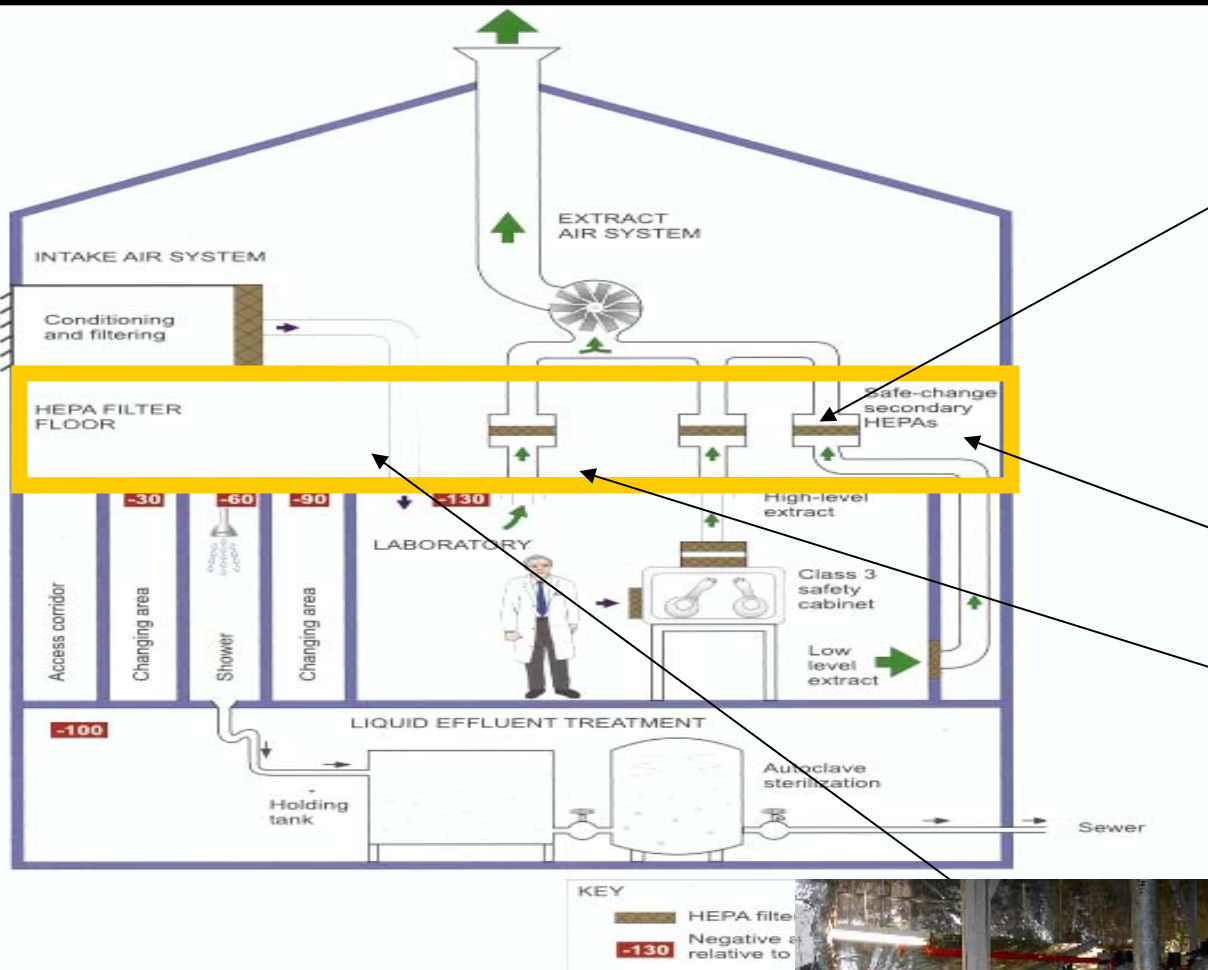


Incubator



Centrifuge

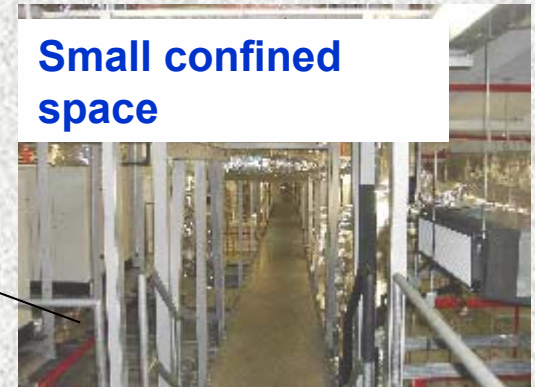
Interstitial Space



Where All
Pathogens
accumulate



Small confined
space



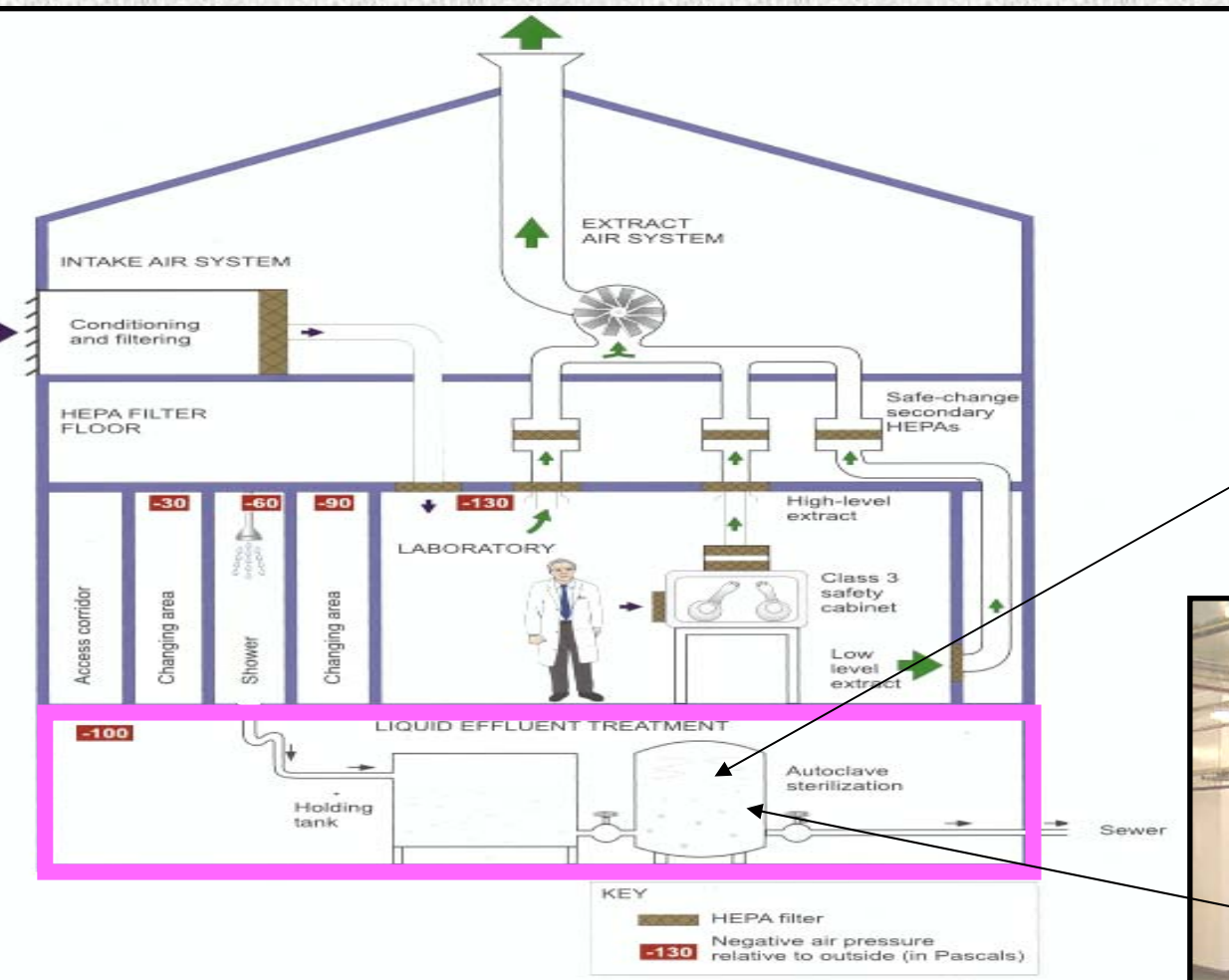
Non-concrete floor
etc for light change



Other Electrical controls
eg Climate control



Waste Treatment



Autoclave (121°C)
or Tissue Digester
(conc Sodium
Hydroxide)



Liq & Solid Waste Treatment

Ante Chambers

Hazard label

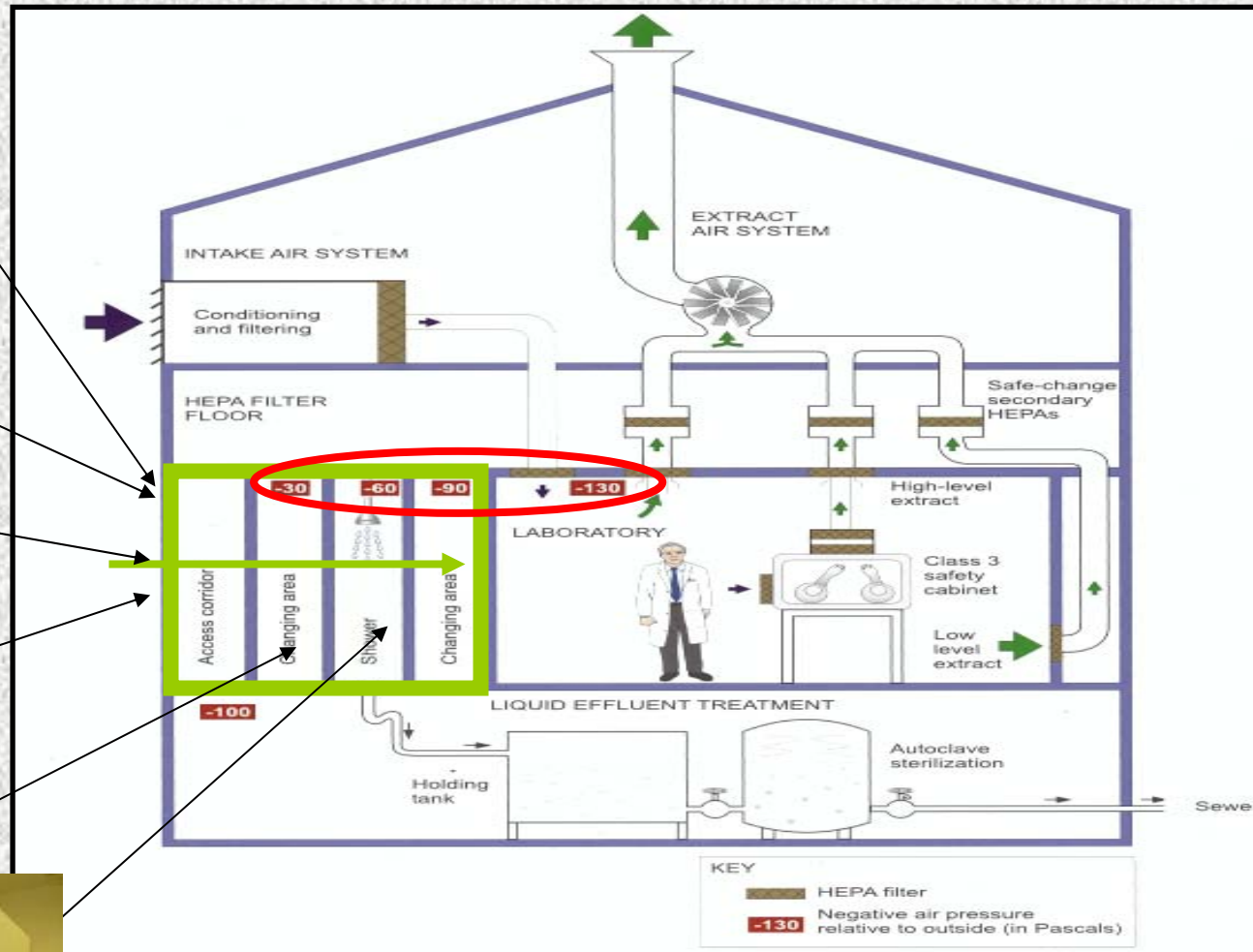
Pressure Gauge

Security

Emergency release

Airlock Access

Shower



Fire Safety Requirements for BSL-3 or BSL-4

- ❖ **Fire compartment**
- ❖ **Fire fighting lobby**
- ❖ **Fire suppression system & Auto fire detection system**
- ❖ **Caution Label**

General Requirements

- **BSL-3 or BSL-4 preferably should be located at the ground floor**
- **Must comply with other relevant authorities' requirements eg. WHO, MOH and NEA etc.**
- **In the plan submission to FSSD for approval, it shall be clearly stated as “BSL-3” or “BSL-4” in bold**
 - ❖ **on the project title and**
 - ❖ **top right corner of the submission plans (at least 15mm height lettering in red)**

Fire Compartmentation

- **In a sprinkler protected building the BSL-3 or BSL-4 shall be fire compartmented with at least ONE hour fire rating**
 - ❖ Including interstitial space, waste treatment areas and anteroom
- **At least TWO hours fire rating in a non-sprinkler protected buildings.**
- **The protecting structure shall be constructed of masonry or drywall**
 - ❖ If drywall construction is used, it shall comply fully with the cl 3.8.7(c)(i) to (iv) of the Fire Code 2002.

Fire Fighting Lobby

- Entry to the BSL-3 or BSL-4 shall be thru' a fire fighting lobby of at least 1-hr fire rating
- The anteroom can also double as the fire fighting lobby and shall have a free working space of 6 m² in size.
- A designated rising main with landing valve (complete with standby fire hose) and fire hosereel shall be installed within this fire fighting lobby/ anteroom

LEGEND:

-  CHEMISTRY
 BIO SAFETY LEVEL 2
 ADMINISTRATION
 MAINTENANCE

Ante Chambers

8TH STOREY PLAN

SCALE 1:100

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PROJECT TITLE:
PROPOSED ADDITIONS & ALTERATIONS TO THE
5TH - 8TH STOREY OF BIOMEDICAL RESEARCH
DEVELOPMENT COMPLEX AT BUILDING 10, 11 & 12
AT NORTH BUONA VISTA DRIVE (MUKIM NO. 3,
98702MPT)

	DRAWING TITLE
--	---------------

8TH STOREY PLAN
ZONING DIAGRAM

Two-Way Emergency Communication System

- **Two-way communication device shall also be installed if the building is provided with such system.**

Fire Suppression and Detection System

- **All BLS-3 or BSL-4 shall be protected with sprinkler system or active fire suppression system
(regardless whether the building is protected with such active fire suppression system)**
- **In a non-sprinkler protected building smoke detectors shall be installed along the outer perimeter of the fire compartmented enclosure**

**Sprinkler System or
stand-alone Fire
Suppression System**

**Fire
Detection
System**

8TH STOREY PLAN

SCALE 1:100

PRELIMINARY

LEGEND

CHEMISTRY

BIO SAFETY LEVEL 3

ADMINISTRATION

MAINTENANCE

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PROJECT TITLE:
PROPOSED ADDITIONS & ALTERATIONS
5TH - 8TH STOREY OF BIOMEDICAL
DEVELOPMENT COMPLEX AT BUILDING
AT NORTH BUONA VISTA DRIVE
98702MPT MUKIM NO.3.

DRAWING TITLE:

8TH STOREY PLAN
ZONING DIAGRAM

Fire Suppression and Detection System

- **The fire protection circuit for BSL-3 or BSL-4 shall be grouped in different fire zone (separate flow switch [fire zone] for sprinkler system) for ease of identification.**
- **Such systems shall be linked to the building fire alarm system & be connected to the fire station through an approved alarm monitoring station.**
- **If water effluent is undesirable or unacceptable, the sprinkler system may be replaced by an approved fire extinguishing system.**

Others

- **The operator of the BSL-3 or BSL-4 has to notify PUB via their hotline, PUBOne @ 1800 284 6600, immediately whenever any an incident occurs.**

Caution Label

- Caution labels shall be provided at all the laboratory entrances and exits complying to SS 286

IMO DANGEROUS GOODS LABELS, PLACARDS & MARKS



Division 1.1, 1.2 and 1.3



Division 1.4



Division 1.5



Division 1.6

** Place of division - to be left blank if explosive is the subsidiary risk

* Place for compatibility group - to be left blank if the explosive is the subsidiary risk



Class 2.1 - Flammable gases



Class 2.2 - Non-flammable, non-toxic gases



Class 2.3 - Toxic gases



Class 3 - Flammable Liquids



Class 4.1 - Flammable Solids



Class 4.2 - Substances liable to spontaneous combustion



Class 4.3 - Substances which, in contact with water, emit flammable gases



Class 5.1 - Oxidizing substances



Class 5.2 - Organic peroxides



Class 6.1 - Toxic substances



Class 6.2 - Infectious substances



Category I - White



Category II - Yellow



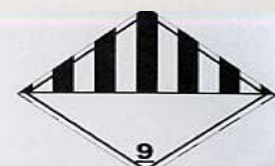
Category III - Yellow



Class 7 - Fissile material



Class 8 - Corrosive substances



Class 9 - Miscellaneous dangerous substances and articles

ADDITIONAL LABELS



Marine pollutant



Elevated temperature substances



Fumigation Warning Sign

Caution Label

- In addition, a label indicating the information as stated in Annex A shall be provided.



BIOHAZARD

MSD 0454

ADMITTANCE TO AUTHORIZED PERSONNEL ONLY

Biosafety Level: _____

Responsible Investigator: _____

In case of emergency call: _____

Daytime phone: _____ Home phone: _____

**Authorization for entrance must be obtained from
the Responsible Investigator named above.**

Conclusion

- Guidelines For Bio-containment facilities or BSL3 or 4
- NFPA 45 is the base design (to apply the modified table)
- Consult FSSD before the actual plan submission

Thank you