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.**

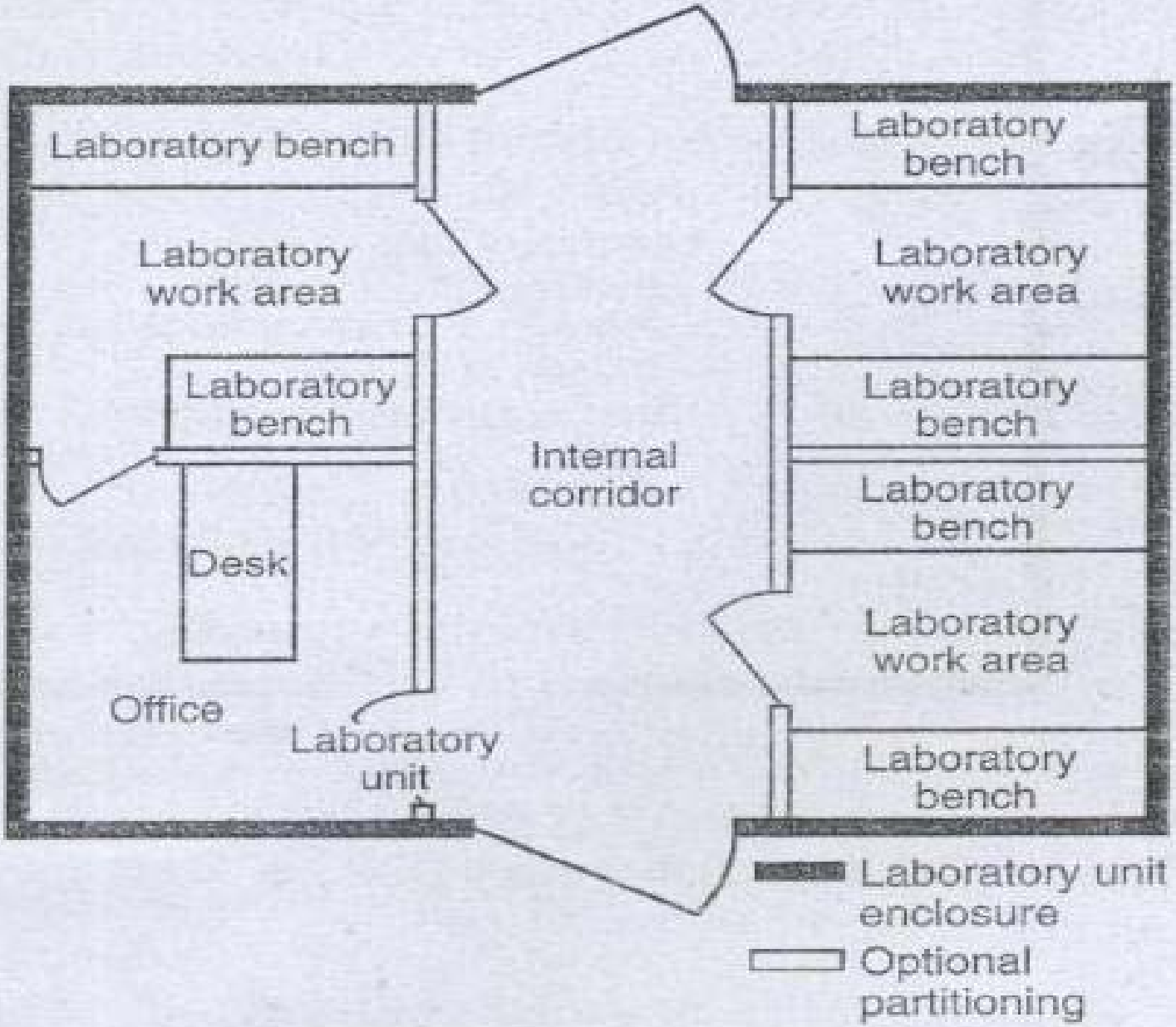


FIGURE D.2.4(c) Laboratory Unit with Optional Partitioning.

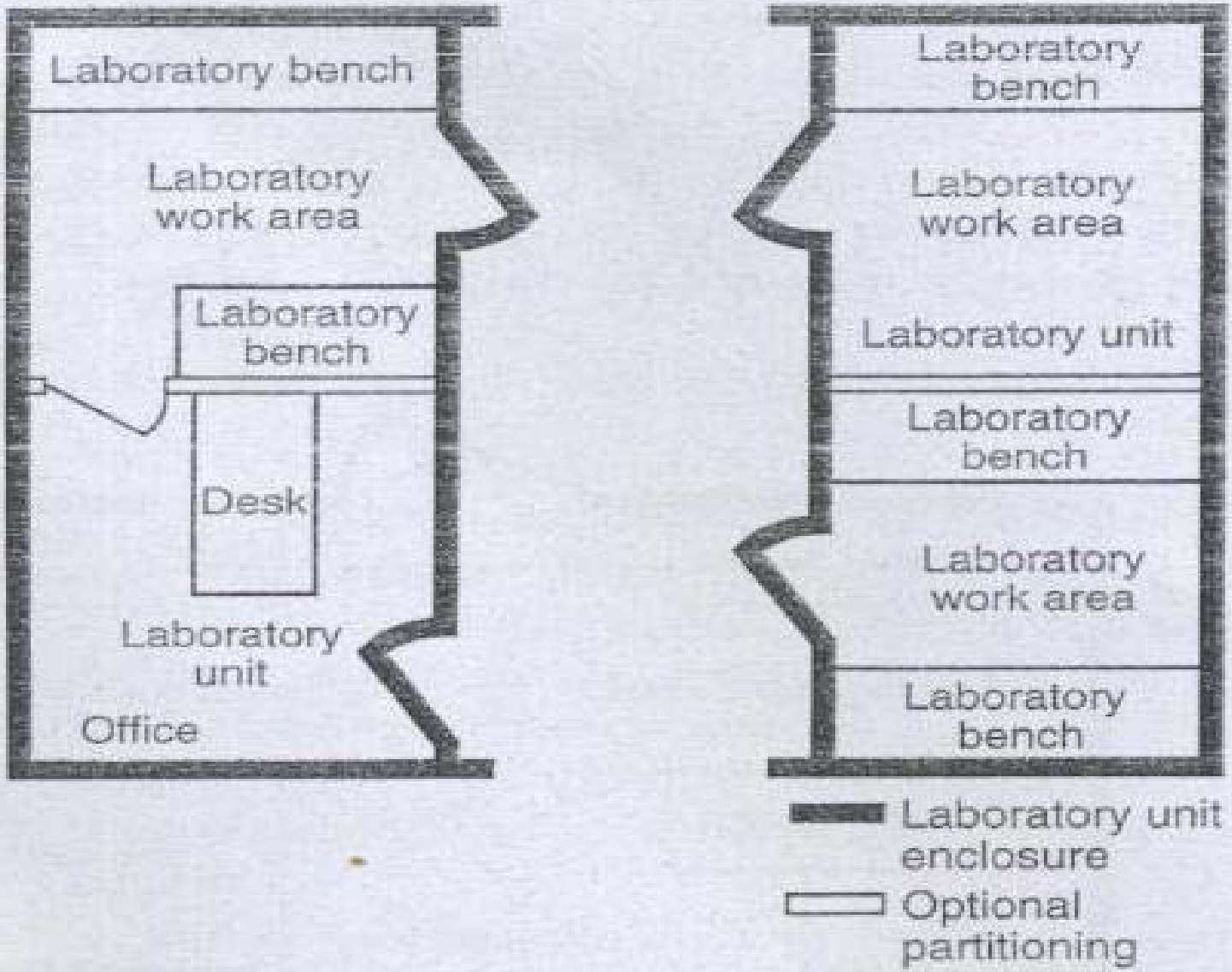


**FIGURE D.2.4(d) Laboratory Units Separated by an Exit Passageway.**

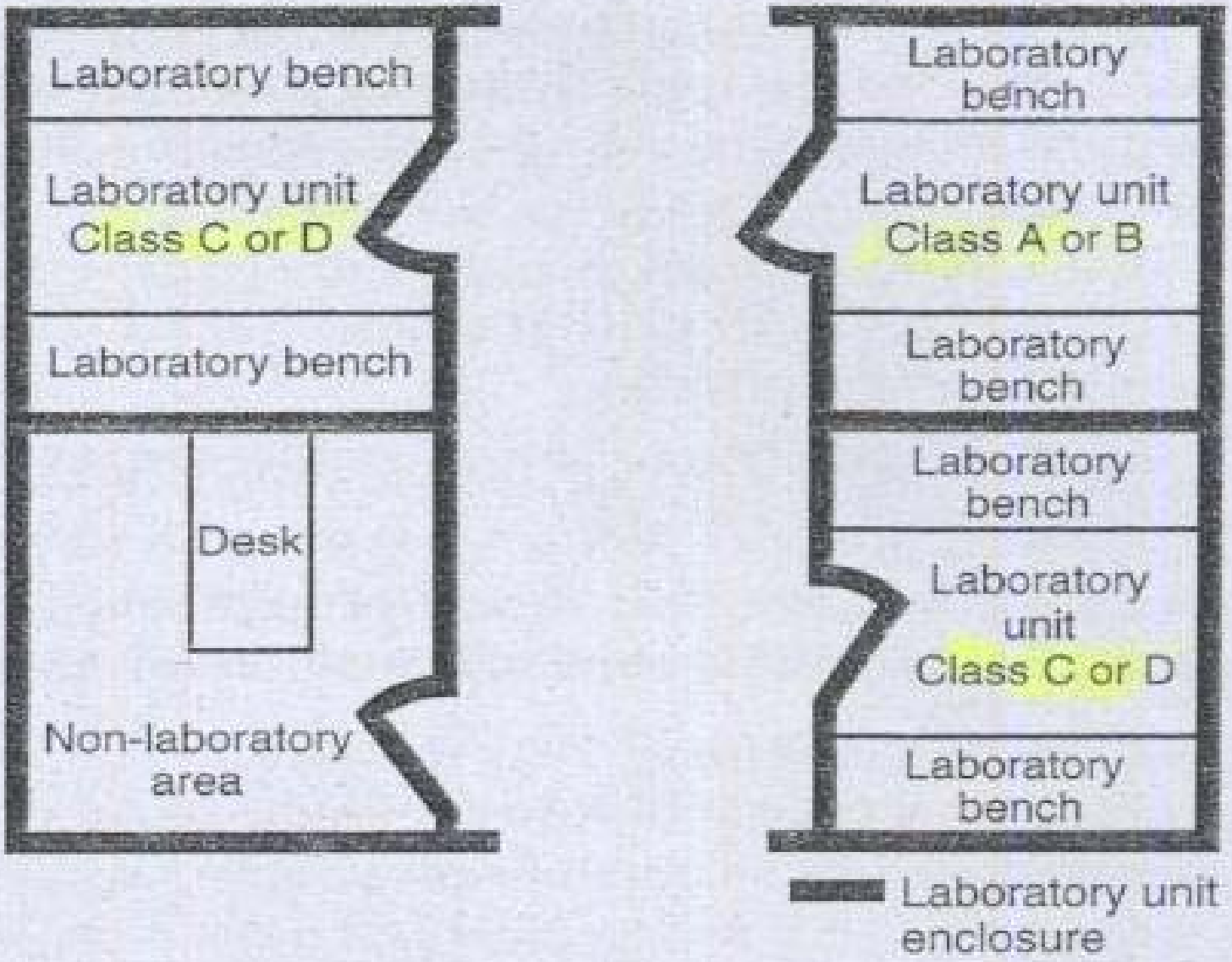


**FIGURE D.2.4(e) Separation of Laboratory Units and Non-Laboratory Areas.**

# 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 only new building **With Sprinkler** System for Liquid – For (up to 93°c)

| Lab Unit Hazard Class | Liquid Class | Excluding Qty in Cabinet: Max Qty (L) Per 9.3 m² | Excluding Qty in Cabinet: Max Qty (L) Per Lab Unit | Including Qty in Cabinet: Max Qty (L) Per 9.3 m² | Including Qty in Cabinet: Max Qty (L) Per Lab Unit |
|---|---|---|---|---|---|
| **A** (floor area to be less than 10,000 ft² with 2 hrs rating) | I | 38 (4.08 l/m²) | 2270 | 76 | 4540 |
| | I, II & IIIA | 76 (8.16 l/m²) | 3028 | 150 | 6060 |
| **B** (floor area to be less than 10,000 ft² with 1 hrs rating) | I | 20 (2.15 l/m²) | 1136 | 38 | 2270 |
| | I, II & IIIA | 38 (4.08 l/m²) | 1515 | 76 | 3028 |
| **C** | I | 7.5 (0.81 l/m²) | 570 | 15 | 1136 |
| | I, II & IIIA | 15 (1.62 l/m²) | 757 | 30 | 1515 |
| **D** | I | 4 (0.43 l/m²) | 284 | 7.5 | 570 |
| | I, II & IIIA | 4 (0.43 l/m²) | 284 | 7.5 | 570 |
| | | | | | |

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

# 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: Max Qty (L) Per 9.3 m² | Excluding Qty in Cabinet: Max Qty (L) Per Lab Unit | Including Qty in Cabinet: Max Qty (L) Per 9.3 m² | Including Qty in Cabinet: Max Qty (L) Per Lab Unit |
|---|---|---|---|---|---|
| A (floor area to be less than 10,000 ft² with 2 hrs rating) | I | 38 (4.08 l/m²) | 2270 | 76 | |
| | I, II & IIIA | 76 (8.16 l/m²) | 3028 | | 6060 |
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| | I, II & IIIA | 4 (0.43 l/m²) | 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) 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 | 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/$m^2$ means 1mm depth of liquid spread over 1 $m^2$

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(up to 93°c)

| | | Excluding Qty in cabinet | | Including Qty in cabinet | |
|---|---|---|---|---|---|
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| **A** (floor area to be less than 10,000 ft² with 2 hrs rating) | I | Not permitted | Not permitted | Not | ermitted |
| | I, II & IIIA | Not permitted | Not permi | ted | Not permitted |
| **B** (floor area to be less than 10,000 ft² with 1 hrs rating) | I | Not permit | | Not permitted | Not permitted |
| | I, II & III | | Not permitted | Not permitted | Not permitted |
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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<br>(ii) 0.8L/$m^2$ and not more than 250L {350L} | (i) -<br>(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<br>(ii) 1.6L/$m^2$ and not more than 350L {500L} | (i) -<br>(ii) 3.2L/$m^2$ and not more than 750L {1000L} |
| Laboratory (in hospital and health care occupancy) | I | (i) 5L or<br>(ii) 0.4 L/$m^2$ and not more than 120L {250L} | (i) -<br>(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<br>(ii) 0.4 L/$m^2$ and not more than 120L {250L} | (i) -<br>(ii) 0.8L/$m^2$ and not more than 250L {500L} |

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

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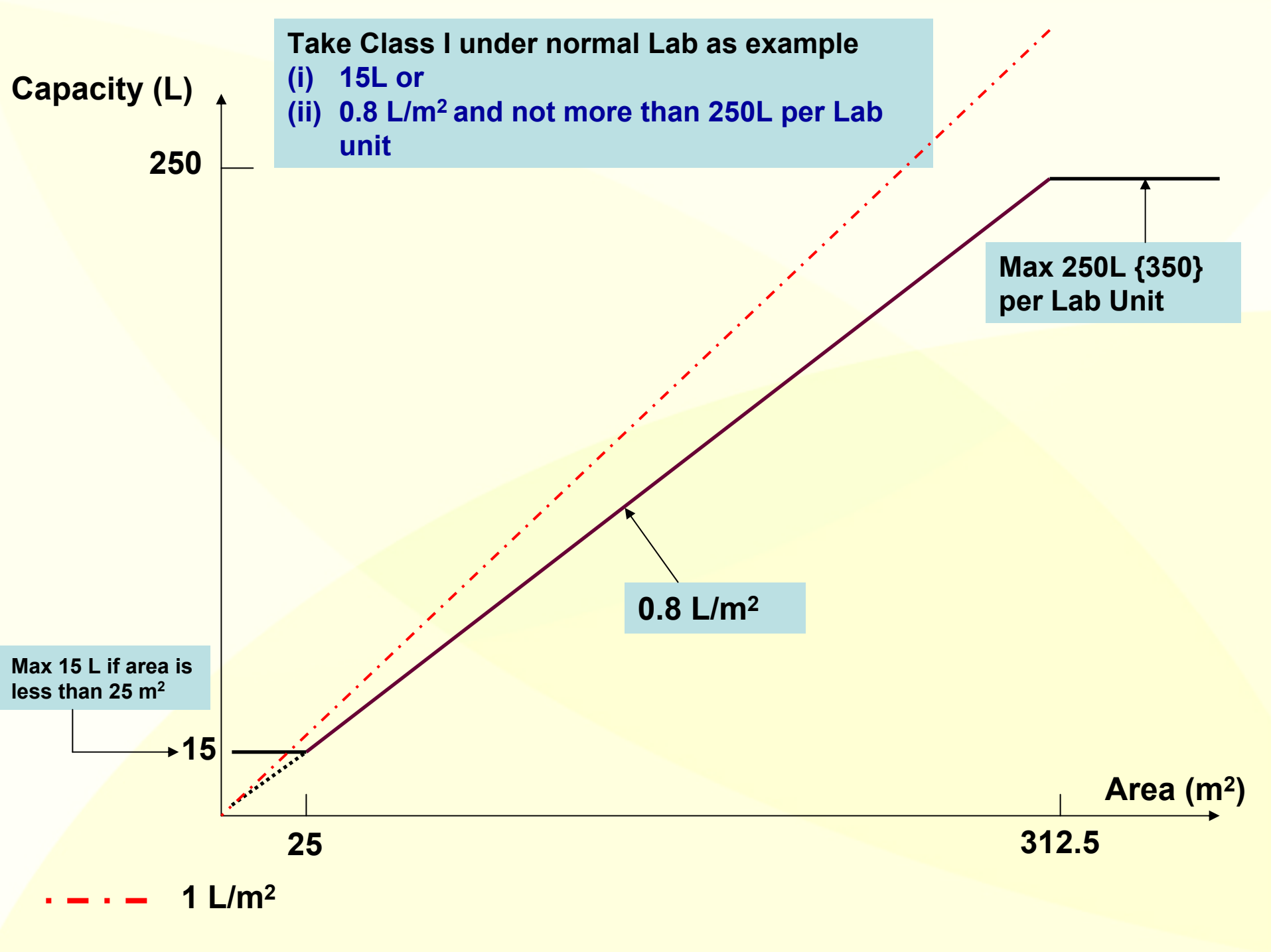
| Laboratory | I | (i) 15L or<br>(ii) 0.8L/$m^2$ and not more than 250L {350L} | (i) -<br>(ii) 1.6L/$m^2$ and not more than 500L {750L} |
| | Mixed | (i) 30L or | (i) - |
| Laborat | | | |
| (in hospital and health care occupancy) | | (ii) 0.4 L/$m^2$ and not more than 150L {250L} | (ii) 0.8L/$m^2$ and not more than 250L {500L} |
| | Mixed (the MAQ for Class I within mixture shall also be restricted to Class I category) | (i) 10L or<br>(ii) 0.4 L/$m^2$ and not more than 150L {250L} | (i) -<br>(ii) 0.8L/$m^2$ and not more than 250L {500L} |

**Each safety cabinet is restricted to 250L**

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


Take Class I under normal Lab as example
(i) 15L or
(ii) 0.8 L/m² and not more than 250L per Lab unit
Capacity (L)
250
Max 250L {350} per Lab Unit
0.8 L/m²
Max 15 L if area is less than 25 m²
15
Area (m²)
25
312.5
1 L/m²

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 x Lab work area for > 50 sq meters

B. **Oxidizing gasses**

170 L for 50 sq meters and less

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

C. **Liquefied flammable gasses**

30 L for 50 sq meters and less

Y (L) = 0.6 x Lab work area for > 50 sq meters

D. **Toxic gasses**

8 L for 50 sq meters and less

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

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30 L for 50 sq met

Y (L) = 0.6 x Lab w

D. **Toxic gasses**

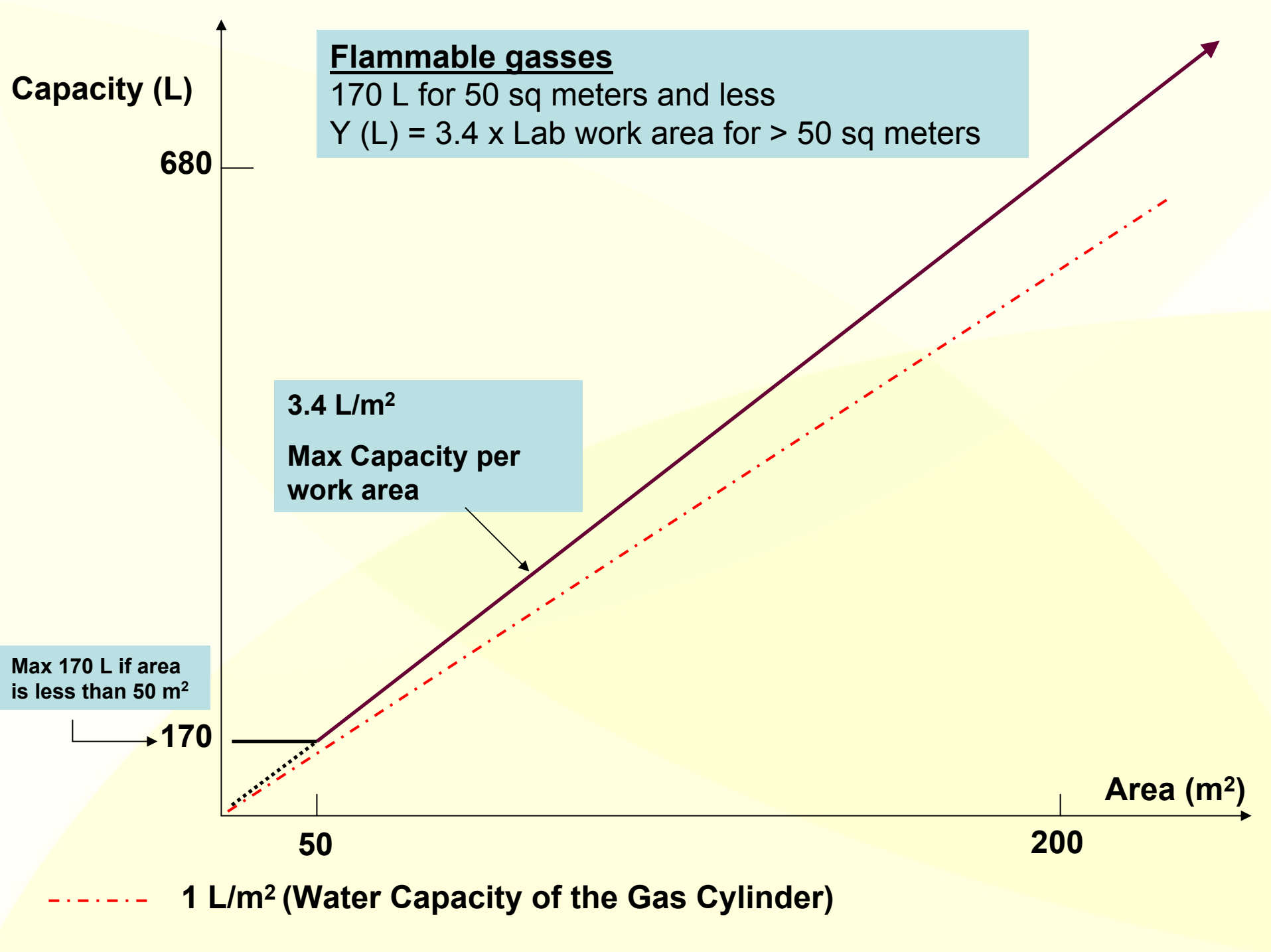
8 L for 50 sq meters and less

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


Flammable gasses
170 L for 50 sq meters and less
Y (L) = 3.4 x Lab work area for > 50 sq meters
Capacity (L)
680
3.4 L/m2
Max Capacity per work area
Max 170 L if area is less than 50 m2
170
Area (m2)
50
200
1 L/m2 (Water Capacity of the Gas Cylinder)

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.

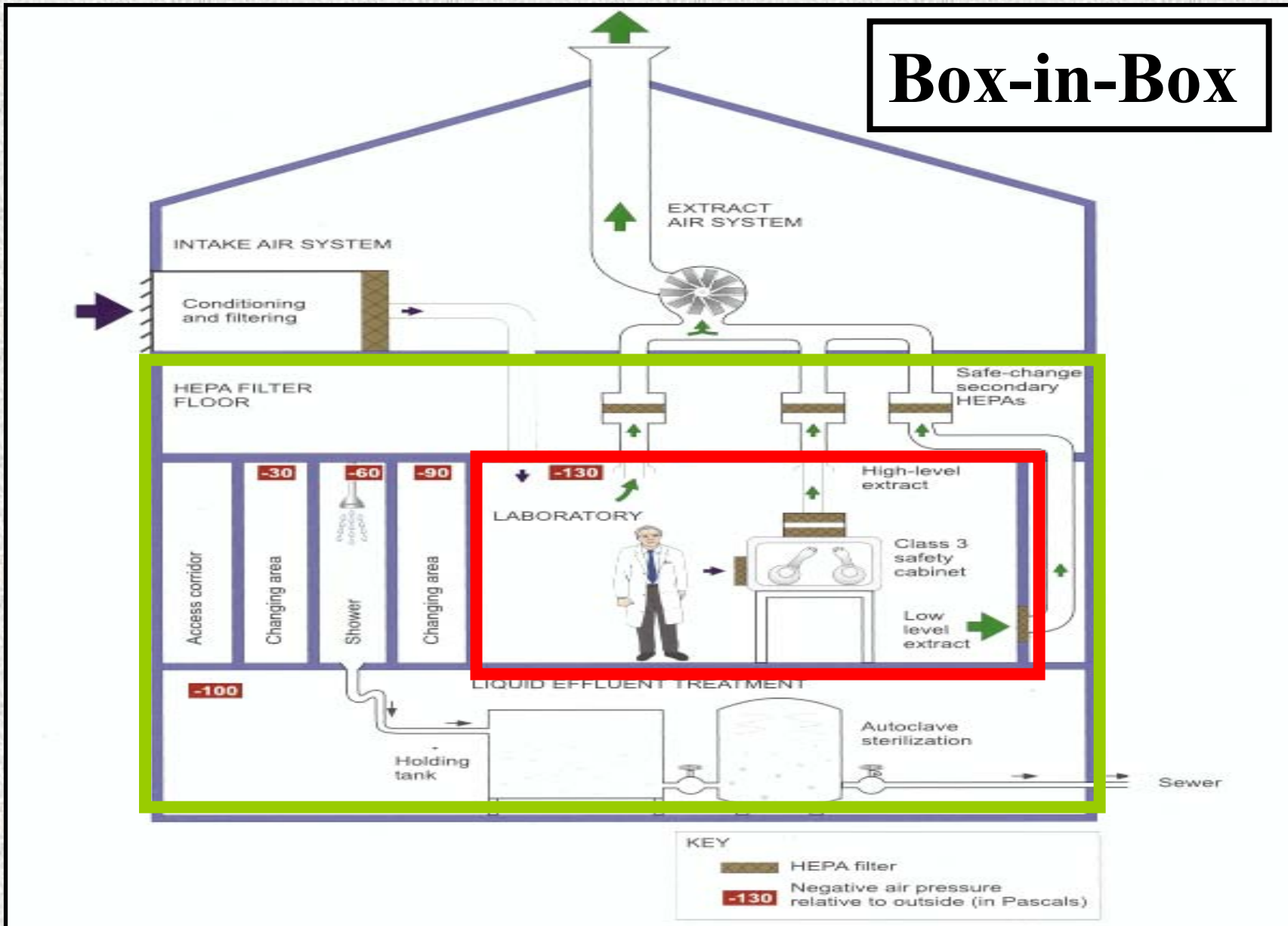
- **"Toxin"** refers to the toxins stipulated in the Fifth Schedule of the Biological Agents and Toxins Act.

# 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.**

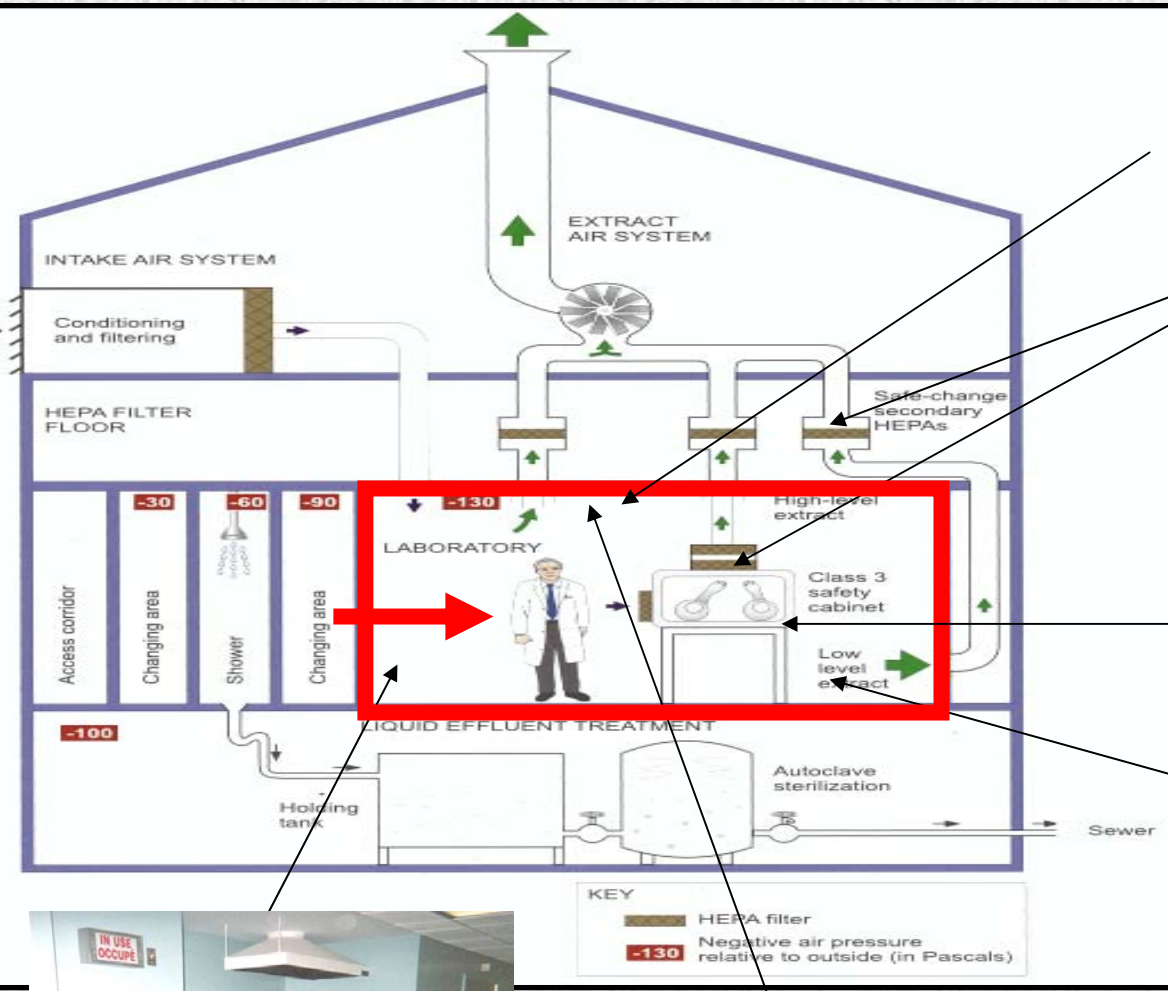
# A Typical BSL 3/4 Containment lab



# BSL 3/4 Work Space

BSL 3/4 work space

HEPA Filters




Class III Cabinet

Other Lab Equipment

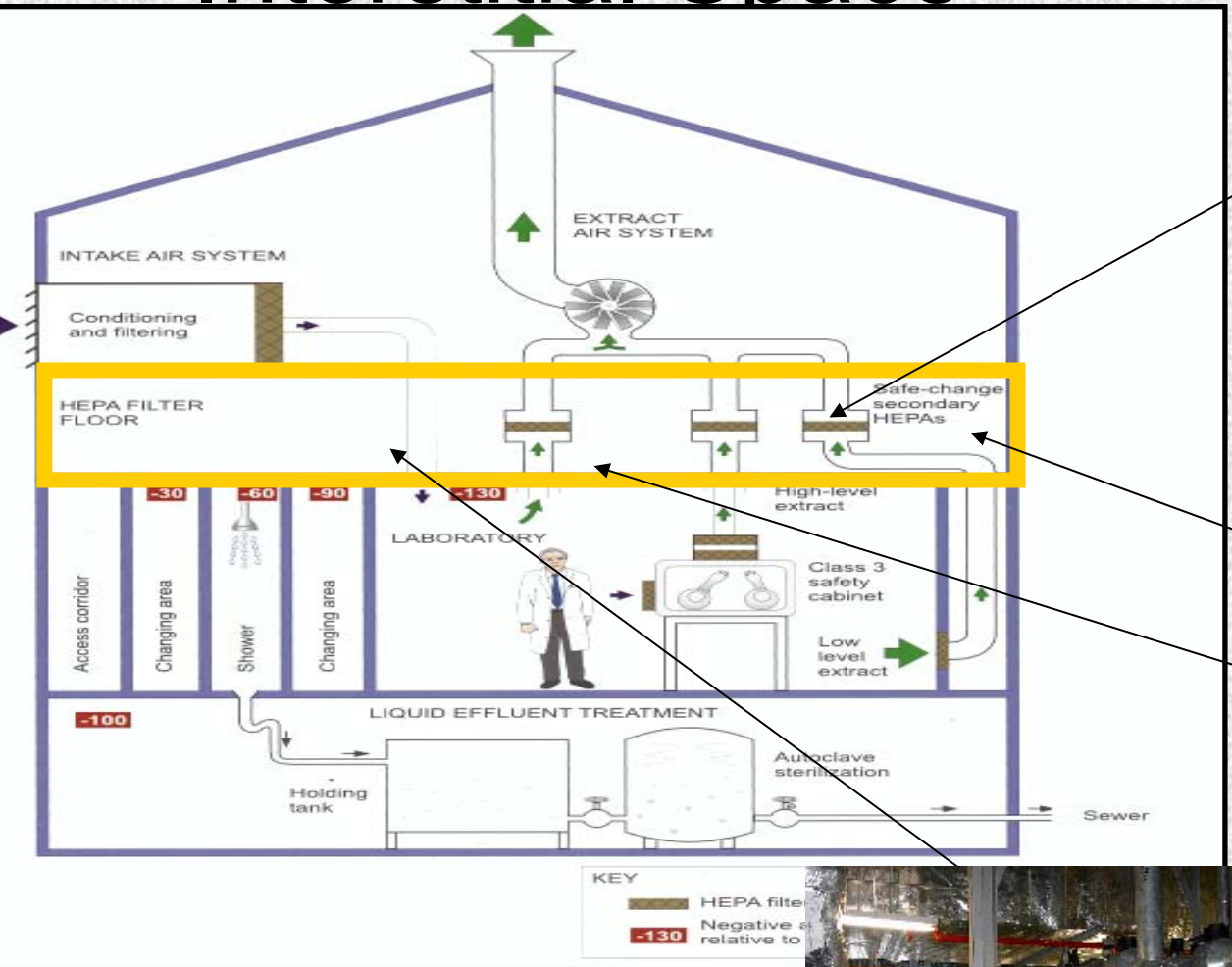
Pass through Autoclave

CCTV

Incubator

Centrifuge

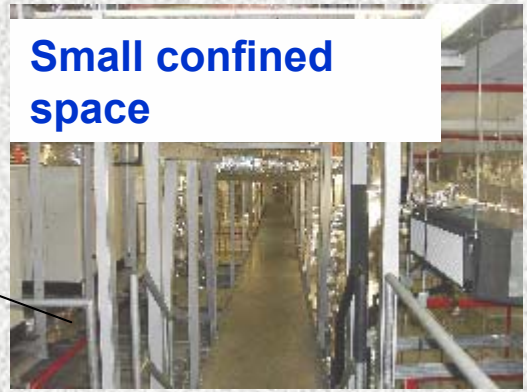
# Interstitial Space




Where All Pathogens accumulate

**Interstitial Space**

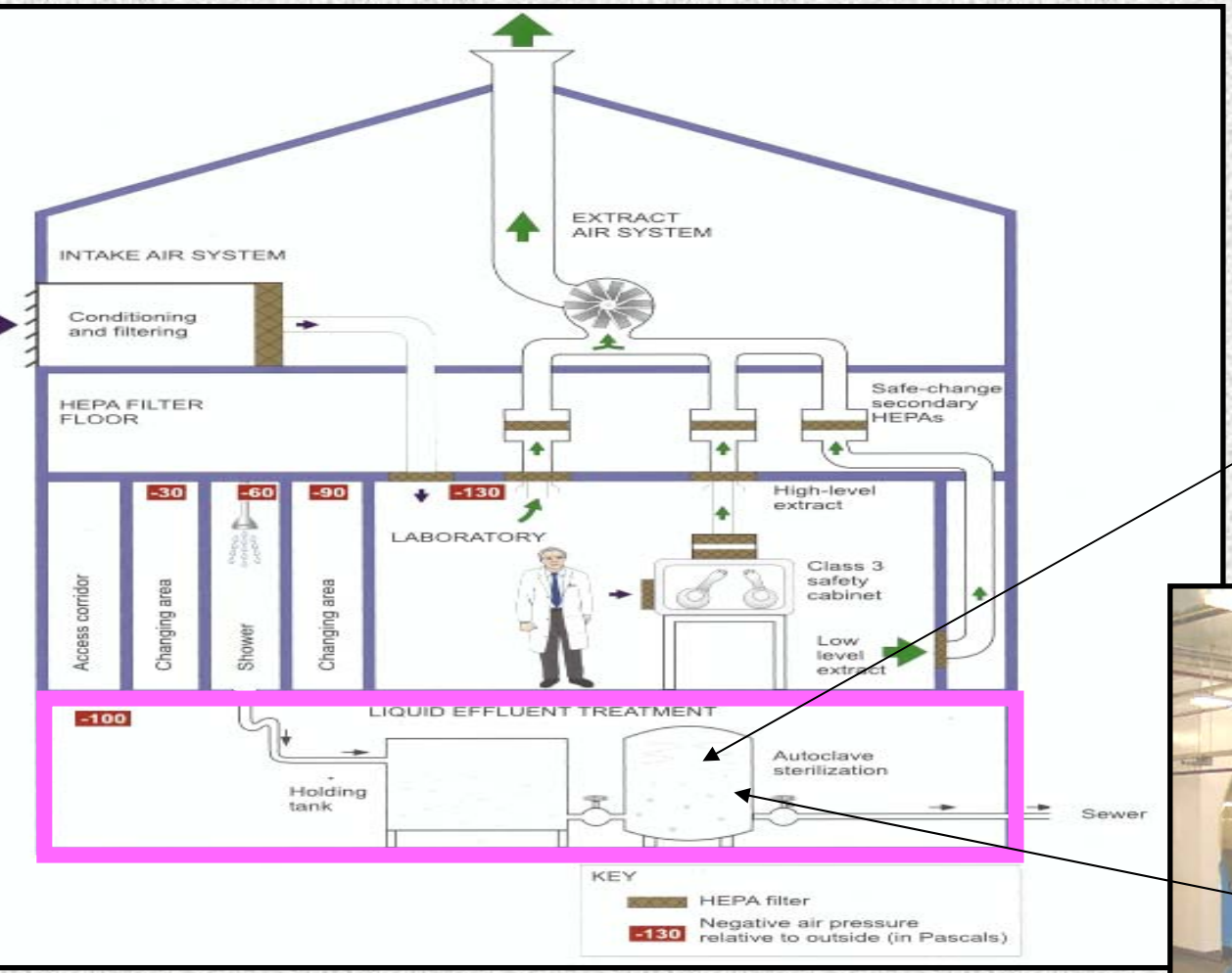
**Small confined space**



Other Electrical controls
eg Climate control

**Non-concrete floor etc for light change**

# Waste Treatment




Autoclave (121$^0$C) or Tissue Digester (conc Sodium Hydroxide)

Liq & Solid Waste Treatment

# Ante Chambers

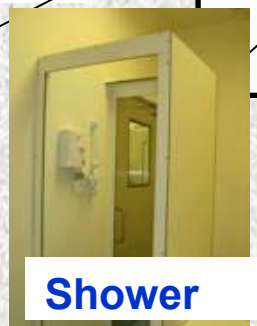
Hazard label

Pressure Gauge

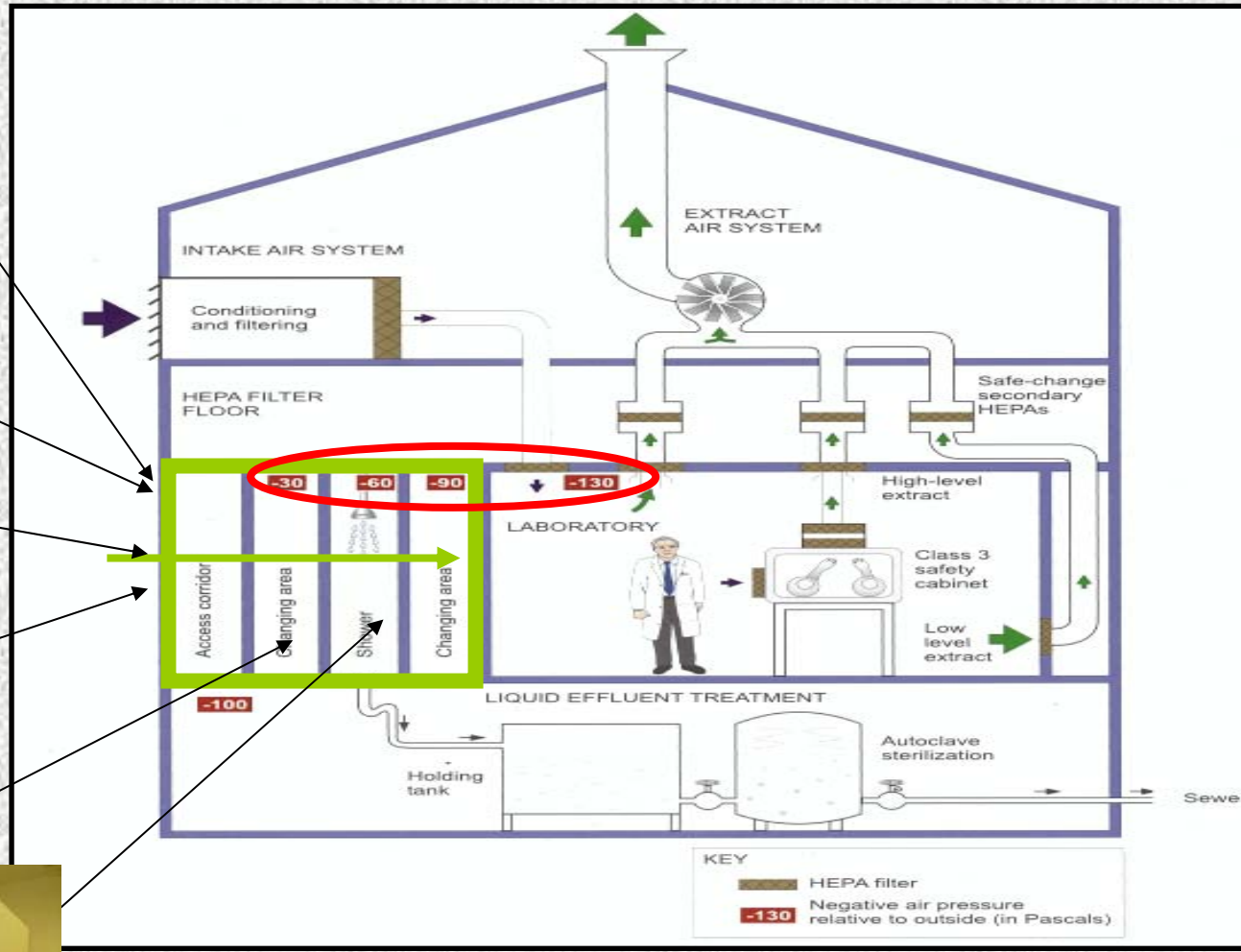
Security

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

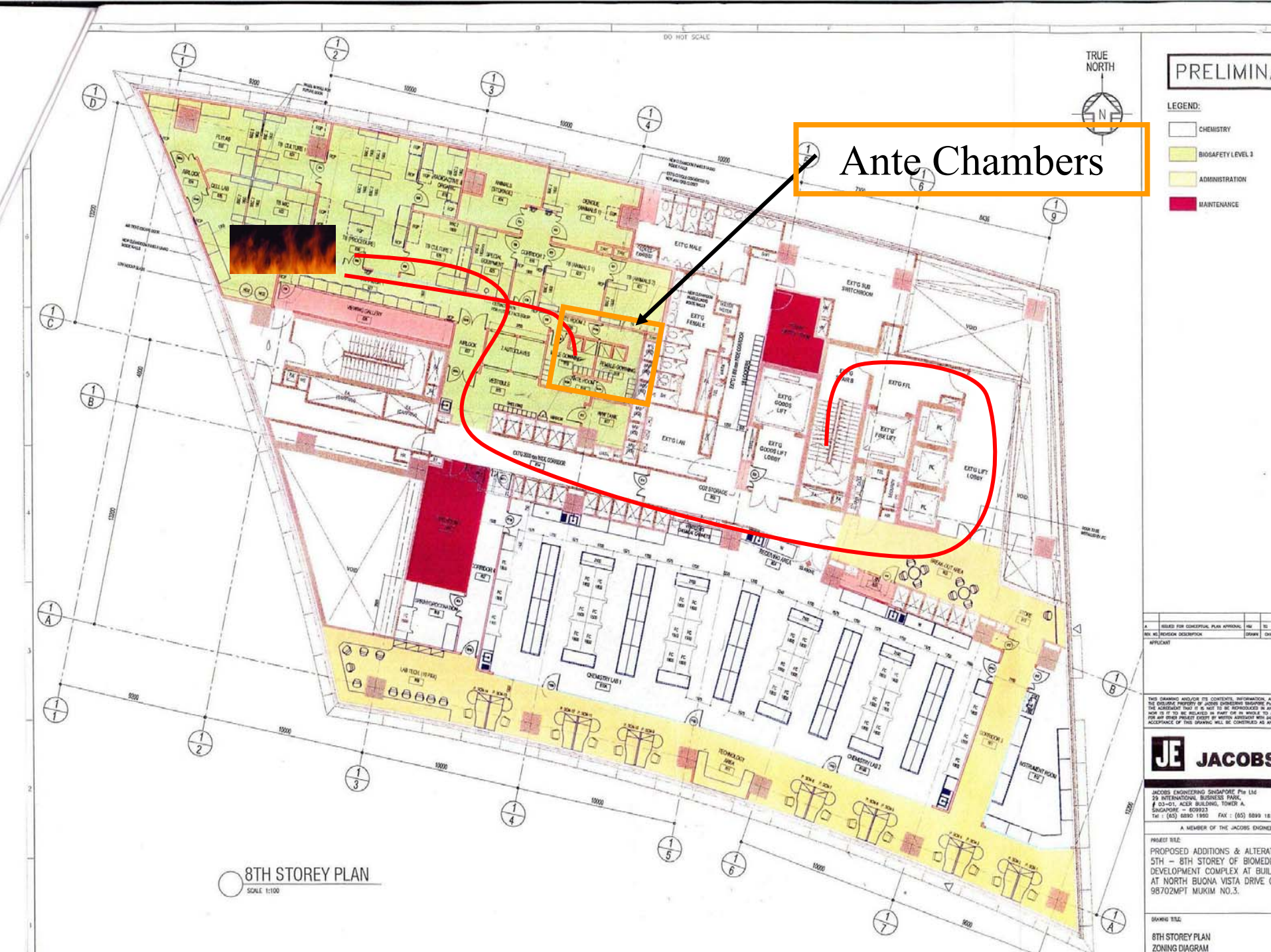
- In a sprinkler protected building the BSL-3 or BSL-4 shall be fire compartmented with at least ONE hour fire rating
  - Including interstitial space, waste treatment areas and anteroom
- At least TWO hours fire rating in a non-sprinkler protected buildings.
- The protecting structure shall be constructed 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 $m^2$ 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


Ante Chambers
TRUE NORTH
PRELIMIN
LEGEND:
CHEMISTRY
BIOSAFETY LEVEL 3
ADMINISTRATION
MAINTENANCE
8TH STOREY PLAN
SCALE 1:100
JACOBS
8TH STOREY PLAN
ZONING DIAGRAM

# Two-Way Emergency Communication System

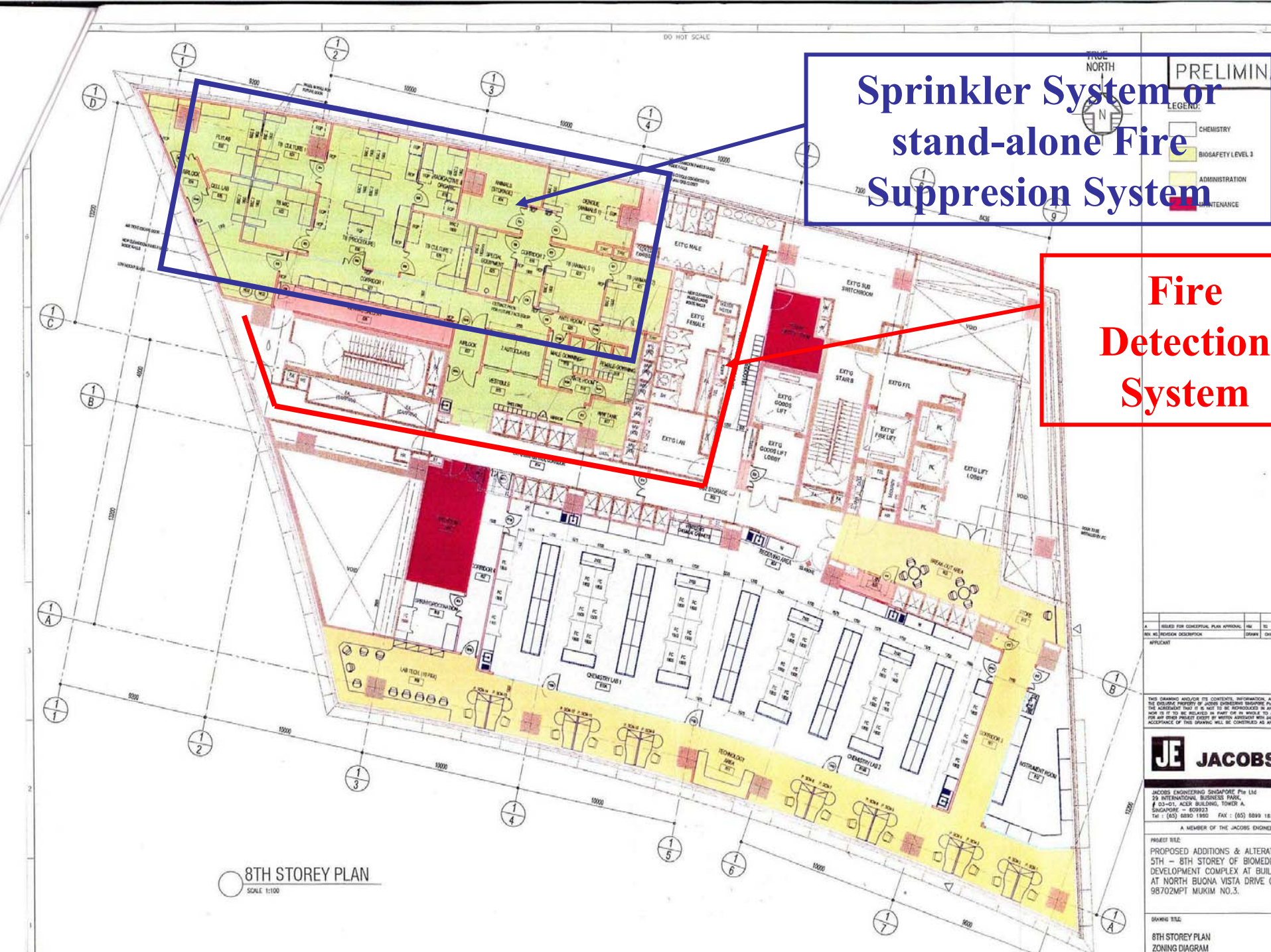
- **Two-way communication device shall also be installed if the building is provided with such system.**

# 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 Suppresion System
Fire Detection System
8TH STOREY PLAN
SCALE 1:100
PRELIMIN
LEGEND:
CHEMISTRY
BIOSAFETY LEVEL 3
ADMINISTRATION
MAINTENANCE
TRUE NORTH
JACOBS
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

**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