GUIDE TO FIRE PROTECTION IN MALAYSIA

GUIDE TO FIRE PROTECTION IN MALAYSIA

GUIDE TO FIRE PROTECTION IN MALAYSIA

Editor
Dato' Hamzah Bin Abu Bakar
Director General
Fire and Rescue Department Malaysia

This book is published by:
The Institution of Fire Engineers (UK) Malaysia Branch (IFEM)

In Association with:
Fire and Rescue Department Malaysia (JBPM)
Pertubuhan Akitek Malaysia (PAM)
Institution of Engineers Malaysia (IEM)
Association of Consulting Engineers Malaysia (ACEM)

22/10/07

This book is published by:

28 Jalan 3/154, Taman Bukit Anggerik, Cheras, 56000 Kuala Lumpur, Malaysia
Tel: +603-9101 2255 Fax: +603-9101 7700
Web: www.ife.org.my Email: info@ife.org.my

First edition: October 1999
Reprint: January 2000
Second edition: March 2006

Every effort has been made to ensure the information in this guide is as accurate as possible. This subject matter is complex and constantly changing, thus the professionals or other interested parties are advised to seek expert advice when faced with specific problems.

Graphics and Editing : YC Creative
Cover Design : www.yccreative.com
Printed : YCD Print
Price : RM 80.00

ISBN 983-808-095-0

ACKNOWLEDGEMENT

This book has been made possible through the smart partnership between The Institution of Fire Engineers (UK) Malaysia Branch (IFEM) and the Fire and Rescue Department Malaysia (JBPM) as well as professional bodies, namely, Pertubuhan Akitek Malaysia (PAM), Institution of Engineers Malaysia (IEM) and Association of Consulting Engineers Malaysia (ACEM).

1st Edition (October 1999)

Main Working Committee

1.	Prof. Datuk Dr Soh Chai Hock	Director General, JBPM
2.	PPjB Tuan Hj Zurkamain bin Mohd Kassim	JBPM
3.	PPjB Edwin Galan Teruki	JBPM
4.	PgB A. Veerasundar	JBPM
5.	PgB K C. Rajinder Kumar	JBPM
6.	Ir Chen Thiam Leong	ACEM
7.	Ar Paul Lai Chu	PAM
8.	Ar Chee Soo Teng	PAM
9.	Ir Thin Choon Chai	IEM
10.	Ir Wong See Foong	IEM
11.	Mr Tay Hao Giang	IFEM/MFPA
12.	Ir Fuad Abas	UPM

Sub-Committee

1.	PgkB Mohd Husain bin Ahmad Takin	JBPM
2.	PgB Hamdan bin Ali	JBPM
3.	Ar Ainon bt Ali	PAM
4.	Ar Chong Lee Siong	PAM
5.	Ar Hui Sheah Ming	PAM
6.	Ar Ng Kim Teh	PAM
7.	Ir Wong Kian Lon	ACEM
8.	Mr Wong Kin Wing	ACEM
9.	Ir Wong Shu Leong	ACEM
10.	Mr Lock Peng Wei	ACEM

2nd Edition (March 2006)

Working Committee

1.	Dato Hamzah bin Abu Bakar	Director General, JBPM
2.	Dato Wan Mohd Nor bin Ibrahim	JBPM
3.	PKPjB Soiman Jahid	JBPM
4.	PKP Ahmad Izram bin Osman	JBPM
5.	TPjB Mohammed Hamdan Wahid	JBPM
6.	PKP Hj Zurkamian bin Mohd Kassim	JBPM
7.	Mr Tay Hao Giang	IFEM
8.	Ar Chee Soo Teng	PAM
9.	Ir Chen Thiam Leong	ACEM
10.	Ir Wong See Foong	IEM
11.	Ar Chong Lee Siong	PAM
12.	Ar Loo Chee Keong	PAM

FOREWORD

It is my pleasure to pen this foreword for the second edition of the "Guide to Fire Protection in Malaysia". I am especially pleased to note that this publication by The Institution of Fire Engineers (UK) Malaysia Branch is a product of joint effort between IFEM, the Fire and Rescue Department Malaysia and the key players in the Fire and Safety Engineering Professionals. This fire safety engineering Guide book reflects the shared vision between the Fire and Safety Engineering Professionals with the Government of Malaysia in respect of the importance of transparency, constant improvement, innovation and smart partnerships.

This "Guide" is an invaluable source of reference to all those who are involved in Fire Safety Engineering and fire protection industry. Be it students, academicians, practicing professionals, local authorities, Fire and Rescue Department personnels, fire equipment manufacturers, suppliers or contractors. The second edition of the "Guide to Fire Protection in Malaysia" will clarify the intent and interpretation of the Fire Safety aspects of the Uniform Building By-laws to all the users, and in so doing, bring about consistency and efficiency in the industry to benefit the members of the public.

In this age of globalization, it is imperative that we all embrace changes as a way of life. It is also inevitable that we also have to evolve new legislation to take into consideration the understanding of fire science and technology which requires a rethink of conventional solutions to fire safety for now and the future.

Once again, I wish to congratulate Dato Hamzah Abu Bakar, Director General of the Fire and Rescue Department Malaysia, his able officers and the team of dedicated local professionals from The Institution of Fire Engineers (UK) Malaysia Branch (IFEM), Pertubuhan Akitek Malaysia (PAM), Association of Consulting Engineers Malaysia (ACEM) and Institution of Engineers Malaysia (IEM) on their commendable efforts in bringing this second Edition of the "Guide to Fire Protection in Malaysia" to fruition.

Y.B. DATO' SERI ONG KA TING
Minister of Housing and Local Government

1 PREFACE

As we move towards acquiring Developed Nation Status, it is essential that in forging ahead to achieve the necessary benchmarks, we do not forget to continue developing and enhancing our existing infrastructure.

Just as new Standards and Codes are being written for the Building Industry, existing Standards, Guides and Codes have to be reviewed to catch up with changing trends, technology and knowledge.

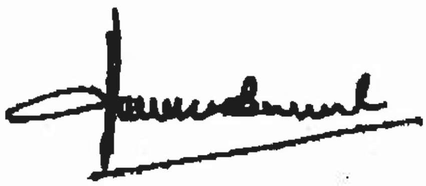
The effort by The Institution of Fire Engineers (UK) Malaysia Branch and the Fire and Rescue Department in updating the 2nd Edition of "Guide to Fire Protection in Malaysia" is commendable, taken into consideration the time and effort contributed by all authors, officers and the fire safety engineering professionals over the last few years.

Among the changes are - Chapters 15 on Smoke Control System that has been updated with the publication of the latest Malaysian Standards 1780; entire Passive Fire Protection System chapter illustrations has been upgraded from 2-dimensional to 3-dimensional diagrams for ease of understanding; Active Fire Protection System chapter 5 on Portable Fire Extinguishers had been rewritten with the introduction of Performance Based Malaysian Standard 1539.

The "Guide to Fire Protection in Malaysia" entails design concepts, standard and code, guidelines, charts, diagrams and illustrations, system check list, testing and commissioning check lists which are very comprehensive for any fire safety engineering professionals, fire officers and industrial players. This will serve as a common platform for all fire industry practitioners to obtain a common understanding and interpretation of the Uniform Building By-laws.

Hence, I will like to congratulate and thank all parties concerned for their meticulous effort in making it possible the publication of the 2nd edition of "Guide to Fire Protection in Malaysia". Special credit should go to Yang Berbahagia (Professor) Datuk (Dr.) Soh Chai Hock (Hon. FIFireE) for initiating this project and the Chief Editor for the first edition of "Guide to Fire Protection to Malaysia"

I will like to express my sincere gratitude to Yang Berhormat Dato' Seri Ong Ka Ting, Minister of Housing and Local Government, who has been instrumental and supportive of Fire and Rescue Department's mission in pursuing world class excellence not only in fire and rescue operation but also in the forward direction of fire safety engineering field of technical studies and applications.



DATO' HAMZAH BIN ABU BAKAR
Director General
Fire and Rescue Department Malaysia

CONTENT

It is probably not practical to design buildings that under no circumstances will any occupant be trapped in case of fire. It is also not possible to secure absolute safety in buildings, generally because of human failure to maintain the fire protection installations or to do the right things right when an emergency arises. The Architects, Engineers and building designers are therefore faced with the constraints of balancing life safety and fire integrity against practicality, aesthetic design and the fire regulations.

Whilst it is not always possible to achieve all the required fire precautionary principles in old structures or existing buildings, they can be applied in new buildings.

The larger the space, the greater is the potential area, the greater the potential fire risks and the greater the likely fire loss should a fire break out. It is often necessary to increase the height of buildings in order to obtain a profitable return on the investments and every inch of the floor area is in consequence highly valued.

2.3 BUILDING CONSIDERED AS A WHOLE

Passive and Active Fire Protection

Passive fire protection is basically a planning matter and must be considered at the planning stage in the building design in terms of mitigation of fire hazard and fire risk. The selection of fire resisting materials, sub division of the building into fire-tight cells or compartments both vertically and horizontally to contain an outbreak of fire and spread of smoke heat and toxic fume are basic precautions at the planning stage.

Effective passive fire precautions represent good planning, good design and sound construction, which could complement other basic functions of a building.

Active fire protection is basically the manual or automatic fire protection systems such as: fire alarms, detectors (heat & smoke) rising mains, hose reels, fire telephones, CO_2 fixed installation, automatic sprinklers and smoke spills system etc. to give a warning of an outbreak of fire and the containment and extinguishment of a fire. The provisions of adequate and suitable facilities to assist rescue and fire suppression operations are also within the active fire defence strategies.

2.4 THE NEW CHALLENGES

The overall fire defence strategies for development projects in Malaysia are based on the "Fire Safety Philosophy" of the Malaysian Uniform Building By-laws 1984 where life safety is the first consideration. The fire prevention and operational requirements for both external and internal fire suppression must be considered together. It must also be possible for the fire fighters to operate at any point in the buildings. Facilities must be built into the buildings to enable the fire fighters to reach the top-most floors and carry out rescue and internal fire suppression operations.

The world's tallest twin towers (KLCC), the Kuala Lumpur International Airport, Kuala Lumpur Tower and other mega projects have created new challenges to the Architects, Engineers and building designers and Malaysian fire fighters. When these mega projects were proposed, the professionals had to venture beyond the perimeter of the "Uniform Building By-laws 1984" and adopt international fire safety guides and practices including "Fire Safety Engineering Approach" and "Performance Based Criteria".

The building designers and fire prevention officers visited many projects and high rise buildings throughout the world. Technical discussions were also held with various Fire Strategists, Fire Chiefs, Standard Institutions and Test Laboratories to determine the most appropriate Fire Codes to be adopted within the framework of the Uniform Building By-laws 1984.

The Uniform Building By-laws 1984, similar to all international building codes, cover a broad range of buildings and use conditions but they cannot be expected to adequately reflect new technology, recent relevant experience, innovation in design and unique building or occupancy conditions.

To address such conditions, By-law 245 of the Uniform Building By-laws 1984 empowers the Director General of the Fire and Rescue Department Malaysia, to accept alternative to the requirements contained in the code where sufficient evidence is provided to demonstrate that the proposed alternative will provide equivalent or better performance.

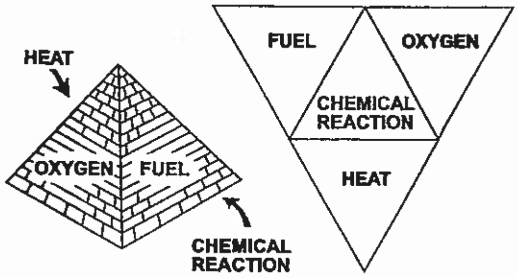
It is hoped that this book will provide a clearer understanding on fire protection and the concept of good fire engineering practice and design strategies to building owners, fire officers, professionals and students in line with the fundamental principles of Uniform Building By-law 1984.

3.1 UNDERSTANDING FIRE SCIENCE

Fire is essentially a chemical reaction known as combustion. It can spread in minutes and kill in seconds. Knowing the characteristics of fire and understanding how it can spread can help Architects, Engineers and other professionals to formulate strategies on life safety and property protection in building designs.

Four factors are needed to start a fire - FUEL, OXYGEN, HEAT and CHEMICAL REACTION. This is known as the 'Fire Tetrahedron'. If this chemical reaction is allowed to spread unchecked, a very small fire will quickly develop into an inferno and become catastrophic.

Diagram A: Fire Tetrahedron

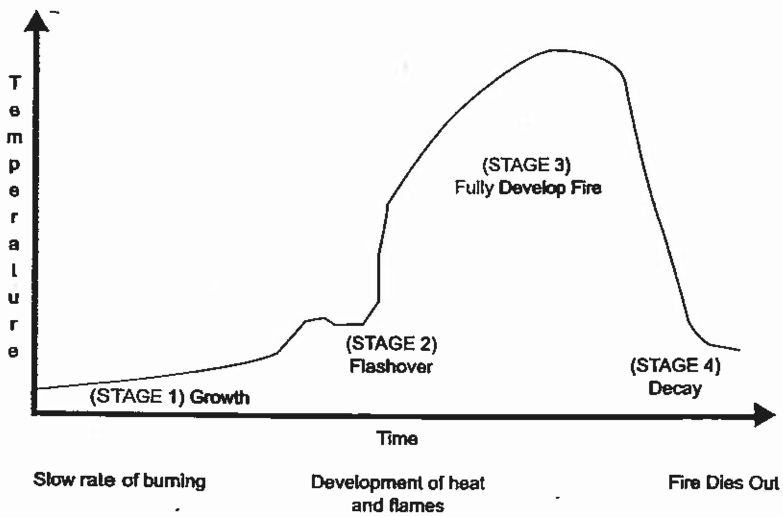


Let us remember "The world's largest fires can be extinguished by pouring a cup of water at the right time."

A fire can easily be extinguished by removing one of the factors in inhibiting the chemical chain reaction of the combustion process. For example we can remove heat by pouring water on the fire or removing the fuel or cutting off oxygen supply by using a fire blanket or foam.

3.2 IGNITION, GROWTH AND DEVELOPMENT OF FIRE

Diagram B: Stages of Fire Development



The time/temperature curve of a typical fire

- **IGNITION** - A process in which fuel reacts with oxygen to give heat and light

- **GROWTH** - A fire once started can grow rapidly as it creates the conditions for its own growth. In an enclosed compartment, a critical stage may be reached where all the combustion materials are heated to flammable concentrations of gases and the fire suddenly flashes throughout the whole compartment - this is known as a ``flashover"

- **DEVELOPMENT** - The fire passes through a development stage after the initial growth. During this stage the fire temperature increases slowly. However the fire continues to spread into other areas, which then in turn continues the process of rapid initial growth and development.

- **DECAY** - In the decay stage, the fire will burn itself out due to lack of fuel or oxygen.

- **FUEL LOAD** - The amount of available and potentially combustible materials to fuel the fire.

- **FLASHOVER** - Simultaneous ignition of all combustible in an enclosed area. Flashover occurs when the majority of the surface in a space are heated to the point at which they give off flammable gases that are hot enough to sustain combustion.

3.3 PRINCIPLES OF FIRE PROPAGATION

Through natural laws, heat and smoke will travel from hotter to cooler areas by any of the three methods:

CONVECTION - More than 75 per cent of the combustion products of a fire, eg. smoke, burning particles, toxic gases are dissipated in rising convection currents of hot gases at temperatures of 800 - 1000°C. It will create a "mushroom effect", when the rising convection current is blocked, eg. by underside of floor or ceiling. It can also smokelog escape routes and prevent escape.

RADIATION - Radiant heat is transmitted to all buildings or materials that is adjacent to and not the fire. It is the transfer of heat energy as electromagnetic waves. Radiation passes through normal glass windows easily, and buildings with many or large windows are more likely to spread fire to other buildings.

CONDUCTION - The movement of heat through materials via excitation of molecules eg. metals are better conductors of heat than stones. Conducted heat can travel through partitions, floors, ceiling, walls, to adjacent rooms, especially through metal piping, metal frames and joists. Combustible materials or internal linings of adjacent rooms can be heated to their ignition temperature by conducted heat.

3.4 FIRE PROTECTION IN BUILDINGS

A total fire safety system for any high rise building must include structural integrity during fire. Structural failure when occupants are still in the building is catastrophic. The quality of workmanship and the sustainability and durability of the building materials and systems require close attention. The UBBL 1984 requires all buildings to have minimum structural integrity based on its usage. Elements of construction can only be effective as fire breaks if they have the necessary degree of fire resistance. The three criteria of fire resistance are:

INSULATION: The ability of an element of construction to resist or inhibit the heat.

INTEGRITY: The ability of an element of construction to maintain its shape and structural properties and at the same time preventing the passage of flames and hot gases.

STABILITY: The ability of an element of construction to maintain overall structural integrity

The principal role of structural fire protection is to prevent the spread of heat and smoke from the seat of fire to other parts of the building. The best way to control spread of fire is early detection and extinguishment - and a reliable way of achieving this is by installing a system and good housekeeping.

3.5 FIRE HAZARDS ASSESSMENT

Main factors contributing to fire hazard:

- The amount of combustible materials present.
- The potential heat output of these materials in a fire, i.e.. their calorific value.
- The surface areas - most materials burn at or near their surfaces.
- The potential heat source.
- Airflow condition and unrestricted air supply that sustain combustion.
- The design and construction of a building can have as much or even more effect on the development of a fire than the contents of the building.

The Architect or Engineer have to assess the fire hazard of the building arising from its usage, location and siting, area volume and height, number of people in the building and mobility of its occupants, design and construction.

Fire tests have proven that all combustible materials when burnt, will produce some asphyxiating or poisonous gases and nearly all produce smoke which hinders vision. Many plastic materials produce highly poisonous vapours and very dense smoke. It is Important for building consultants to check on the features of certain materials before installing into the building. These include:

- Susceptibility to heat, smoke and waler damage.
- The potential for producing burning droplets - skylight etc.
- Issue of repair after they have been in a fire.
- Issue of maintenance and replacement.

3.6 GOOD BUILDING DESIGN WITH FIRE SAFETY MEASURES

- Provide adequate fire appliances access, fire hydrants and other facilities to assist fire and rescue personnel.
- Provide adequate fixed installation, where appropriate, for quick and effective detection and extinguishment of fires.
- Designing and installing building services so that they do not assist the spread of fire, smoke or toxic fumes.
- Designing and providing adequate and safe escape routes for the occupants of the building.
- Selecting materials for the construction which will not promote the rapid spread of fire or generate dangerous smoke and poisonous gases.
- Subdividing buildings into compartments of reasonable sizes by means of fire resisting walls and floors, providing fire stops to protect openings between floors and compartments.
- Designing and constructing the exterior of a building so that fire is unlikely to spread to it from another burning building.

3.7 EXISTING STRUCTURE AND HISTORICAL BUILDINGS

It is normally quite straight forward for Architects and Engineers to comply with the various fire protection requirements for new buildings. However, it is often difficult for any building designer to meet all the legislative requirements on fire protection when it comes to upgrading of old buildings. Fire prevention officers and professionals should therefore always attempt to achieve a reasonable level of fire precaution for their buildings to ensure adequate safety to occupants. For example reduce fire resistance of timber structures in historical buildings could be compensated by increased/extra provision of direction device and alarms together with extra fire suspension systems.

3.8 FIRE AND THE LAW

Architects and Engineers must remember that the fire safety regulations in Malaysia are based on international norms to protect life. However, some of the fire safety provisions in the UBBL 1984 and the Fire Services Act 1988 will also offer protection to buildings and their contents as well as fire fighters. A section in this book provide detail requirements of the Fire Services Act 1988. The UBBL 1984 and the Fire Services Act 1988 should not be read in isolation, but should be read in conjunction with all relevant Malaysian and International legislations and standards.

3.9 CONCLUSION

When considering fire protection measures for buildings, it is important to understand that the safety of occupants and fire fighters are interrelated, and that design solution should address the effect of fire, smoke and toxic fumes in totality.

PASSIVE FIRE PROTECTION

4.1 PURPOSE GROUPS

4.1.1 Purpose Groups And Compartments

Purpose Groups (By-law 134) categorise buildings or compartments within a building in accordance with their uses/intended usage or the dominant use in accordance with the Fifth Schedule. The intended use or occupancy (Purpose Group) of a building or part of a building is a fundamental consideration of the relevant sections of the Uniform Building By-laws in establishing minimum standards that need to be complied in order to achieve a satisfactory level of life safety of the users or occupants.

Some buildings exceed the physical size allowable for its designated Purpose Group. In that event, it is divided into smaller compartments for Fire Safety management reasons to limit the spread of fire and to restrict the movement of smoke. Alternatively, a building, designed to accommodate different activities that fall under different Purpose Groups can be divided into compartments each housing its own Purpose Group activity to enable each compartment's fire safety to be considered in relation to the risks associated with the different types of usage. A compartment when used in this Fire Safety context denotes a physically delineated volumetric space or part of a building which is separated from all other parts by one or more compartment walls or compartment floors or by such walls and floors.

The anticipated fire hazards presented by any building will predominantly be dictated by the use or purpose to which the building is put to (Purpose Group). This is influenced by the nature (residential, working or public gathering) and level of occupancy of the buildings as well as the types of material or anticipated fire loads used in connection with that type of occupancy. For example, warehouses differ greatly from department stores when it comes to the number of anticipated occupants as well as the potential fire load of their contents. Consequently, the minimum requirements to ensure fire safety such as means of escape for occupants, permissible volume of compartments, fire resistance rating of compartment walls, level of fire detection and fire fighting systems are directly related to these usage groupings. These different provisions relating to the different usage groups in turn form the basis for both designers such as Architects or Engineers and the Fire And Rescue Department of Malaysia (JBPM) to establish the minimum passive safety requirements as well as the minimum fire safety installations necessary to comply with the UBBL.

The Fifth Schedule (Designation of Purpose Groups) in the UBBL (By-law 134, 138) lists the respective usage description of each designated Purpose Group. Generally, Purpose Groups I, II and III cover groups with a Residential element where there is sleeping accommodation and therefore extra danger in the event of fire. The remaining five Purpose Groups cover usage with no sleeping accommodation. (See Appendix 1)

The Second Table in the Fifth Schedule (By-law 136) lists the physical dimensional limits or parameters (height, area and volume) permissible for each building or compartment in the respective Purpose Groups. (See Appendix 2)

The Purpose Group designation arrived at in turn becomes the basis for checking for compliance with different areas of Fire Safety. These are contained in the Sixth Schedule (Permitted Limits of Unprotected Openings - By-laws 142 and 145), the Seventh Schedule covering Maximum Travel Distances (By-laws 165[4], 166[2], 167[1], 170[b]) and Calculation of Occupant Load And Capacity Of Exits (By-laws 167[2], 168[2], 170[c], 171[c], 175), the Eighth Schedule (Restriction of Flame Spread Over Walls and Ceilings-By-laws 204, 206), the Ninth Schedule (Limits Of Compartments And Minimum Periods Of Fire Resistance For Elements of Structure - By-laws 143[3], 147,158[1], 162, 213, 216[2]) and the Tenth Schedule (Table Of Requirements For Fire Extinguishment Alarm Systems And Emergency Lighting - By-laws 226[1], 237[1]) of the UBBL.

FIFTH SCHEDULE OF UBBL

Number Of Purpose Group	*Descriptive Title*	*Purpose for which building or compartment is intended to be used*
I	Small residential	Private dwelling house detached or semidetached (not including a flat or terrace house) not comprising more than (1) a ground storey; (2) one upper storey; and (3) a basemen storey or basement storeys
II	Institutional	Hospital, school or other similar establishment used as living accommodation for, or for treatment, care or maintenance of, persons suffering from disabilities due to illness or old age or other physical or mental disability or under the age of 5 years, where such persons sleep in the premises
III	Other residential	Accommodation for residential purpose other than any premises comprised in groups I and II
IV	Office	Office, or premises used for office purposes, meaning thereby the purposes of administration, clerical work (including writing, book-keeping, sorting papers, filing, typing, duplicating, machine-calculating, drawing and the editorial preparation of matter for publication), handling money and telephone and telegraph operating
V	Shop	Shop, or shop premises, meaning thereby premises not being a shop but used for the carrying on there of retail trade or business (including the sale to members of the public of food or drink for immediate consumption, retail sales by auction, the business of lending books or periodicals for the purpose of grin, and the business of a barber or hairdresser) and premises to which members of the public are invited to resort for the purpose of delivering their goods for repair or other treatment or of themselves carrying our repairs to or other treatment of goods
VI	Factory	Factory means all premises as defined in section 2 of the Factories and Machinery Act 1967, but excluding those buildings classified under purpose group VIII - storage and general
VII	Place of assembly	Place, whether public or private, used for the attendance of persons for or in connection with their social, recreational, educational, business or other activities, and not comprised within groups I to VI
VIII	Storage and general	Place for storage, deposit or parking of goods and materials (including vehicles), and other premises not comprised in groups I to VII

In the interpretation of the application of the Tenth Schedule, it is generally accepted that the residential portion (apartments and flats) is excluded from consideration.

In mixed use buildings, By-law 215[2] (Height Of Buildings) of the UBBL allows height of different compartments within a single building to be individually considered (measured in accordance with By-law 135 of the UBBL) in compliance with the Sixth to Tenth Schedules when the compartments are separated by continuous vertical planes. (See Diagram 4.1.4.1).

Sprinklers have over time been proven to be a most effective form of fire control. The effectiveness of automatic sprinklers (coupled with detectors) as an early fire suppression and containment system in effect extends the evacuation time which occupants have to make their way to safety (By-law 136). This effectiveness in suppressing and containing fire before it gets out of control is recognised. Consequently, the limits of dimensions for areas and volumes in buildings and compartments which are installed with automatic sprinklers are allowed to be double that of buildings or compartments not fitted with sprinklers to reflect the reduced risks in sprinkled buildings.

4.1.2 Shopping Centres And Shop Compartments

Single Department Store buildings developed and evolved through retail and design innovations into buildings where several stores or shops open onto and are linked by a covered or roofed over "street" that combined the circulation paths for means of egress with pedestrian routes. Within this mall can be found a mixture of large stores or users termed Anchor Tenants (like a Department Store within a mall or complex) and smaller shops that open onto the mall. It is generally expected that within this mall will be a mixture of other uses such as food courts and cinemas and occasionally amusement arcades. Malls extended vertically become the modern day large shopping complexes.

When malls and large shopping complexes became popular, they required new interpretations of the UBBL as their nature did not fit into any single typology either in size or in complexity, bearing in mind the paramount need to maintain as efficient a flow of shopper traffic as possible. In the United States, the code provisions for covered mall buildings grew out of many years of application of special interpretations of existing codes.

In Malaysia, the following recommended guidelines are to be observed when designing shopping centres (as contained in the Sarawak Building Ordinance) :

(i) The size of shop compartments shall not exceed:

(a) 7,000 cubic metres and 2,000 square metres floor areas for unsprinklered buildings;

(b) 14,000 cubic metres and 4,000 square metres floor area for fully sprinklered buildings and shall be fully compartmented from any other parts of the shop area.

(ii) Where the floor area of building with fully automatic sprinkler installation is subdivided, there shall be no restriction on the total area, provided that:

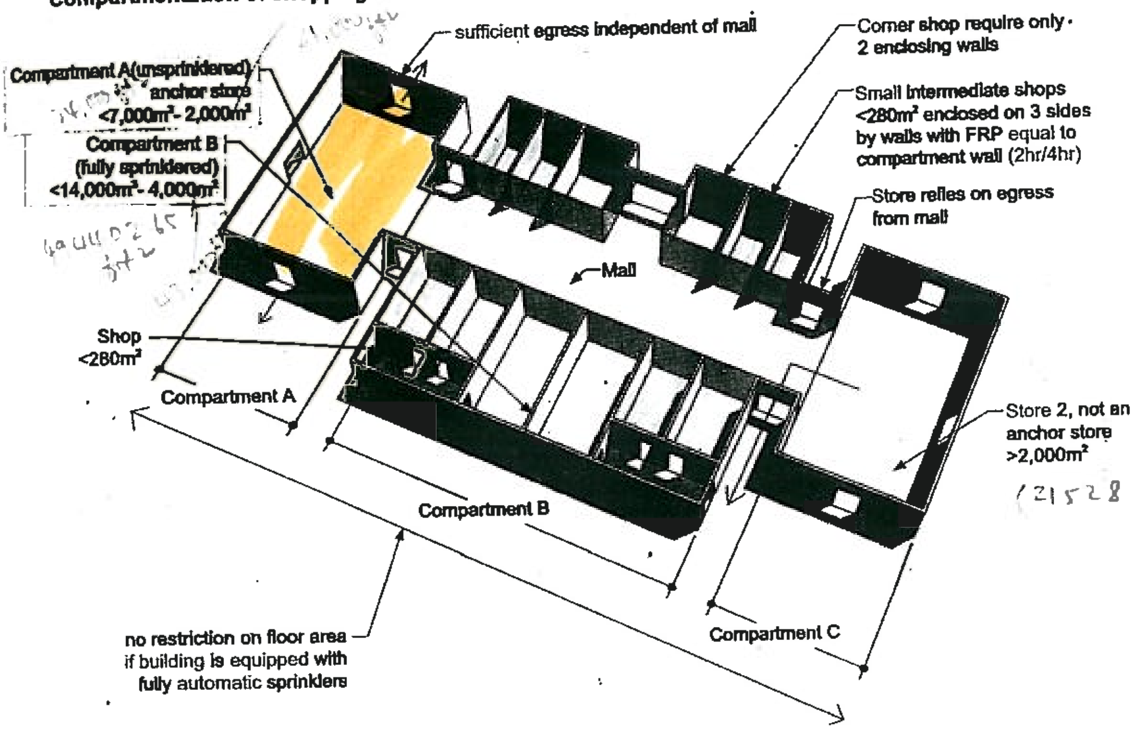
(a) not less than 60% of the total area shall consist of units of separate shops not exceeding 280 square metres each of which is enclosed as in paragraph ii.; and

(b) shop units referred to in paragraph (i). shall be enclosed on three sides by walls having a fire resistance equal to the compartment wall as required above; and the frontage onto a covered mall or open pedestrian footpath constitutes the fourth side, and shops on a corner side will not require a third enclosing wall. The remaining areas may consist of shops larger than 280 square metres but not exceeding 2,800 square metres; provided that:

(b.1) shop areas exceeding 2,000 square metres shall not face each other across a mall or a pedestrian footpath unless both frontage are protected by automatically operated shutters giving at least one hour fire resistance; and

(b.2) where shops which adjoin one another with their open sides in a same place are of floor areas exceeding 8,000 square metres each, they shall be protected by back-up walls behind the shop windows for a distance of at least 3 metres on both sides of the intervening wall or be separated from each other by at least one small unit of not more than 280 square metres area.

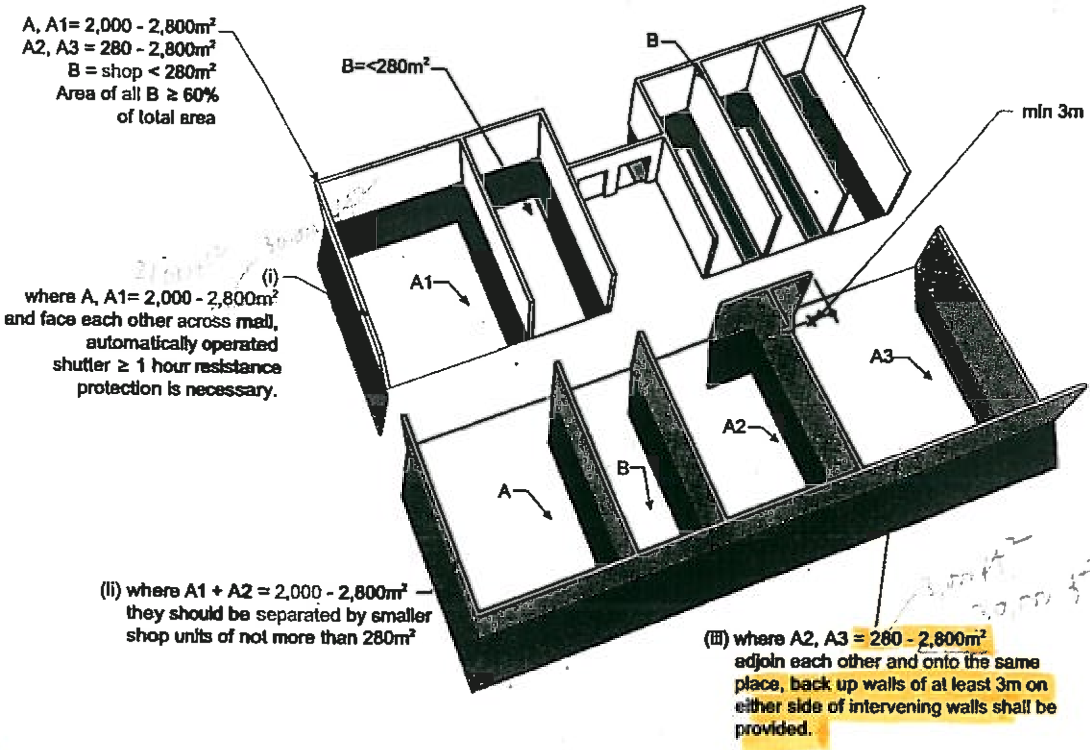
Diagram 4.1.2.1
Compartmentation of shopping centres



Notes:

(ii)(a) In compartment B, retail spaces/shops floor area shall be 60% or more of the total compartment area.

Diagram 4.1.2.2
Arrangement of shops



4.1.3 Atriums

The National Fire Protection Association Life Safety Code (NFPA 101) defines Atrium as "A large volume space created by a floor opening or a series of floor openings connecting two or more stories that is covered at the top of the series of openings and is used for purposes other than an enclosed stairway; elevator hoist way; escalator opening; or utility shaft used for plumbing, electrical, air conditioning, or communications facilities"

The Building Regulations 1991 of England and Wales define an Atrium as "a vertical space in a building which openly connects three or more floors and is enclosed at the top by a roof or floor. (Shafts containing exclusively stairs, escalators, lifts or services are not included in this definition)".

The two definitions are not inconsistent and both define a vertically linked volume of space over several floors. Atrium buildings very often combine aspects of malls and high rise buildings. The greatest concern regarding atrium fires involves the control of smoke. Where atriums are used, there is actually an added degree of safety to the occupants because there is a large volume of space into which the smoke can be drawn into and then dissipated. However, there is a need to ensure that dangerous concentrations of smoke are promptly removed from the atrium, and the exhaust system needs careful design.

Atriums may be permitted in buildings provided the following conditions are met:

(i) The minimum horizontal dimension between opposite edges is no less than 6 metres and the area of the opening is not less than 95 square metres. Atriums need not only be rectangular shaped, and for practical reasons, the horizontal dimension obviously cannot be applied in corner or niche locations. The minimum dimensional requirements are aimed at ensuring that the atrium designers create a large smoke accumulation chamber, which manages the smoke concentration early in the fire before the building sprinkler system achieves control of the fire and before the required smoke control system begins to control smoke accumulation. The geometry specified by the minimum dimensions help to keep the atrium opening from behaving as a flue or chimney in lieu of an initial smoke accumulation chamber. The 6 metres and 95 square metres represent the best aggregated thinking of experts in the field of fire safety.

(ii) The exits are separately enclosed from the atrium. Access to the exits is permitted to be within the atrium. It is considered that given the compliance with the stringent conditions (i) to (vii) of this part an adequate overall package of safety measures is afforded to allow exit access to be within the atrium.

(iii) The atrium is open and unobstructed, with a low to ordinary hazard content.

(iv) The building is fully protected by automatic sprinklers. The entire building rather than just the atrium opening and its communication space, must be protected by a supervised sprinkler system.

(v) The sprinklers to ceiling or roof of the atrium may be omitted if the ceiling/roof is more than 17 metres above the floor of the atrium. The reason for this exception is that above 15 metres, it has not been demonstrated that sprinklers directly over the fire will effectively respond to the fire in a timely manner. In fact, the mist resulting from the sprinkler spray being evaporated by the hot column of rising air may most probably interfere with the functioning of the smoke collection chamber at the top of the atrium by lowering the temperature of the smoke and thus affecting its density and affecting the plume characteristics.

(vi) A smoke control or smoke exhaust system is provided for the atrium and adjacent spaces, complying with approved standards. The exception is when an engineering analysis can demonstrate that life safety during the egress period will not be compromised.

(vii) The smoke control or smoke exhaust system installed shall be activated by:

(a) Smoke detectors located at the top of the atrium and adjacent to each of the return air intake from the atrium or beam detectors at the appropriate level; or

(b) The automatic sprinkler system serving the atrium zone/s; or

(c) The automatic detector system (but not manual call point system); or

(d) Manual controls readily accessible to the fire brigade.

(viii) The atrium is separated from adjacent occupancy by a fire barrier with at least one hour fire resistance with the exception that:

(a) Any number of levels of the building shall be permitted to open directly to the atrium without enclosure based on the results of an engineering analysis acceptable to JBPM. This engineering analysis shall demonstrate that the building is designed to keep the smoke layer interface above the highest unprotected opening to adjoining spaces, or 2,000mm above the highest floor level of exit access open to the atrium for a time period equal to 1.5 times the calculated egress time or 20 minutes, whichever is greater.

The engineering analysis shall include but not be confined to the following elements:

(a.1) Fire dynamics, including fire size and location, materials likely to be burning, fire plume geometry, fire plume or smoke layer impact on means of egress and tenability conditions during the period of egress.

(a.2) Response time and performance of building systems including passive barriers, automatic detection and extinguishing and smoke control.

(a.3) Required safe egress time for the occupants to reach building exits, including time required to exit through the atrium as permitted by this guideline.

(b) Glass walls may be used in lieu of fire barriers where automatic sprinklers are spaced not more than 1.8 metres or less apart along both sides of the glass wall and not more than 0.3 metre from the glass so that the surface of the glass is wet upon operation of the sprinklers. The glass used shall be tempered, wired or laminated glass held in place by a gasket system that permits the glass frame system to deflect without breaking the glass before the sprinklers operate. The intent of the requirement for the closely spaced sprinklers to wet the atrium glass wall is to ensure that the surface of the glass is wet upon operation of the sprinklers. Automatic sprinklers shall not be required on the atrium side of the glass wall and inoperable windows where there is no walkway or other floor area on the atrium side above the main floor level. The concept of wetting the glass that is exposed to fire without specifying a water application rate is that as long as there is some water present to absorb the heat, the glass will not reach excessive temperatures that would cause failures. To ensure that water will reach the surface of the glass, window blinds and security shutters must not be placed between the glass and in the line of closely spaced sprinklers.

(c) Glazed doors forming part of the glass walls shall be fitted with door closers complying with By-law 164.

(ix) The selection of materials used to line the roof/ceiling over the atriums has to be made with care. Materials that melt and drip molten debris to the atrium floor below can pose an additional hazard both to users as well as aiding fire spread. Plastics are to be avoided. In any event, By-laws 203 and 207 are to be complied with, and only materials with a Class O - surface of No Flame Spread - rating should be used [By-law 204A., a. and b.]. By-law 207 - Exception relating to ceilings should be exercised very carefully when applied to ceilings over atriums as the risks posed by the exceptions are different when compared to conventional ceilings over non-atrium spaces or voids.

Diagram 4.1.3.1
Plan view of a typical atrium

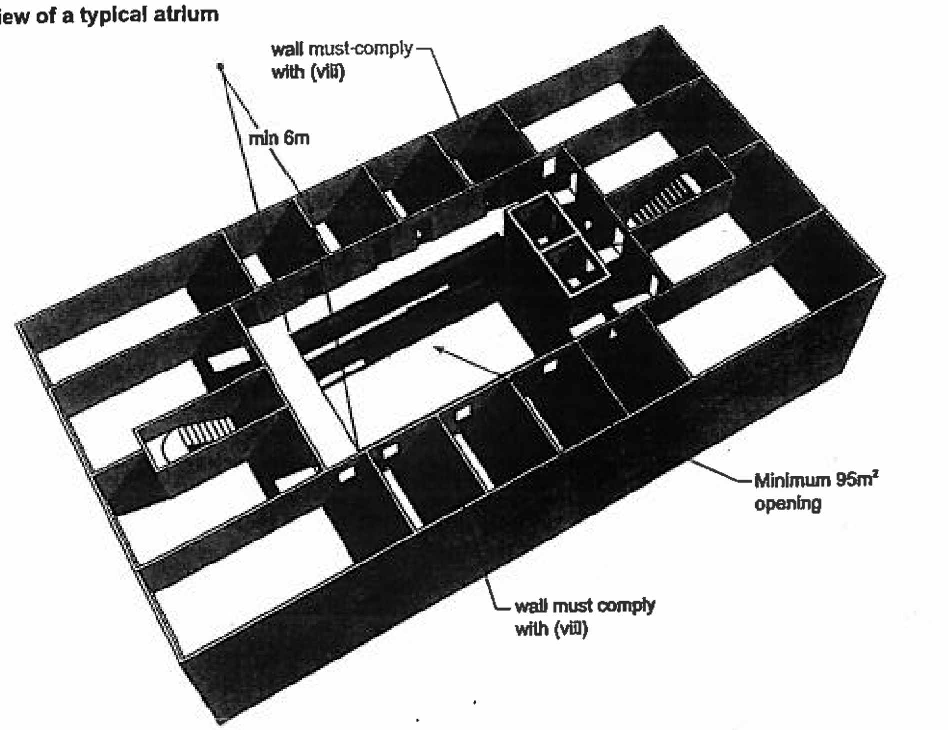


Diagram 4.1.3.2
Sectional view of a typical atrium

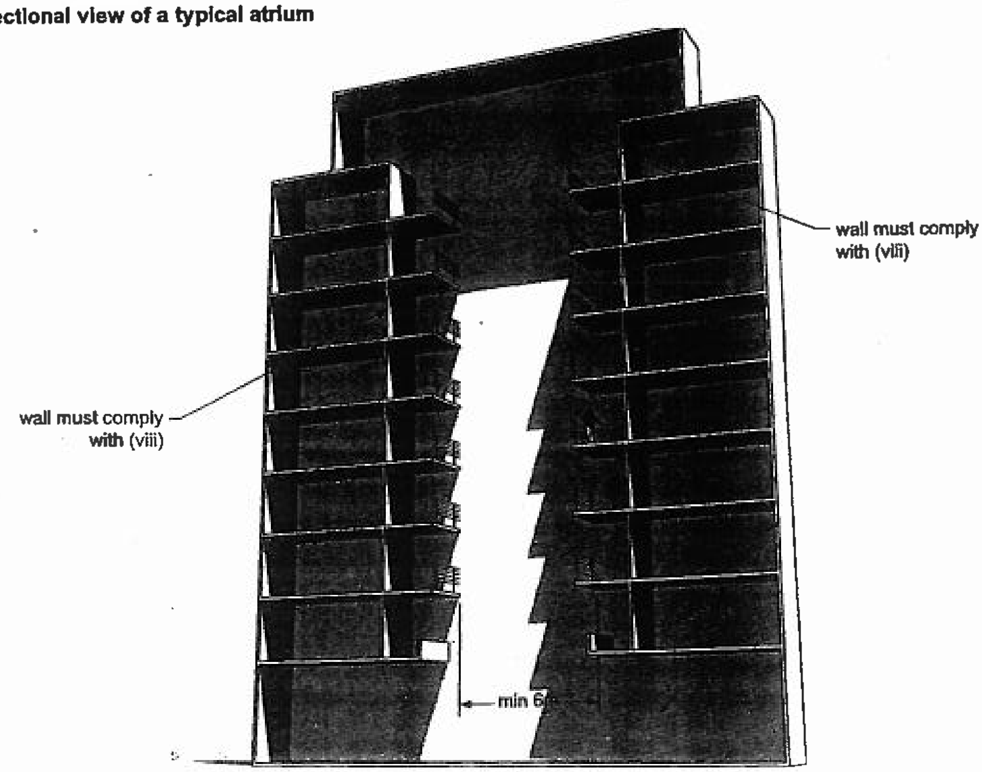
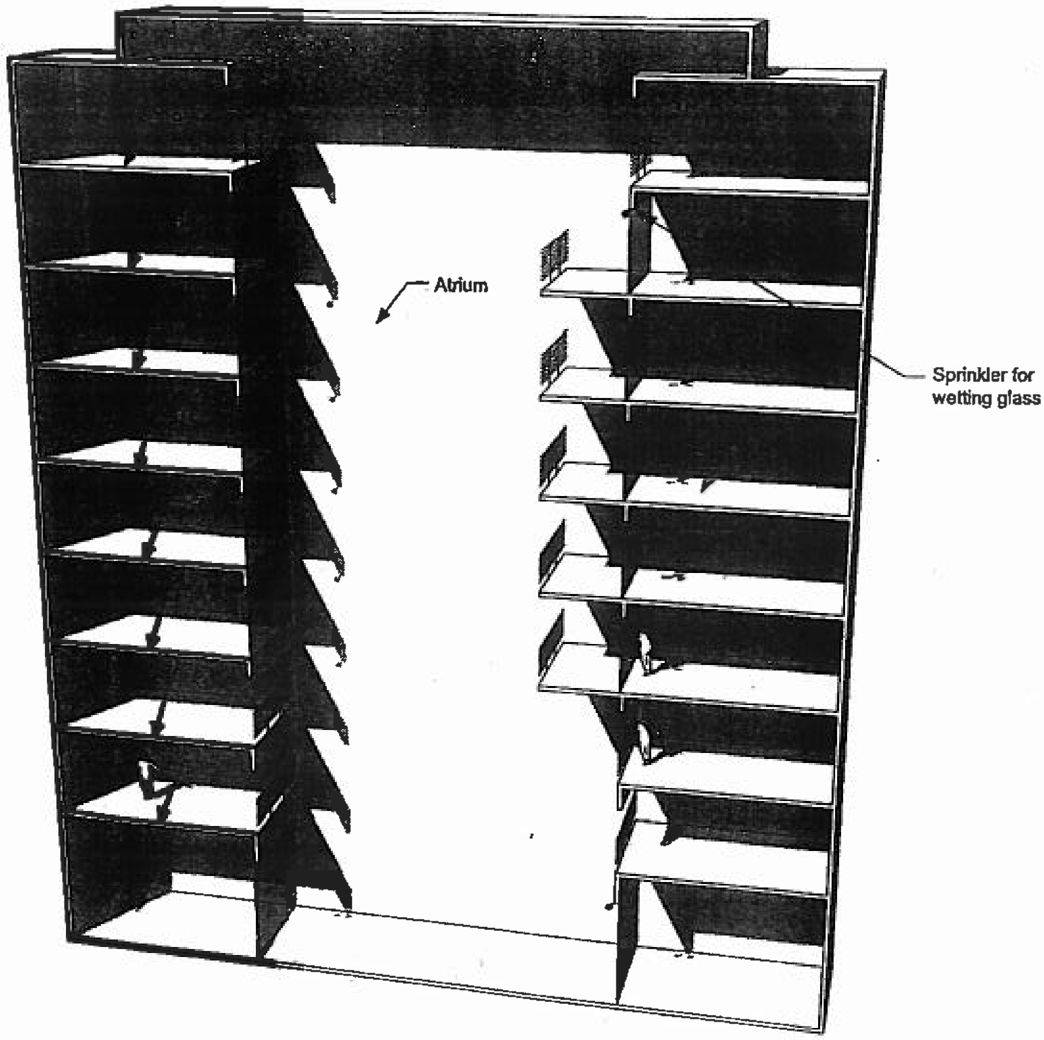


Diagram 4.1.3.3
Sprinkler for wetting glass

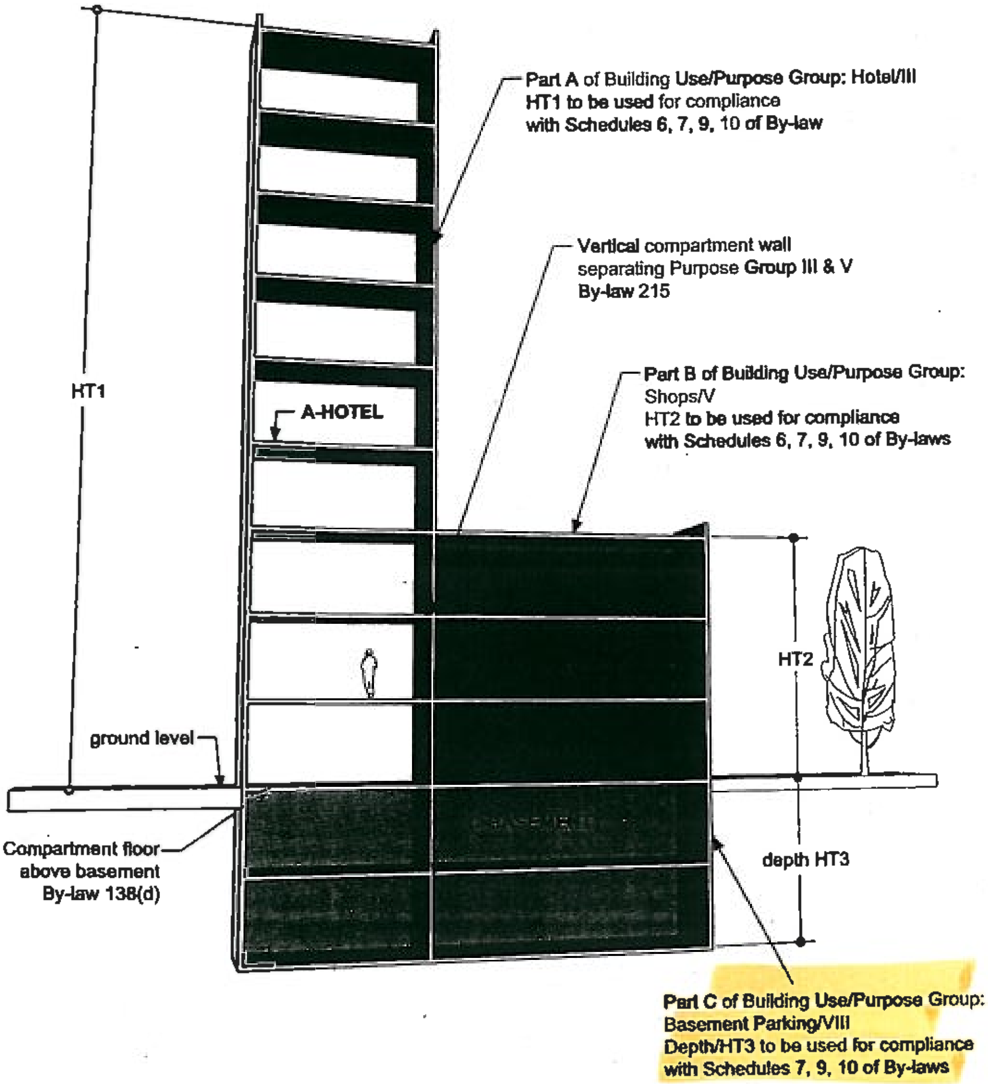


Floor levels opening to atrium. Levels 2, 3 and 9 open to atrium; levels 1 and 4 through 8 enclosed by glass walls. Sprinklers required on non-atrium side of all glass walls, on atrium side at base of atrium, and on atrium side on other levels with walkways.

4.1.4 Mixed Use Buildings

Where a building contains usage falling under different purpose groups and each is contained within compartments, By-law 215 of the UBBL allows the height of each part of the building housing a different purpose group, if they are vertically separated, to be considered separately for compliance with Schedule 6 (calculation of permitted limits of unprotected areas), 7 (calculation of occupant load and capacity of exits), 9 (limits of compartments and minimum periods of fire resistance for fire extinguishment alarm systems and emergency lighting) in the UBBL.

Diagram 4.1.4.1
Computation of mixed use building in compliance with UBBL



4.2 FIRE APPLIANCE ACCESS

4.2.1 Design Notes

Vehicular access to the exterior of a building is needed to enable high reach appliances, such as turntable ladders and hydraulic platforms, to be used and to enable pumping appliances to supply water and equipment for fire fighting and rescue activities.

Access requirements increase with building size and height.

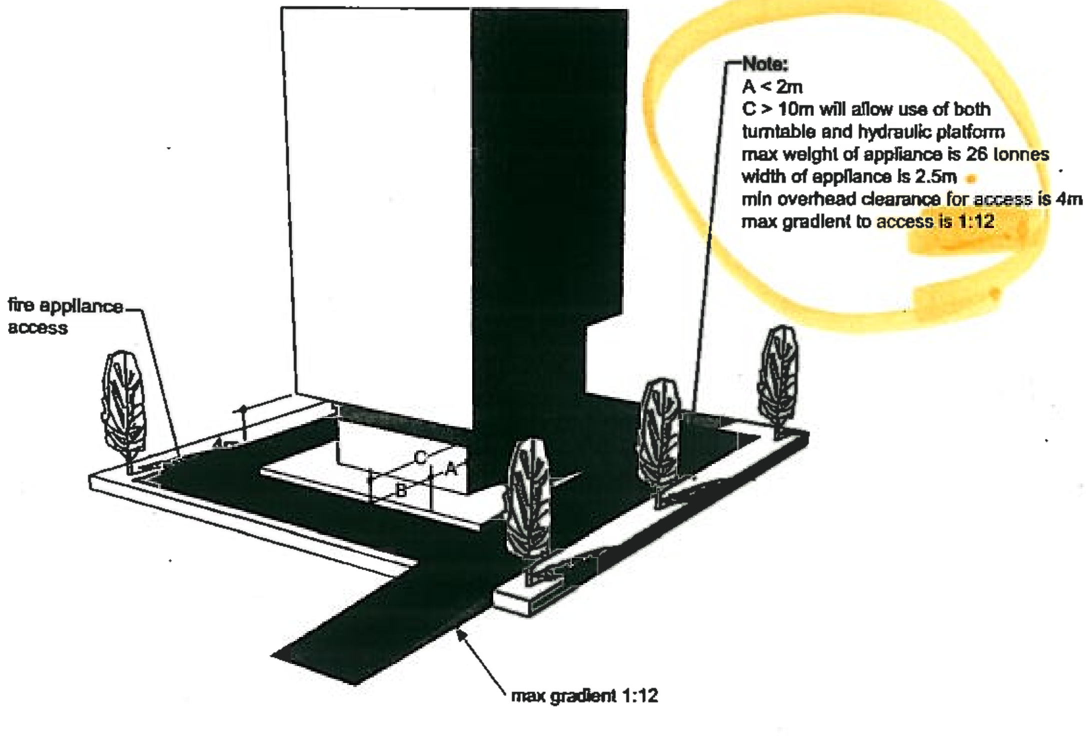
The table in By-law 140 stipulates the proportion of the building perimeter that must be accessible to fire fighting appliances.

In planning the vehicular/appliance access, consideration should be given to the design of the hard standing/access road in relation to the building with respect to features such as overhangs, canopies, turning radius and other obstructions to the free operation of the fire fighting appliances. (See diagram 4.2.2.1).

Location of hydrants must similarly be considered. Too close a placement adjacent to the building or beneath an overhang may expose Fire and Rescue personnel to unnecessary risks or worse, render them inoperable in an emergency. Similarly, too close a location to routes of vehicular traffic may render them susceptible to damage.

4.2.2 Access Considerations

Diagram 4.2.2.1
Relationship between building and access for Fire Appliance
(Medium to highrise and new buildings)

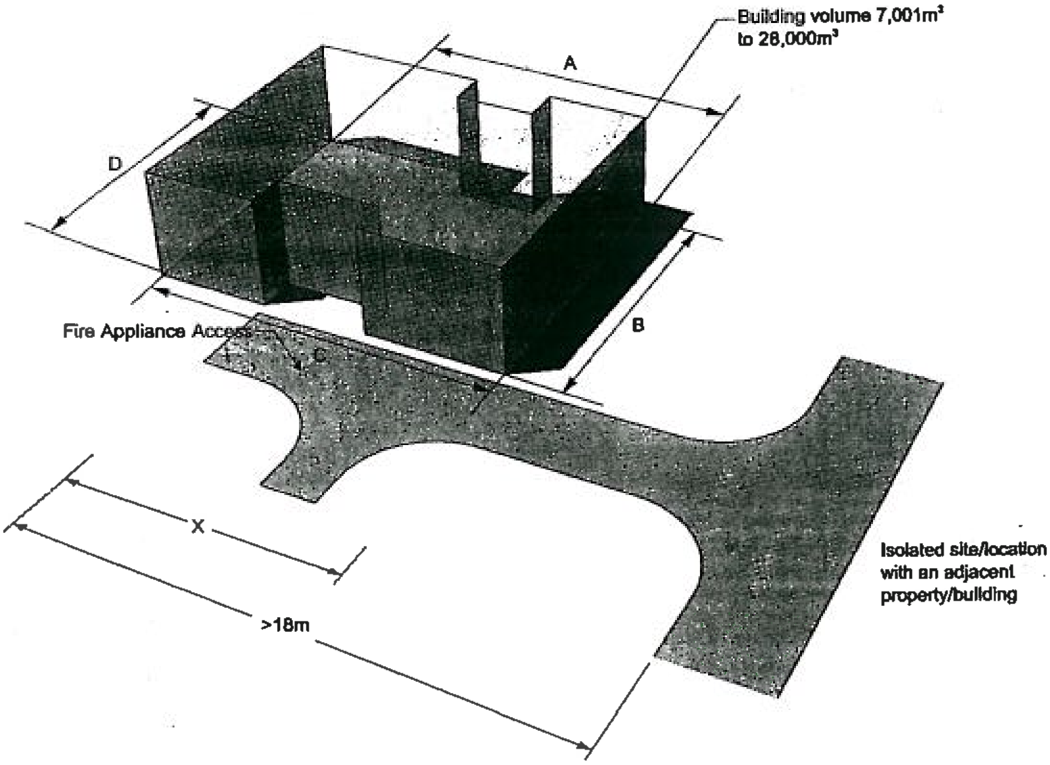


	Type of Appliance	
	Turntable (m)	Hydraulic Platform (m)
A. Maximum distance from edge of hardstanding to building	4.9	2.0
B. Minimum width of hardstanding of hardstanding to building	5.0	5.5
C. Minimum distance of far edge of hardstanding to building	10.0	7.5

See Appendix 1 for Specifications of Fire Appliances for the purpose of Designing for Fire Access for Fire Rescue Vehicles.

4.2.3 Perimeter Appliance Access Illustrations

Diagram 4.2.3.1
One sixth perimeter appliance access



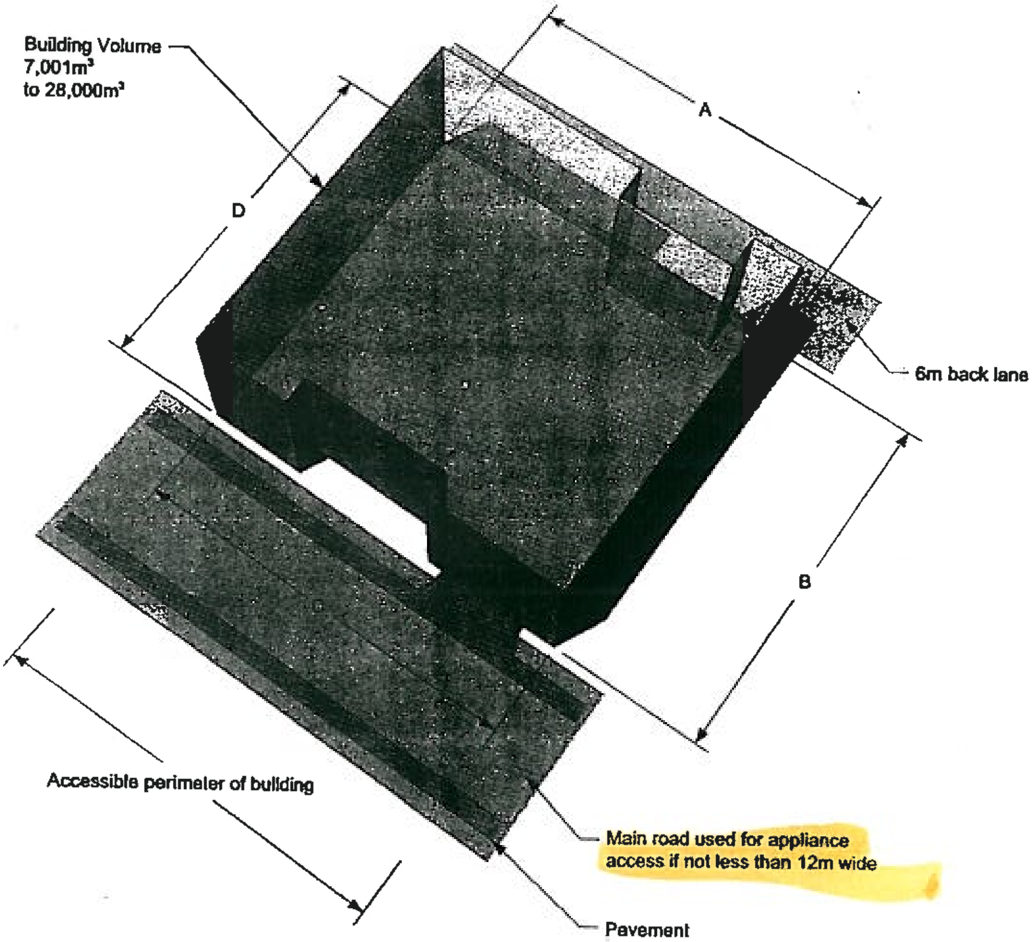
X > 1/6 (A+B+C+D)

Note: Turning provision required for the fire appliance if dead end access exceeds 18m.
Turning provision can be in the form of hammer-head or turning circle.

Diagram 4.2.3.2

One sixth and one fourth perimeter appliance access

City/Built up location with adjacent buildings



$C \geq 1/6\ (A+B+C+D)$

Appliance access from main road is sufficient if the building volume does not exceed 28,000m³.

In the event the 6m back lane is accessible by fire fighting appliance and the building volume 28,000m³ but is less than 56,000m³, then,

$A + C \geq 1/4\ (A+B+C+D)$

Diagram 4.2.3.3
One half perimeter appliance access

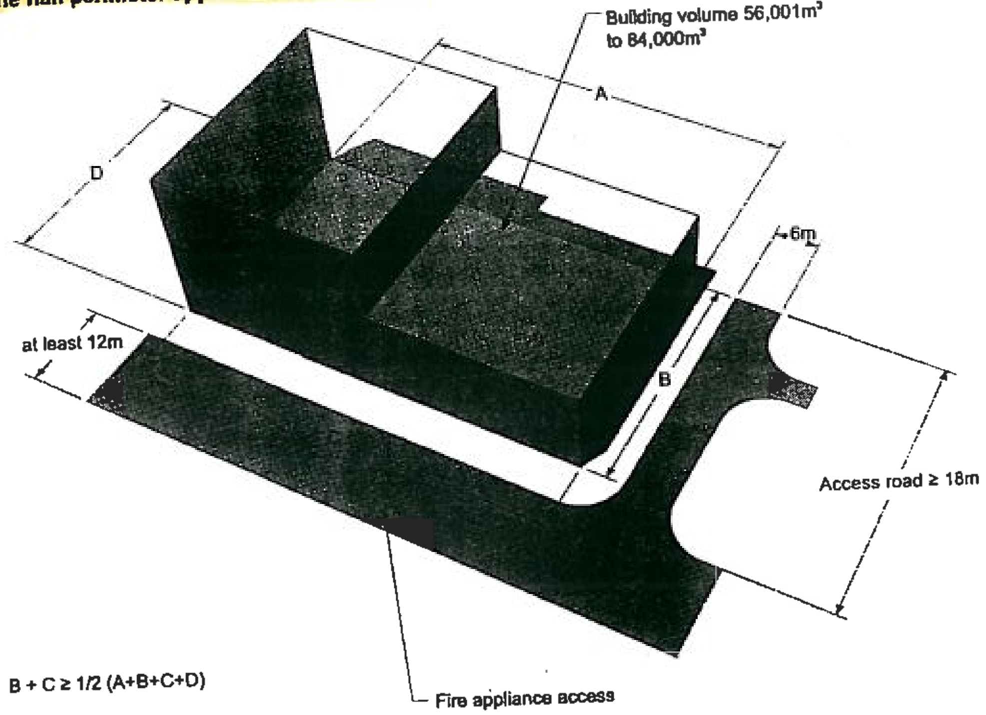


Diagram 4.2.3.4
One half perimeter appliance access in city site with adjacent buildings

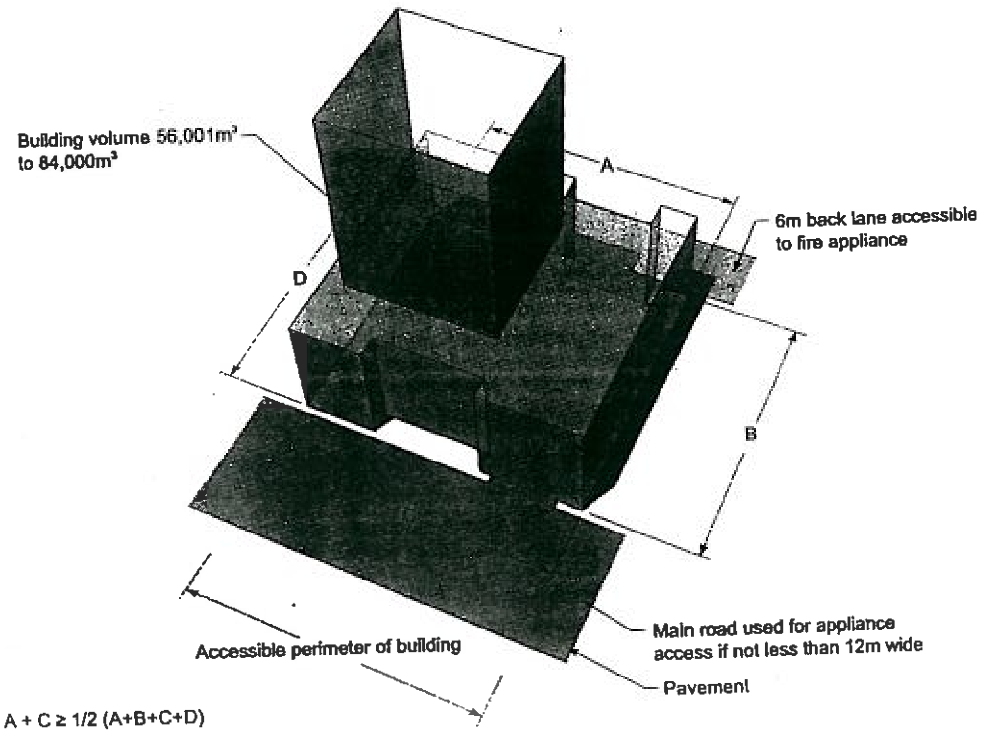
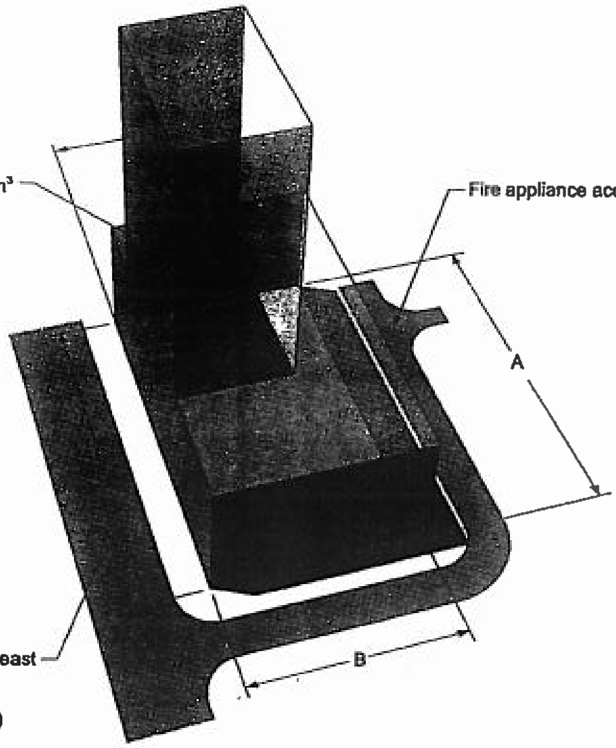
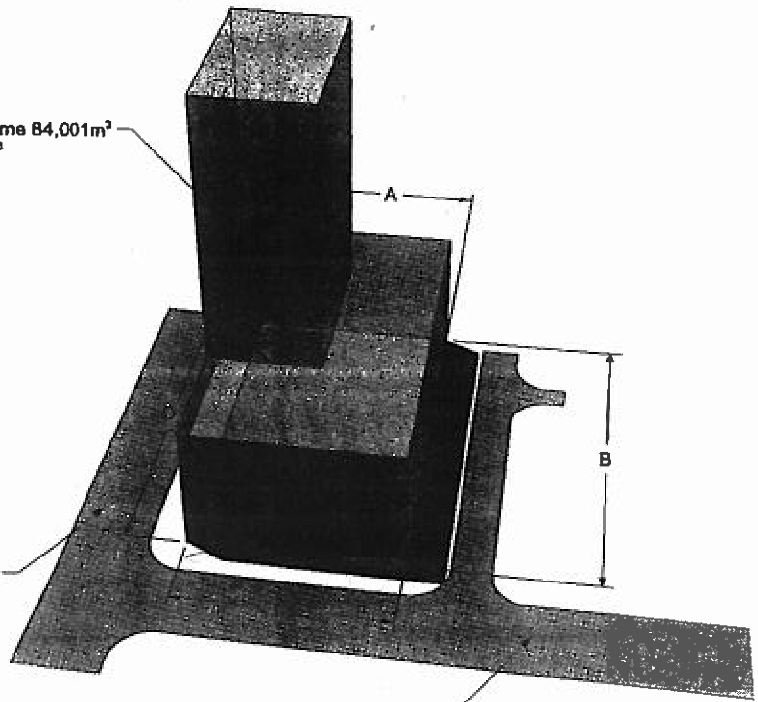


Diagram 4.2.3.5
Three fourth perimeter appliance access



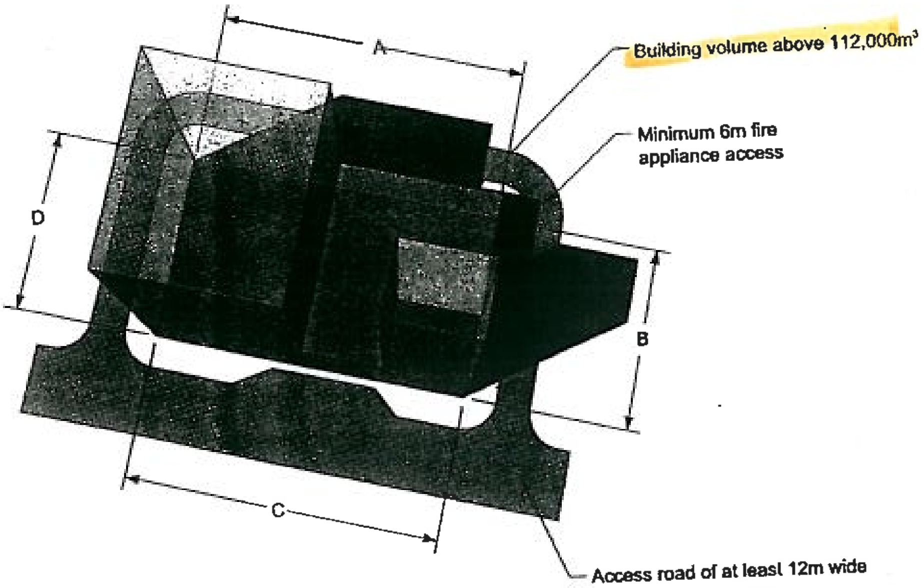
$A + B + C \geq 3/4\ (A+B+C+D)$

Diagram 4.2.3.6
Three fourth perimeter appliance access



$B + C + D \geq 3/4\ (A+B+C+D)$

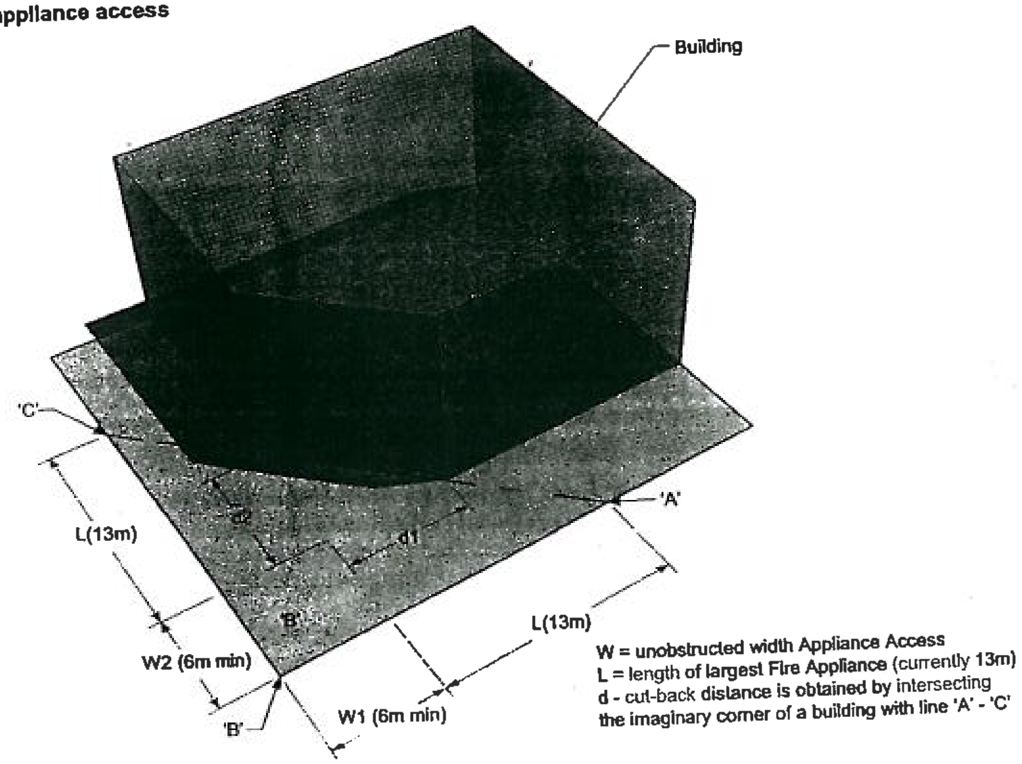
Diagram 4.2.3.7
Island site



The minimum permissible width of a Fire Appliance Access is 6m.

The minimum turning radius around corners of building shall be provided as follows:

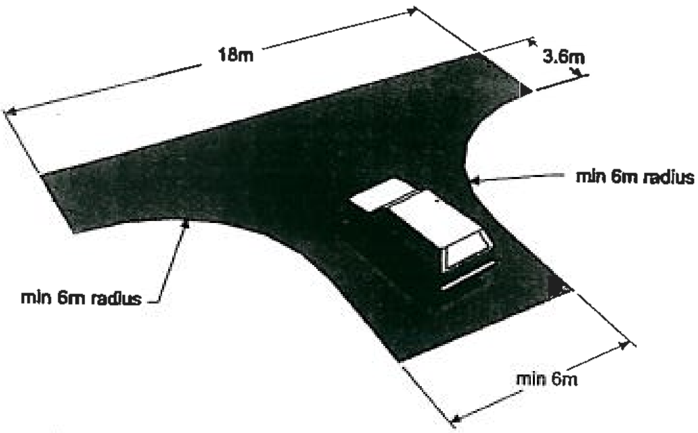
Diagram 4.2.3.8
Fire appliance access



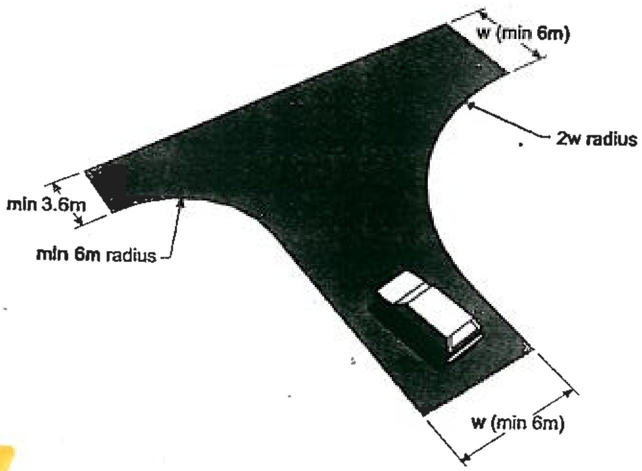
These dimensions are preferred dimensions.
Discretion should be applied in built up sites eg. city centres.

Diagram 4.2.3.9
Fire appliance turn-around dimensions

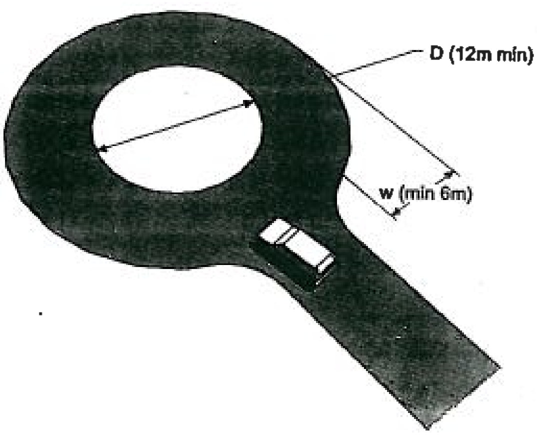
i) T-Turn



ii) Shunt

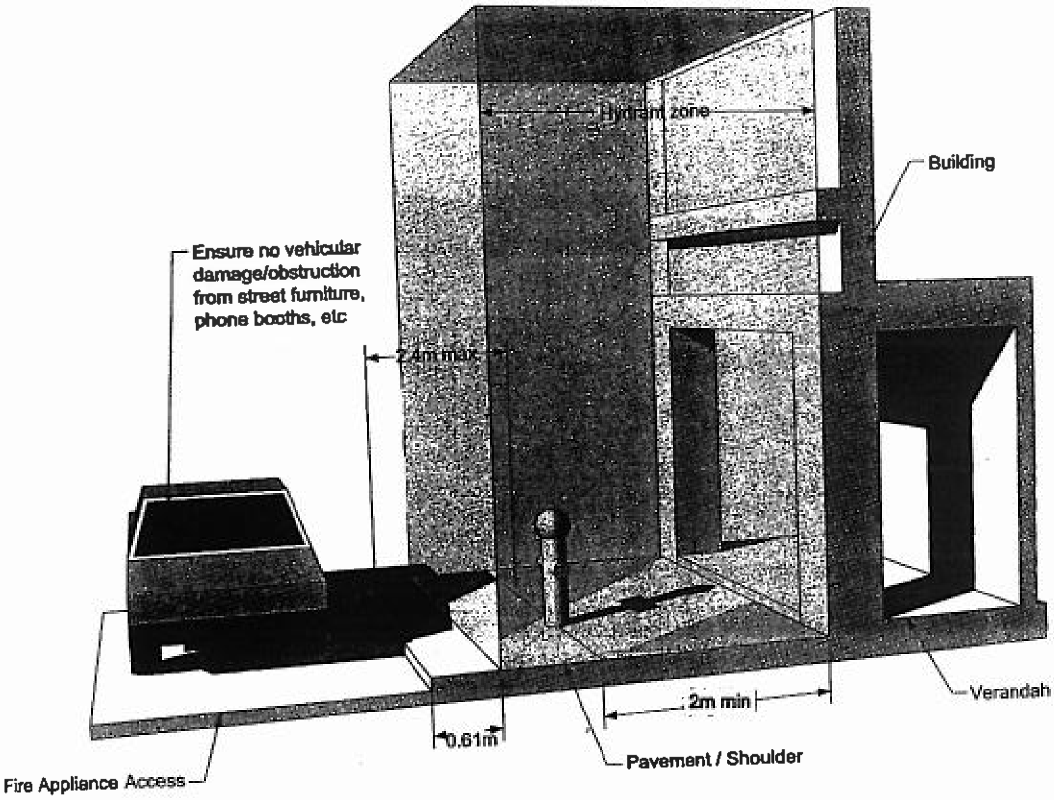


iii) Circle



4.2.4 Hydrant Locations

Diagram 4.2.4.1
Location of hydrants



Hydrants should be located:

(i) away from obstructions such as street furniture (benches), phone booths, etc.

(ii) not less than 2m from adjacent buildings and overhangs.

(iii) between 0.61m to 2.4m from Fire Appliance Access.

(iv) away from risks of vehicular damage.

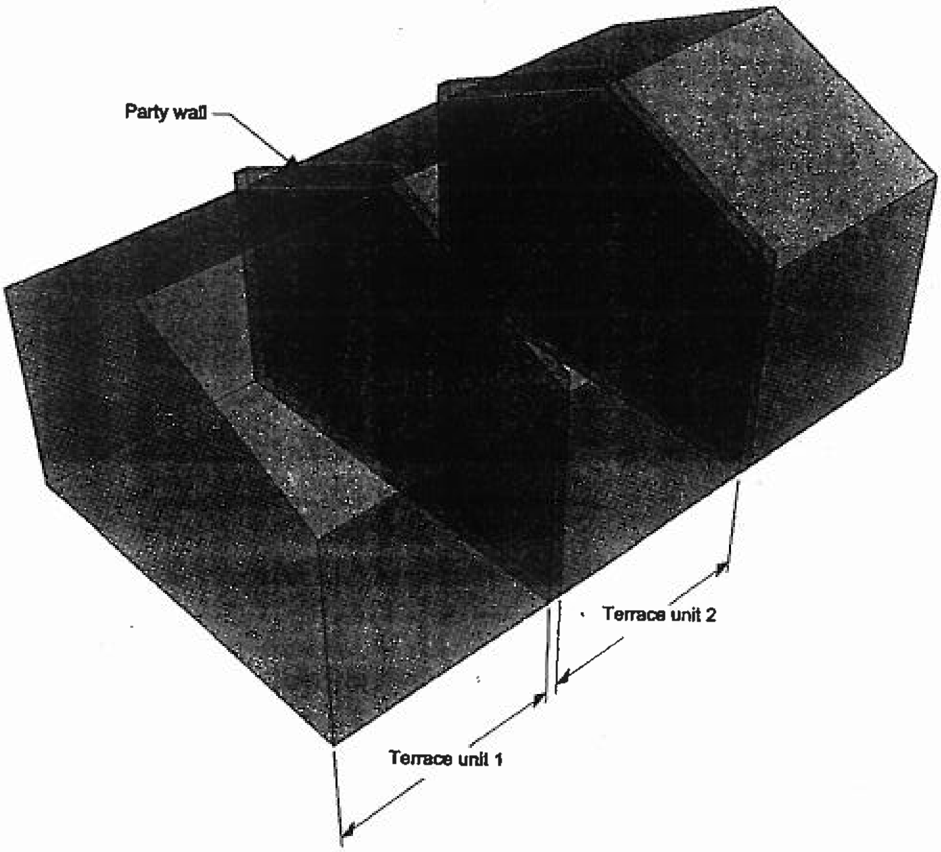
(v) not more than 90m apart from each other (in new buildings adjacent to existing developments, a new hydrant or hydrants will have to be provided if there is no hydrant within 45m radius of the new building).

4.3 WALL AND FLOORS

4.3.1 Party Walls

Party walls in the fire safety context refer to walls that separate units of different ownership as in walls separating houses, flats or shops. Party walls (By-law 86) serve to prevent the spread of fire from one terrace unit to the next. The UBBL states that party walls shall be of solid masonry or in-situ concrete of not less than 200mm thick or if constructed at different times, made up of two skins, each of not less than 100mm thick.

Diagram 4.3.1.1
Party wall to terrace houses



In multi-storeyed flats and terrace houses of reinforced concrete or protected steel framed construction, the thickness of the non-load bearing party wall shall not be less than 100mm. This exception applies to framed residential buildings only.

Party walls must be raised 230mm above the upper roof surface measured at right angle to the surface to act as flame deflectors.

Diagram 4.3.1.2
Junction of party wall with roof

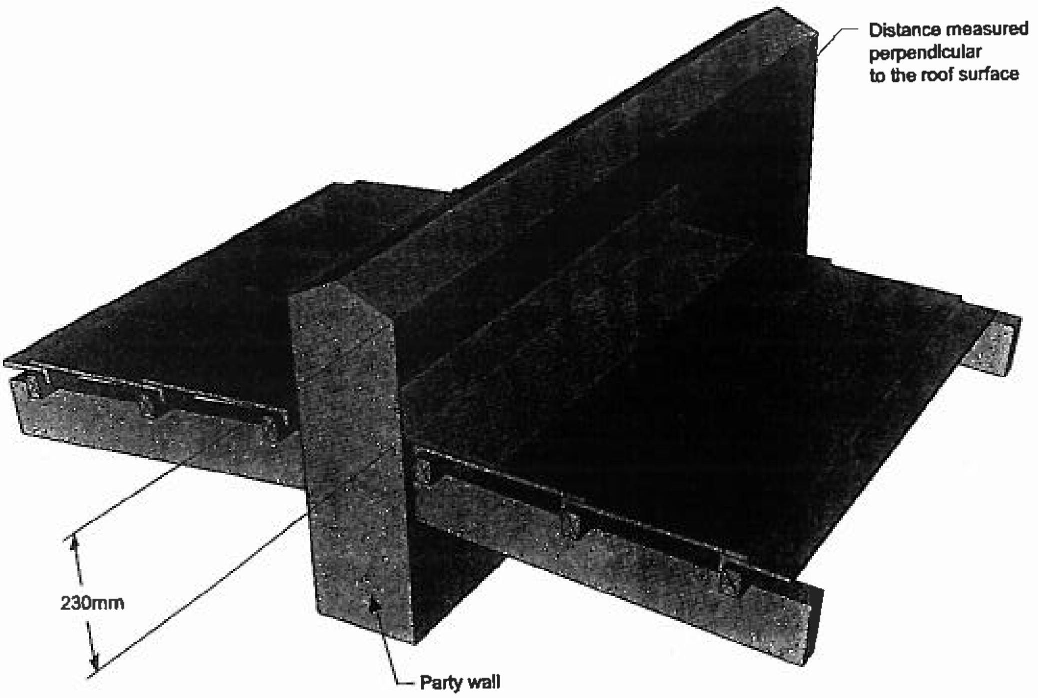
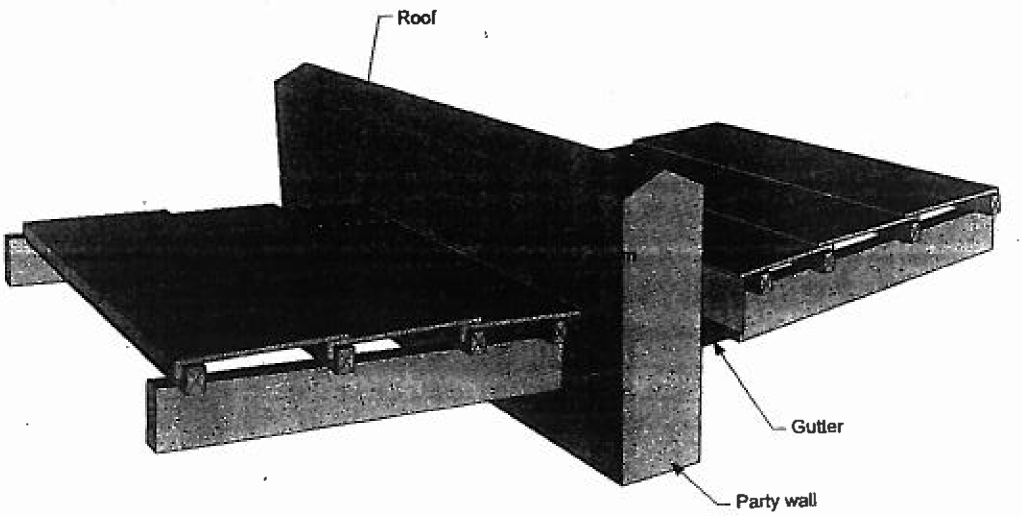
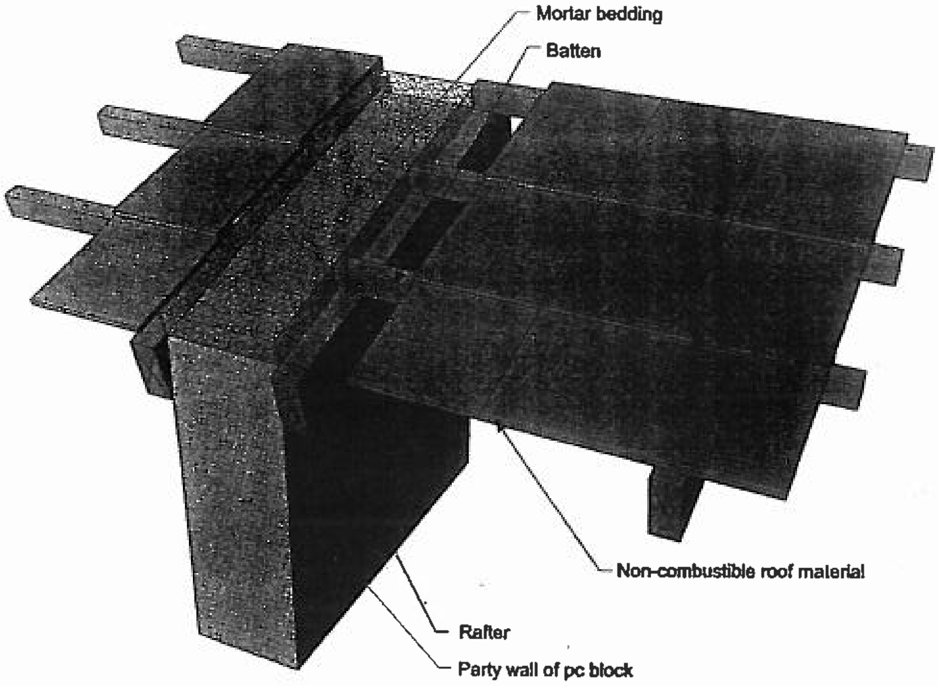


Diagram 4.3.1.3
Junction of party wall with roof valley gutter



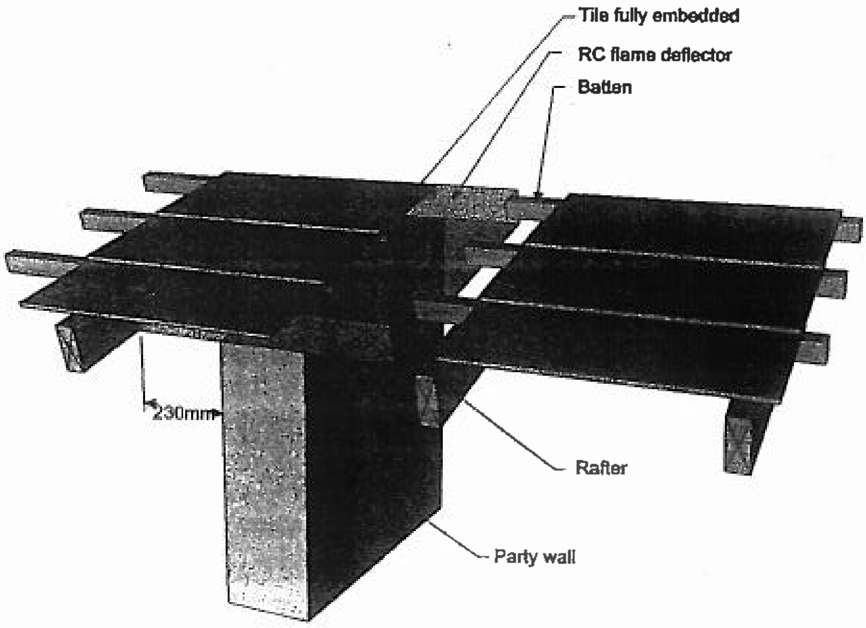
For low-cost terrace house (not flats), the following detail may be accepted by JBPM.

Diagram 4.3.1.4
Alternative party wall/roof detail for low-cost terrace house



The following illustrated T-barrier may be accepted in lieu of the 230mm raised party wall

Diagram 4.3.1.5
Alternative party wall/roof detail



4.3.2 Recess and Chases

By-laws 88 and 89 allow recess and chases to be made in walls but dimensions are limited such that the minimum fire resistance integrity of external and party walls are maintained.

Diagram 4.3.2.1
Illustration of recess in external wall

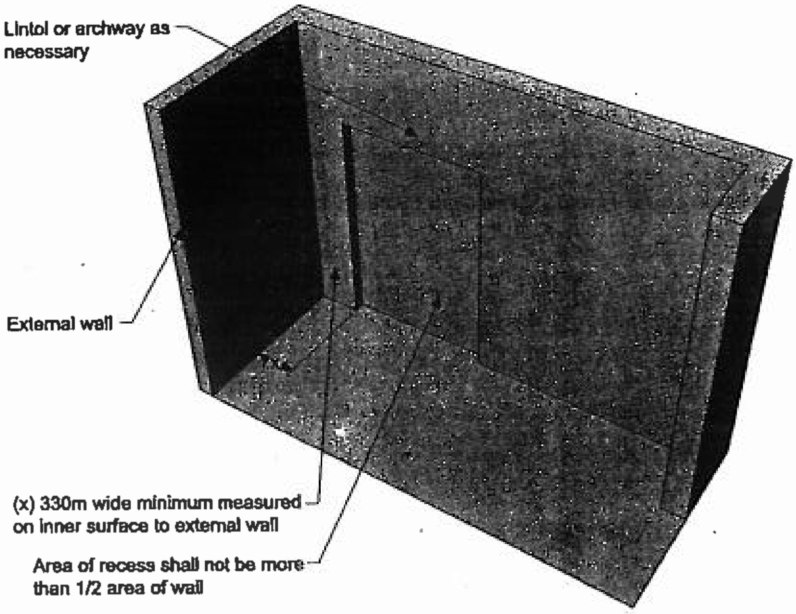


Diagram 4.3.2.2
Recess in external wall

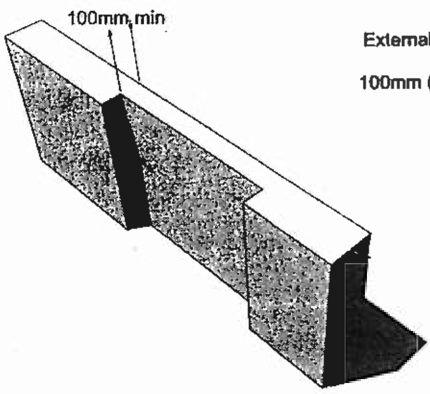
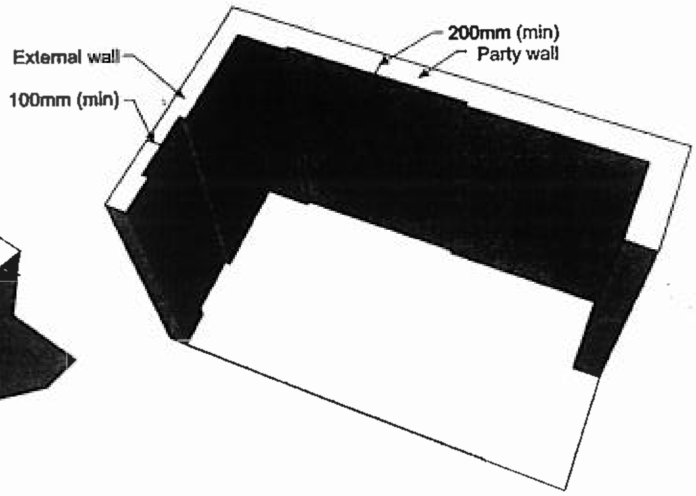
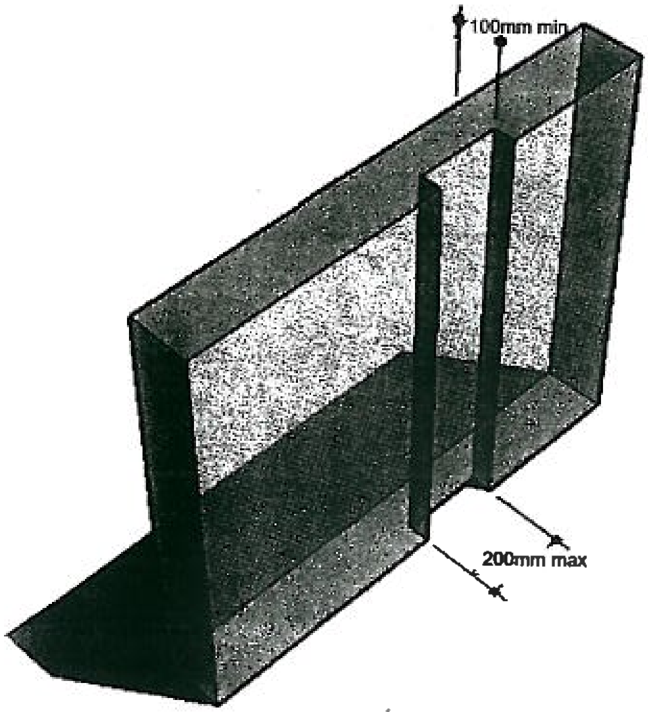


Diagram 4.3.2.3
Recess in party wall



A chase may be made in a wall for pipes and other services. The thickness of the wall at the back shall not be less than 90mm for external wall and 100mm for party wall. Width of chase shall not exceed 200mm.

Diagram 4.3.2.4
Chases in party wall and relevant external wall



4.3.3 Separating/Compartment Walls and Floors

By-laws 147 (construction of separating wall) and 148 (compartment walls and floors) allow separating and compartment walls which are not party walls to be constructed of materials other than masonry so long as they comply with the required FRP [Fire Resistance Period]. Similarly, structural elements carrying the separating or compartment walls shall themselves comply with the same FRP requirements (By-law 217).

In the event of a compartment wall separating two or more purpose groups, it shall be protected in accordance with the more stringent requirements of the purpose groups. (By-law 216 para 2).

Single-storey buildings (including factories/warehouses) are not required to provide fire protection to their structures if they do not form part of compartment walls. (By-law 216).

Non load-bearing compartment walls (party walls) separating a flat or maisonette from other parts of the same building shall not be required to have fire resistance exceeding 1 hour unless the purpose group of the part of the building separated by that compartment wall is different (or is protected shaft) and the minimum period of fire resistance required is 1.5 hours or more (By-law 218).

By-law 137 stipulates that floors in buildings exceeding 30 metres in height shall generally be constructed as compartment floors. (See diagram 4.3.3.3)

Diagram 4.3.3.1
Special requirement as to compartment walls and compartment floors

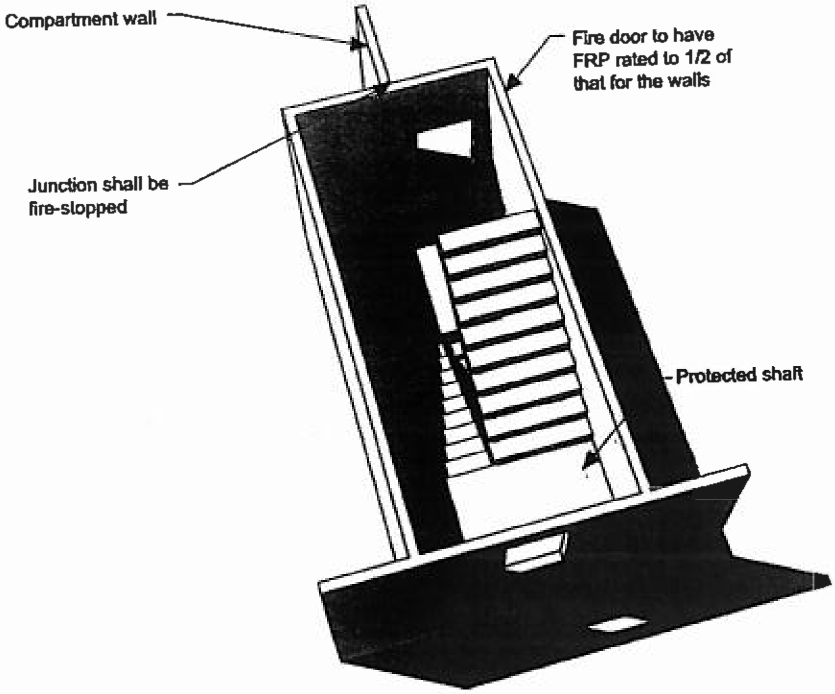


Diagram 4.3.3.2
Separation of ducts/flues in compartment

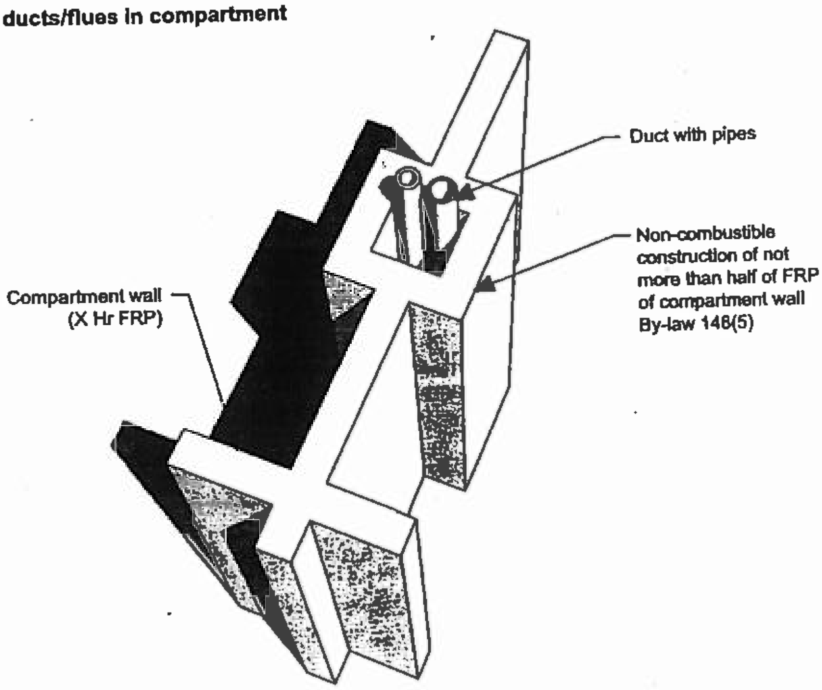
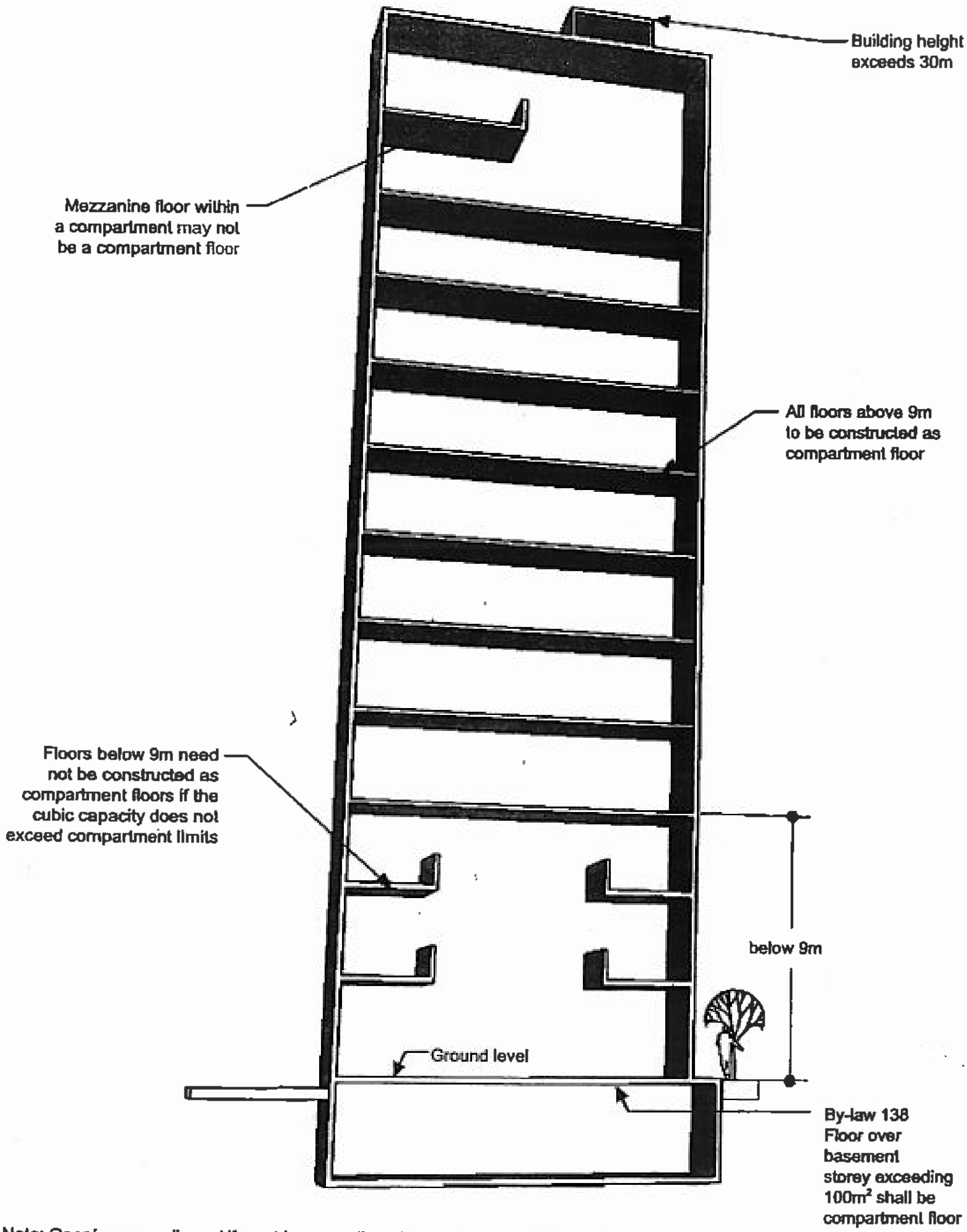


Diagram 4.3.3.3

Floor in building exceeding 30 metres to be constructed as compartment floor.



Note: Openings are allowed if an atrium complies with requirement of Fire Authorities

4.3.4 Stages in Places of Assembly

The proscenium wall is to be regarded as a fire isolation wall, allowing the containment of fire back-stage and to minimise risk of smoke infiltration into the main hall.

Diagram 4.3.4.1
Stage in places of assembly (section)

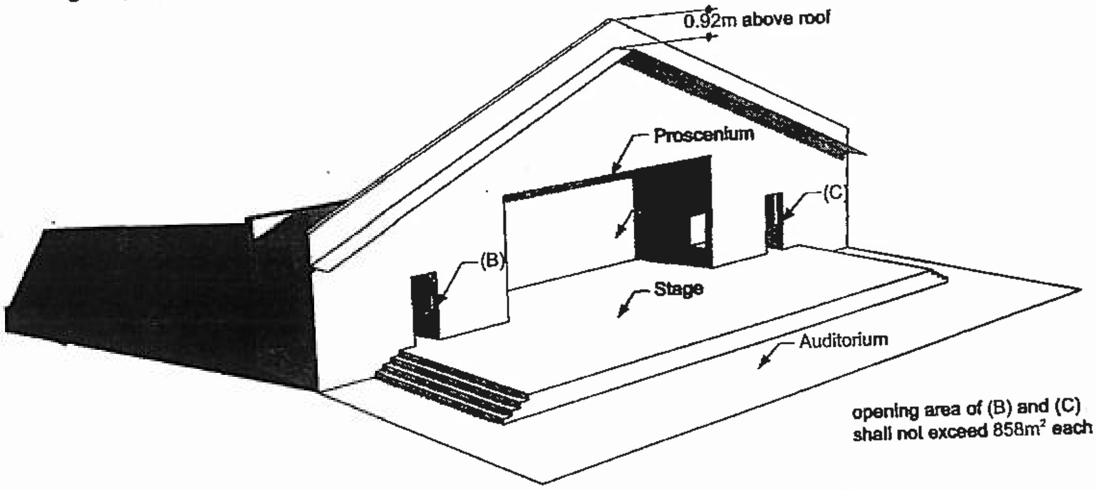
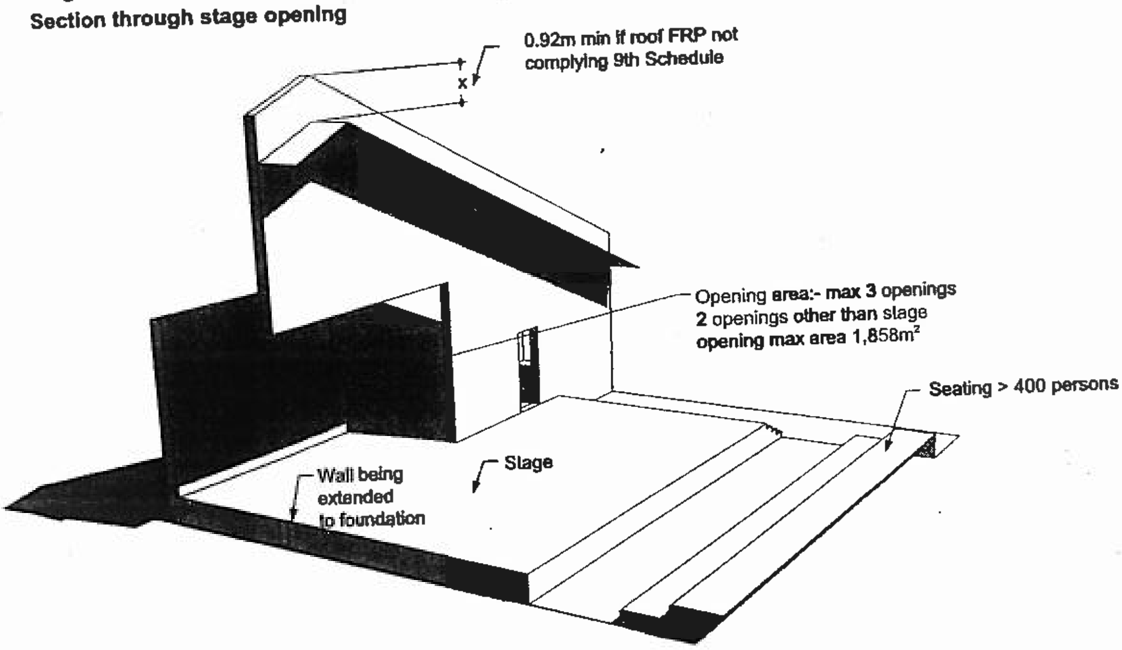


Diagram 4.3.4.2
Section through stage opening



4.3.5 Horizontal and Vertical Barriers of the External Wall

These walls or deflectors are inserted to prevent flame spread via the external facade to the floors above eg. window to window. They shall comply with the same FRP as the compartment walls.

Care has to be taken in curtain-wall detailing to prevent the external skin of the building from becoming the casing to a smoke stack by allowing smoke to travel up to a different floor. Smoke barriers shall retain integrity over the period of fire resistance required.

Diagram 4.3.5.1
Fire barriers to external wall

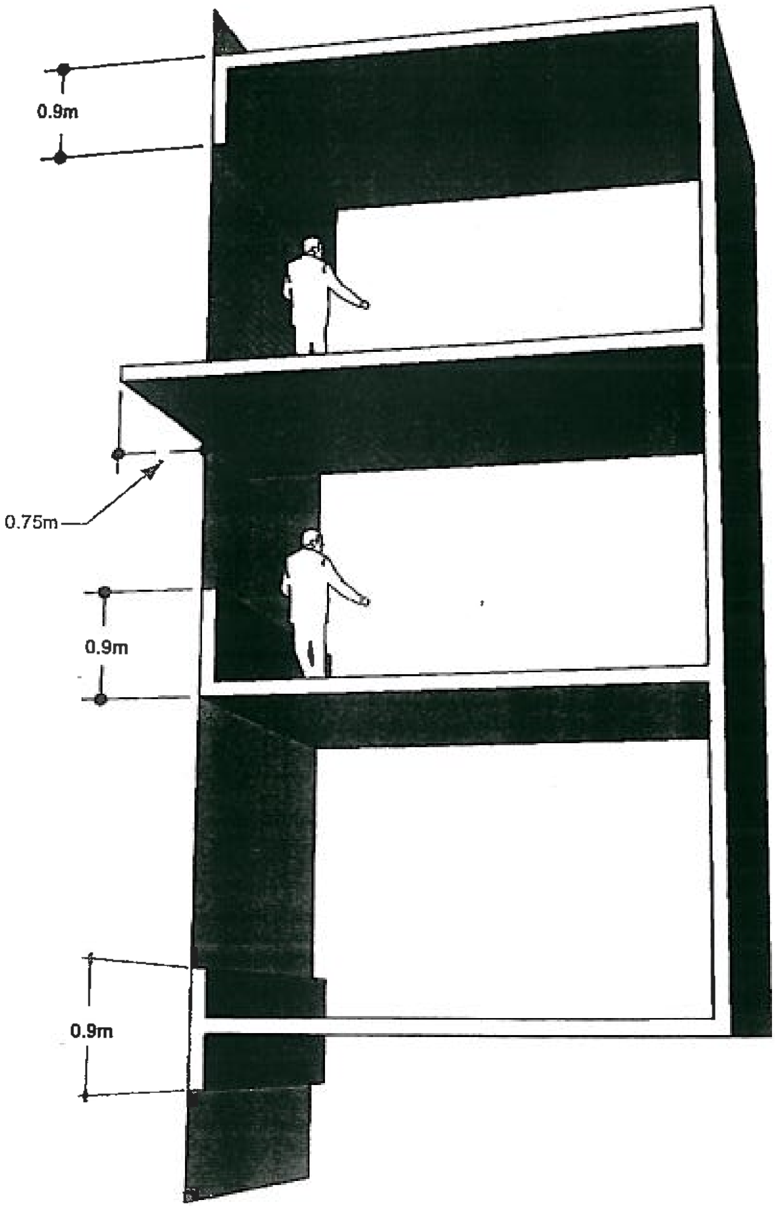
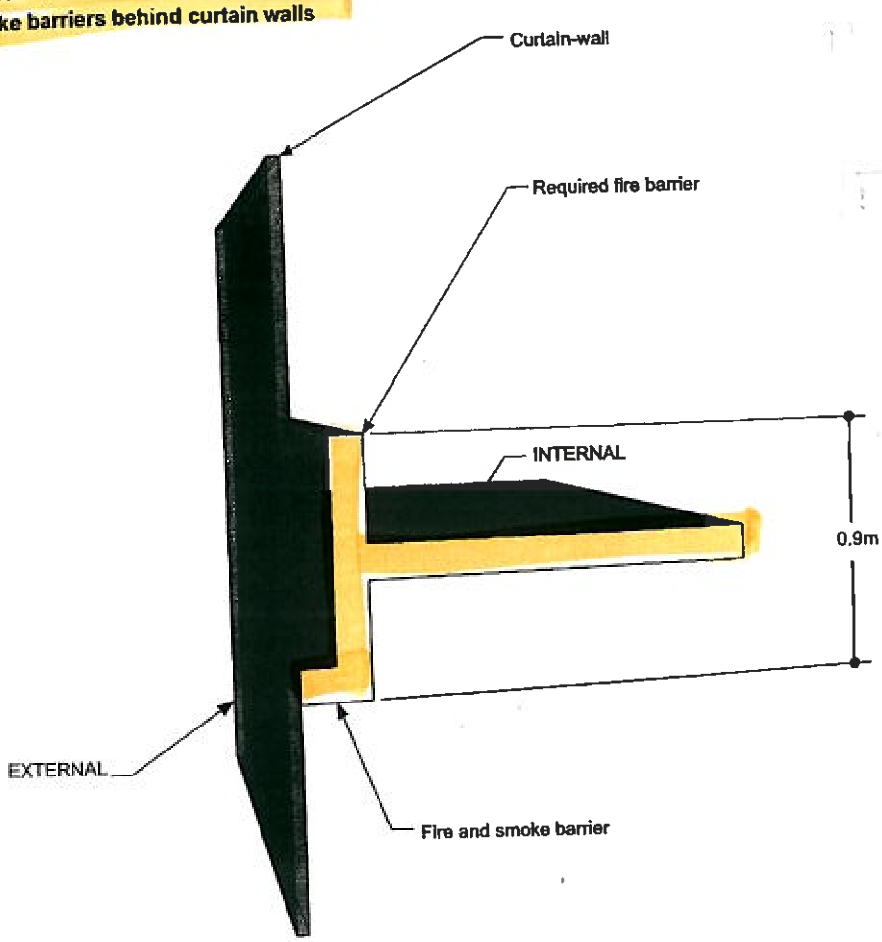


Diagram 4.3.5.2
Smoke barriers behind curtain walls



4.3.6 Protected Service Shafts

Protected shafts penetrate across compartments or floors in a building. They can be shafts carrying utilities (piping, electrical and telecommunication service etc.) or are service shafts carrying lifts and including escape staircases.

In the former context, all penetrations of floors and walls shall be fire-stopped.

In the latter context, they often enclose protected staircases or lift lobbies that will have to be ventilated or pressurised to allow venting of smoke or prevent infiltration of smoke to provide safe passage for both escaping occupants and safe access for fire fighters.

Diagram 4.3.6.1
Fire stop at pipe openings in protected shaft

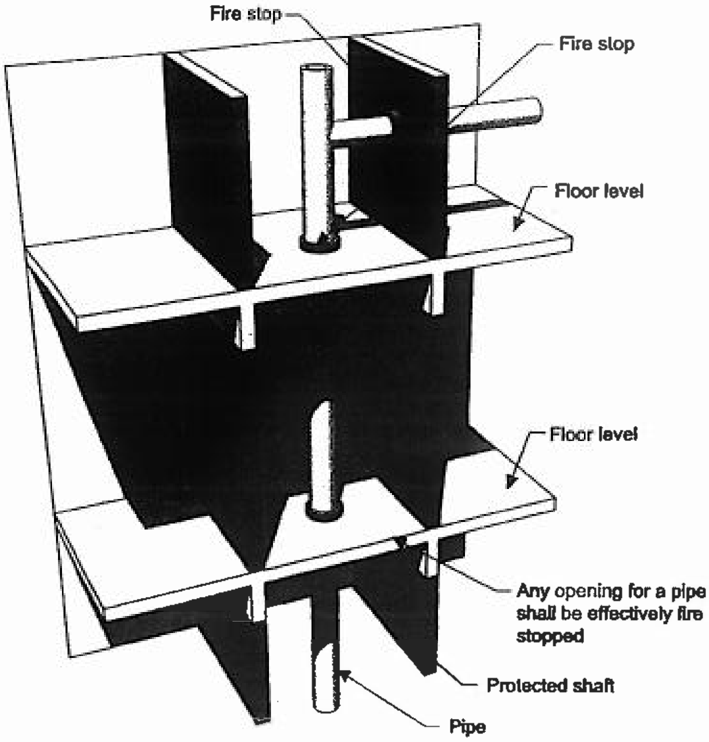


Diagram 4.3.6.2
Ventilation for lift shaft not opening to protected lobby

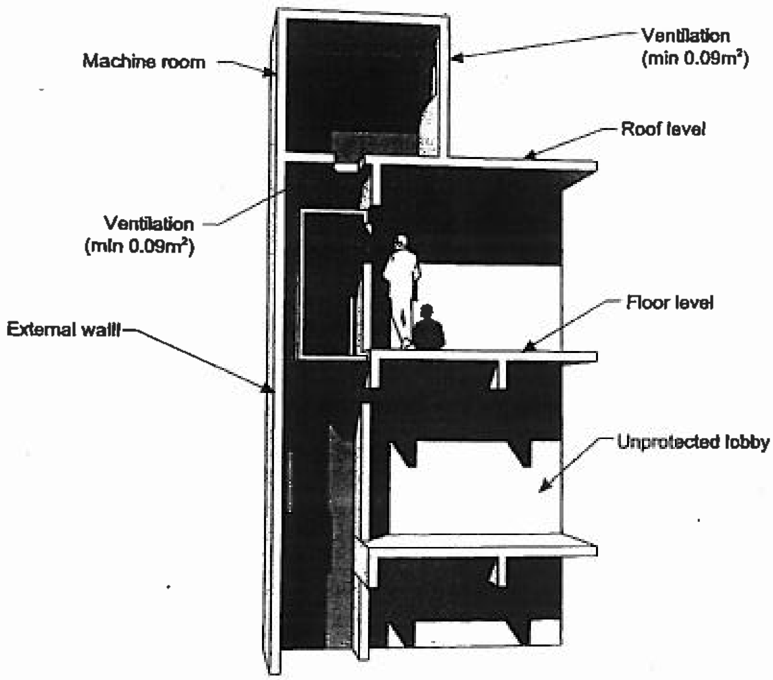


Diagram 4.3.6.3
Ventilation for lift shaft not opening to protected lobby

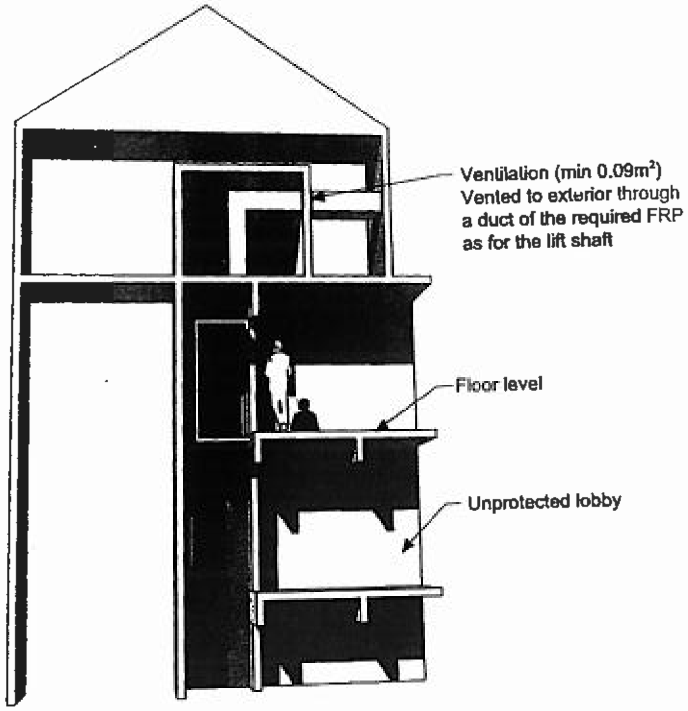
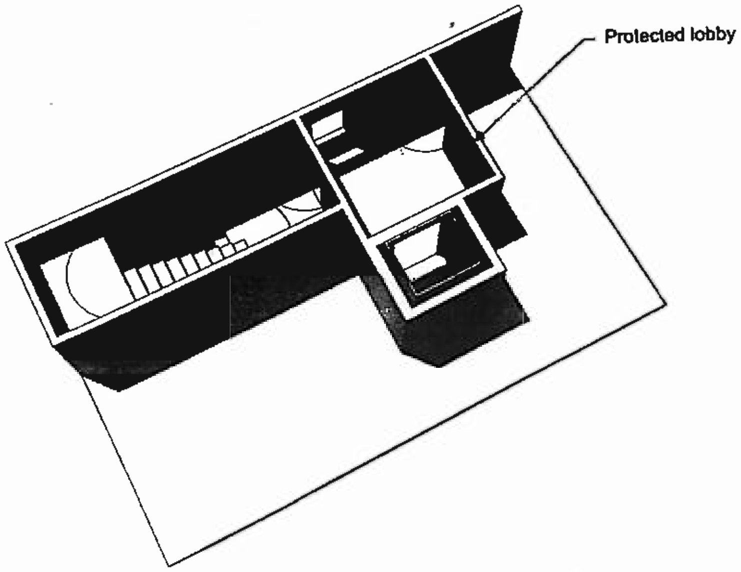


Diagram 4.3.6.4
Opening of lift shaft or lift entrance shall open into a protected lobby



Note: Protected lobby may be omitted when the following are observed:

(i) Fire rated landing doors are provided to life shaft.

(ii) This lift shaft is pressurised to prevent smoke infiltration and spread to other floors.

4.3.7 Cladding on External Wall

Vide a directive issued by the Director General of JBPM in April 1997, all aluminium composite claddings on buildings above 18m height shall be supplied with non-combustible cores. This directive was issued to avoid a scenario where the occurrence of a fire in a high rise building could result in the core of a composite panel catching fire, melting and spreading the fire by dripping molten and flaming core material to other areas below the source of fire. In addition, the dripping molten core material could also pose a danger to occupants leaving the building or Fire Rescue personnel working on the fringe of the building at ground level.

Diagram 4.3.7.1

Class O cladding on external wall < 1.2m from boundary

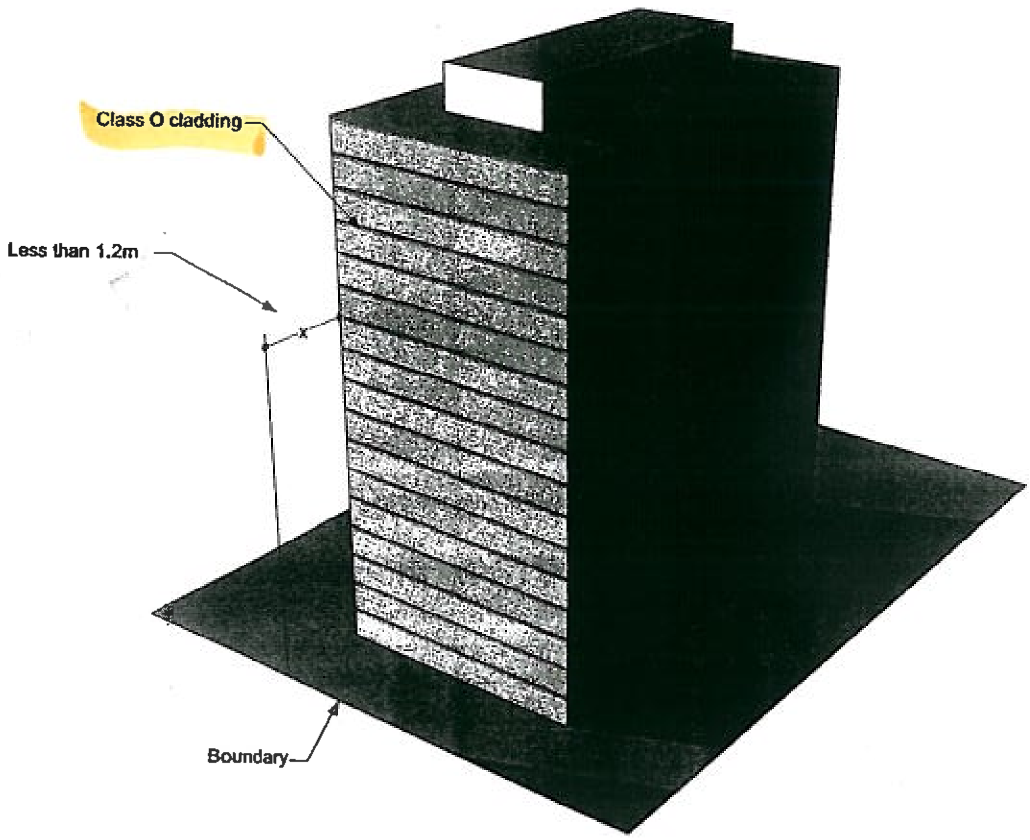


Diagram 4.3.7.2
Class O cladding on external wall > 1.2m from boundary

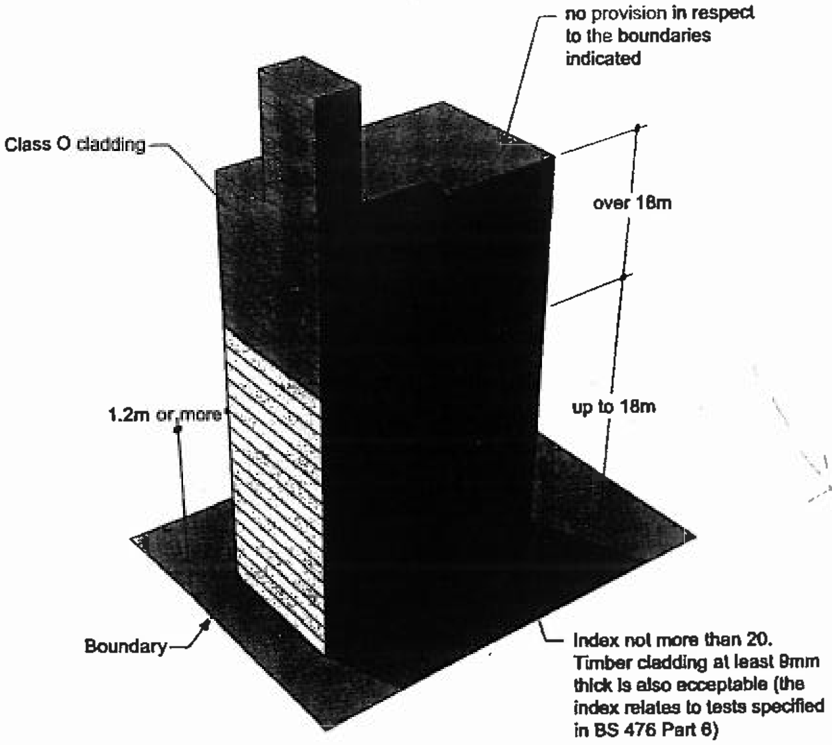
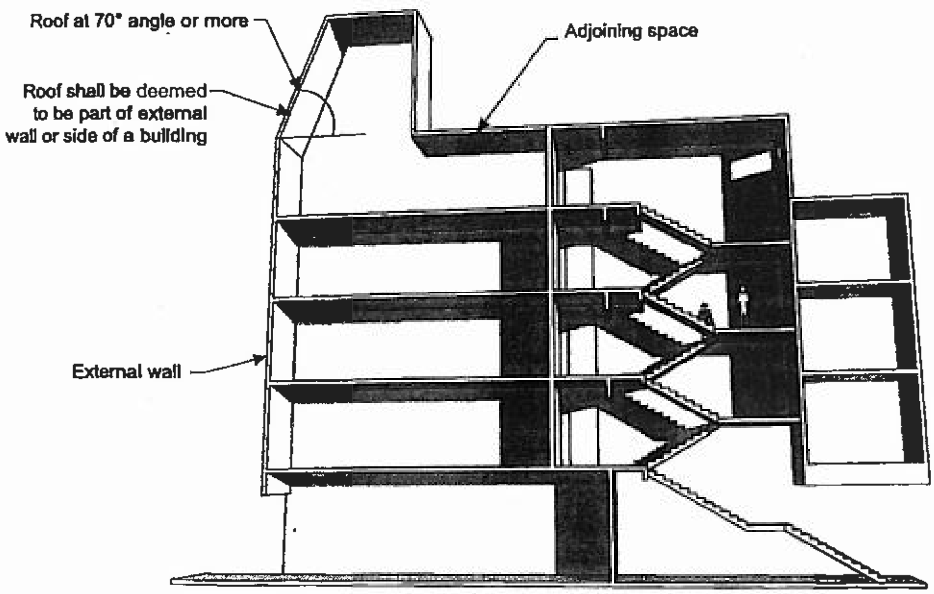


Diagram 4.3.7.3
Roof inclination more than 70°



4.3.8 Reference to Sixth Schedule

a. Background
The provisions of the Sixth Schedule and By-laws 142 to 146 are based on the objective of establishing a reasonable basis and standard of space separation to be specified between buildings for reasons of prevention of flame spread and protection from external fire sources.

The external walls of a building are required to resist the spread of fire over their surfaces and from one building to another. In assessing the adequacy of resistance to fire spread, regard must be given to the height, use and position of the building.

In this respect, the roof of a building must also offer adequate resistance to the spread of fire across its surface and from one building to another. Hence the treatment of the roof as a wall element when it is at an angle steeper than 80 degrees [By-law 145a].

External walls serve to restrict the outward spread of fire to a building beyond the boundary and also help to resist fire from outside the building. This is achieved by ensuring that the walls have adequate fire resistance and external surfaces with restricted fire spread. Fire spread between buildings usually occurs by radiation through openings in the external walls (termed 'unprotected areas').

For obvious reasons, if the external wall forms part of the structure, then it or the structural part of it must of necessity be constructed of non-combustible materials or as in the case if steel structures, be adequately protected with non-combustible materials. [By-law 142.3].

The risk of fire spread and its consequences are related to:
(i) the severity of the fire;
(ii) the fire resistance offered by the facing external walls including the number and disposition of the unprotected areas;
(iii) the distance between the buildings; and
(iv) the risk presented to people in the opposite building.

In general, the severity of a fire will be related to the amount of fuel/combustible material contained in the building per unit of floor area (fire load density). Certain types of buildings, such as shops, industrial buildings, and warehouses may contain large quantities of combustible materials and are usually required to be sited further from their boundaries than other types of buildings.

The provisions of the Sixth Schedule limit the extent of unprotected areas in the sides of a building which will not give adequate protection against the external spread of fire from one building to another. Based on the general background above, the Sixth Schedule makes assumptions on the following:

(i) that the size of a fire will depend on the compartmentation of a building, so that a fire may involve one complete compartment, but will not spread to other compartments;

(ii) that the intensity of the fire is related to the use of the building (ie. Purpose group); and

(iii) that the amount of radiation that passes through any part of an external wall that has fire resistance may be discounted.

b. Boundaries
A **relevant boundary** as the name implies represents a boundary that is relevant to that side of the building for the purposes of checking compliance with the Sixth Schedule. (See diagram 4.3.8.1)

It need not be a legal boundary as in a land boundary established by survey which is for the purposes of land ownership demarcation. The relevant boundary marks the base line from which measurements are taken for the purpose of establishing the set back distance of a side or of a building for the purposes of Sixth Schedule calculations. This distance is then used to establish the percentage of unprotected openings permissible in the relevant proposed building facades.

If a building abuts onto an existing playground or road, the relevant boundary may extend into both those spaces eg. centre line, as they are not anticipated to be occupied by buildings in the foreseeable future.

For the purpose of practicality and preservation of legal rights of land owners in an existing built up environment like Kuala Lumpur, it is advised that the side boundary facing an existing building be used as the relevant boundary for compliance. It is impossible to haul up owners of existing buildings to reduce their unprotected openings if their relevant boundaries extend beyond their site/ side boundaries! By the same token, it would not be fair to expect a new owner to set back further or reduce his opening because the neighbour had not complied originally.

Notional boundary (See diagram 4.3.8.2) is an assumed or imagined boundary between two buildings built or to be built on the same site. This boundary is established by reference to the Sixth Schedule. In the case of an existing building on site, the notional boundary is set by checking the building against the Sixth Schedule, then it becomes the basis for establishing either the set back or permissible opening percentage in the new building proposed.

Relevant Boundary
This diagram sets out the rules that apply in respect of a boundary for it to be considered as a relevant boundary.

For a boundary to be relevant, it should:
(i) coincide with, or
(ii) be parallel to, or
(iii) be at an angle of not more than 80 degree to the side of the building

Diagram 4.3.8.1
Relevant boundary (Refer to By-law 142)

Sixth Schedule Part II (1)

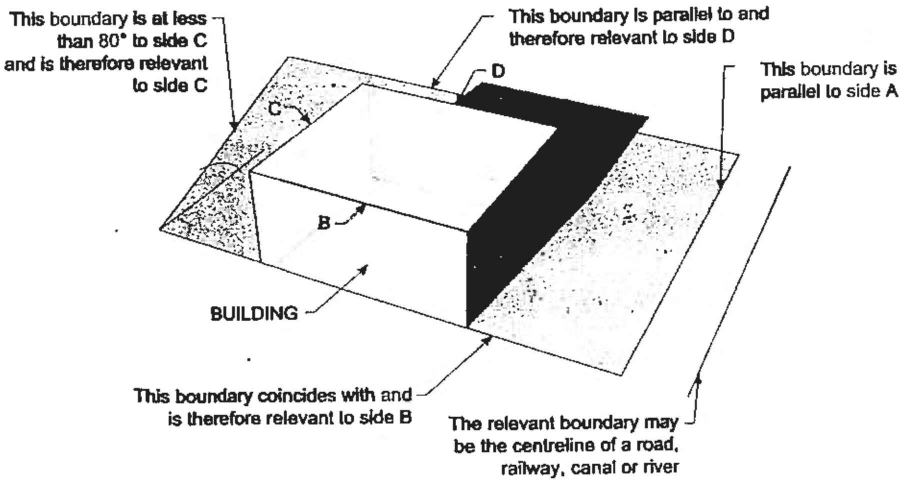
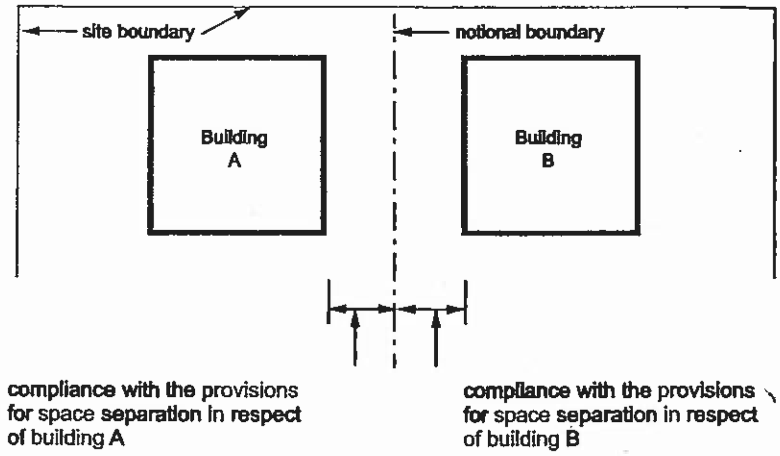


Diagram 4.3.8.2
Notional Boundary

This diagram sets out rules that apply where a building is proposed on the same site as another building, so that a notional boundary needs to be assumed between the building.



The notional boundary should be set in area between the buildings using the following rules:

1. It is only necessary to assume a notional boundary when the building are on the same site. The building can be new or existing.

2. The notional boundary is assumed to exist, in the space between the building and is positioned so that one of the buildings would comply with the provisions for space separation having regard to the amount of its unprotected area. In practice, if the buildings is existing, the position of the boundary will be set by the space separation factors for that building.

3. The sitting of the new building or the second building if both are new, can then be checked to see that it also complies - using the notional boundary as the relevant boundary for the second building

Diagram 4.3.8.3
Status of combustible surface material as unprotected area

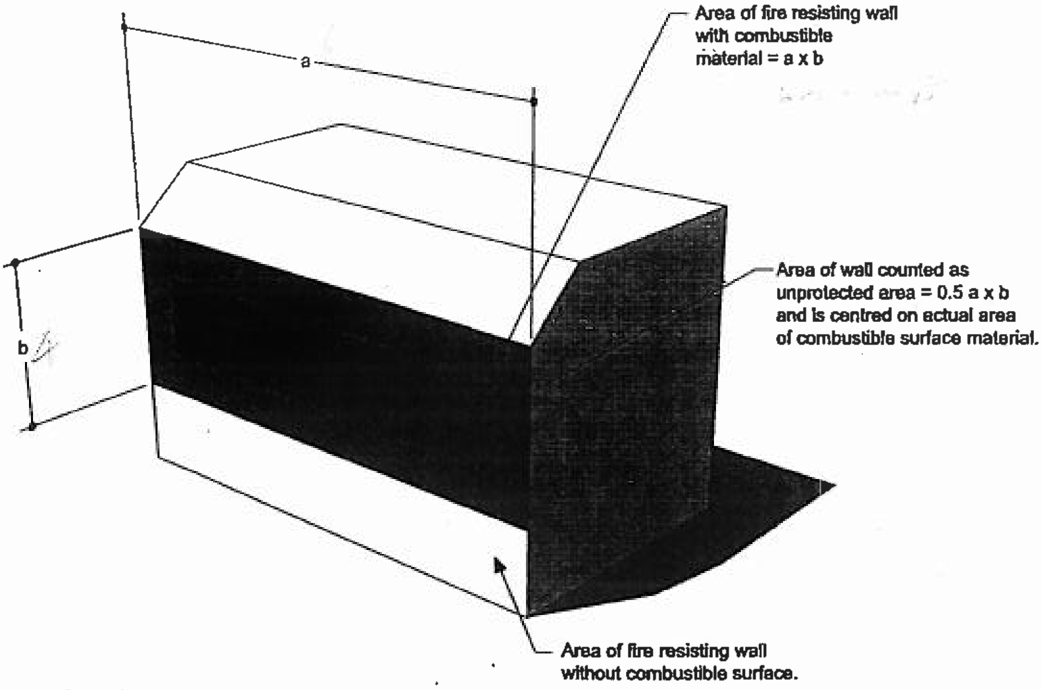
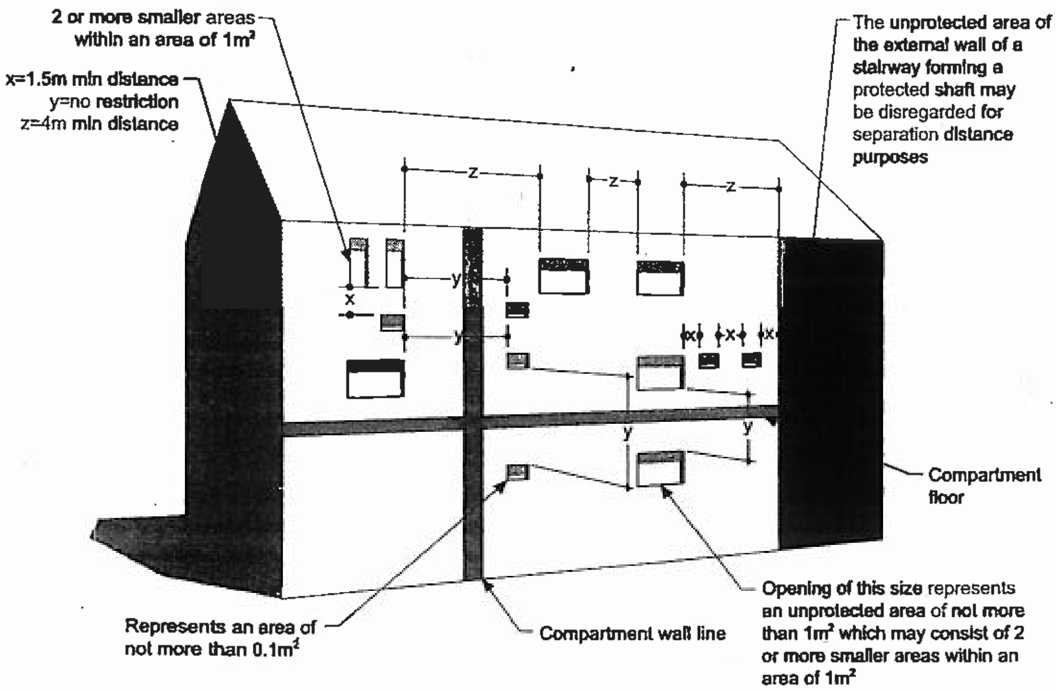


Diagram 4.3.8.4
Unprotected areas which may be disregarded in assessing the separation distance from the boundary



c. Sample Calculations

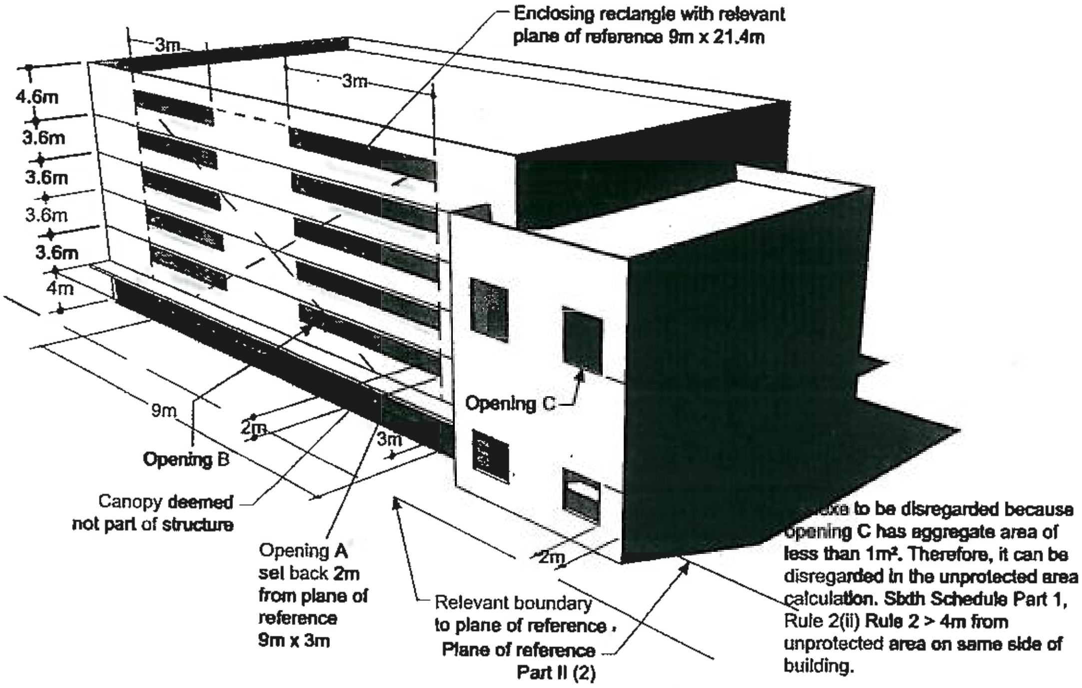
Calculations of permitted limits of unprotected areas (By-laws 142 and 145)

Assumptions:

- Single building which is not compartmented
- Purpose Group IV (Office)

Diagram 4.3.8.5

Sample calculation using the Sixth Schedule



Enclosing rectangle size on relevant plane of reference

9m (w) x 21.4m (h) = 192.6m²

Relevant boundary distance from enclosing rectangle 7.5m

Using Table 1 of Part II Sixth Schedule for enclosing rectangle 234m high, width of 9m, distance of 7.5m from relevant boundary, the limit of unprotected percentage of the enclosing rectangle shall not exceed 70%.

Calculations to check compliance

Opening 'A' - 9m (w) x 3m (h) = 27m³

Opening 'B' - 10 nos x 3m (w) x 2m (h) = 60m²

Total Opening Area = 87m²

Check 1 - Total area of 87m²

Unprotected Opening Area is less than 210m² (purpose Group IV).
Therefore it satisfies Part III 1(a) of Sixth Schedule.

opening A & B = 87 m²
Total area of enclosing rectangle size in relevant plane of reference.

Check 2 - Unprotected percentage of enclosing rectangle is 87m² / 192.6m² = 45.17%.
Limit of unprotected percentage of enclosing rectangle is 70%.
Therefore it satisfies Part II of the Sixth Schedule.

4.4 MEANS OF ESCAPE

4.4.1 Explanatory Notes

(i) Fire does not normally start in two different places in a building at the same time. At the initial stage, fire poses a danger only in the part of the building in which it starts. Thus, an important principle in the design of fire safety is to contain the fire within a compartment and to extinguish it while preventing fire and smoke from spreading to other parts of the building.

(ii) The items that are the first to be ignited are often furnishings and other items not controlled by the regulations. It is less likely that fire will originate in the structure of the building.

(iii) The primary danger associated with fire in its early stage is not flame but smoke and noxious gases produced by the fire. A person can withstand a smoky situation for only about 3 minutes after which he will faint or die.

(iv) Smoke also obscures the way to escape routes and exits and impede movement. In this situation, a person can move only about 12 metres (40 feet) per minute. In allowing a minute to escape, travel distance to safety in an unprotected escape route is generally to be no more than 12 metres (40 feet).

(v) Because of the danger posed by smoke and fumes, fire safety design must limit the spread of smoke and fumes especially through concealed spaces in buildings.

4.4.2 Basic Principles of Design

(i) In the event of fire, the occupants of any part of a building must be able to escape safely without reliance on external assistance or rescue by the fire service and without having to manipulate appliance or apparatus.

(ii) The design of means of escape should take into account the form of the building, the activities inside the building, the likelihood of fire and the potential of fire spread through the building. The UBBL 1984 stipulates differing requirements for different purpose groups of buildings and differing requirements for sprinklered and non-sprinklered buildings.

(iii) There should be alternative means of escape in most situation as there is always the possibility of an escape being impassable by fire or smoke. Single staircase (with no alternative means of escape) and dead ends are allowed under certain conditions where fire risk is low because of the small size and low height of the building and the small number of persons accommodated within it.

(iv) The provision of an appropriate warning and fire extinguishment systems should be an essential element in the overall strategy for safety.

(v) In addition to safety and egress of occupants, practical and safe access to the building by fire fighters and rescue personnel and equipment in order to stage rescue, fire containment and extinguishment has to be provided.

4.4.3 Means of Escape

(i) An escape route should lead to a place of safety. The ultimate place of safety is the open air outside the building, clear from the effects of the fire.

(ii) In large complexes where this is not possible, it should be possible to reach a place of reasonable safety such as a protected staircase or a protected corridor from where people can travel in relative safety to a final exit.

(iii) For this to be possible, protected staircase and protected corridor must not contain combustible materials and are designed to keep out flame, smoke and gases.

(iv) The maximum permissible distance of an unprotected escape route is worked out by the period a person exposed to fire and smoke can reasonably be expected to endure when escaping a fire.

4.4.4 Measurement of Travel Distance to Exits

Means of Escape - Concepts

Primary principles of means of escape:

(i) Alternative means of escape to be made possible.

(ii) Means of escape is to direct a shortest route to a place of safety, such as outside the building, or if still within a building, a protected or isolated passageway, stairs or refuge areas which lead to the outside of a building.

(iii) Generally means of escape consist of two parts:
  (a) unprotected areas, leading direct to exit
  (b) protected areas, leading direct to exit

Unprotected areas forming escape routes are to be limited in distance to minimise exposure to smoke and fire, and this is the basis of the limits of 'travel distance'.

Diagram 4.4.4.1
Travel distance
(dead end)

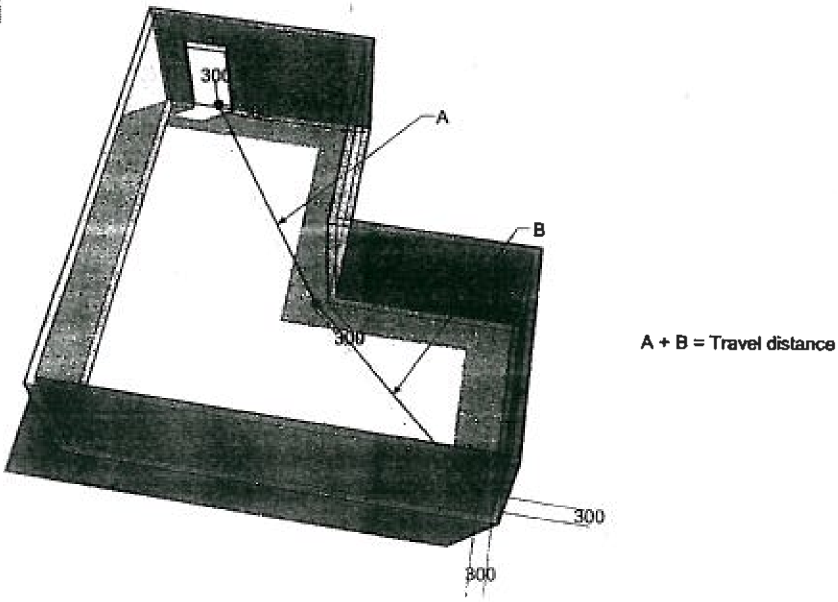
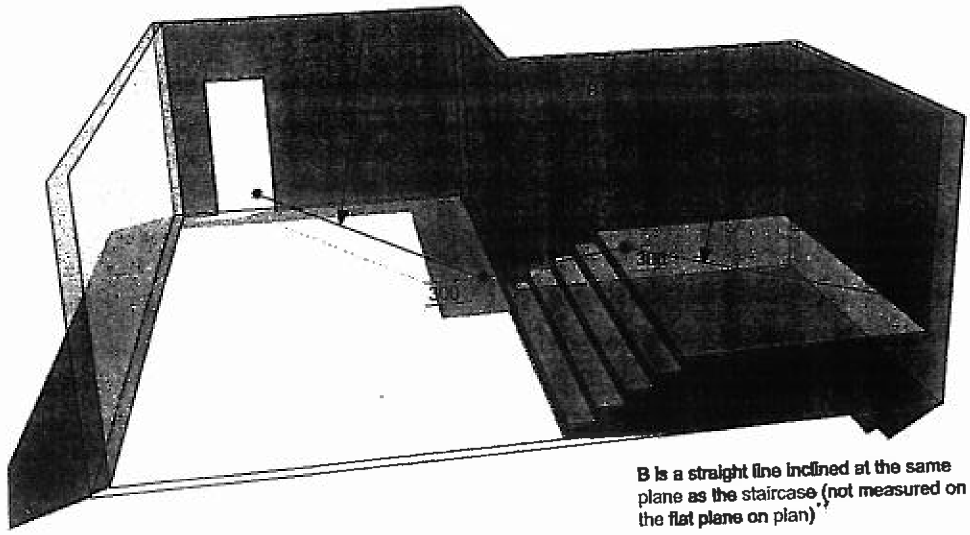
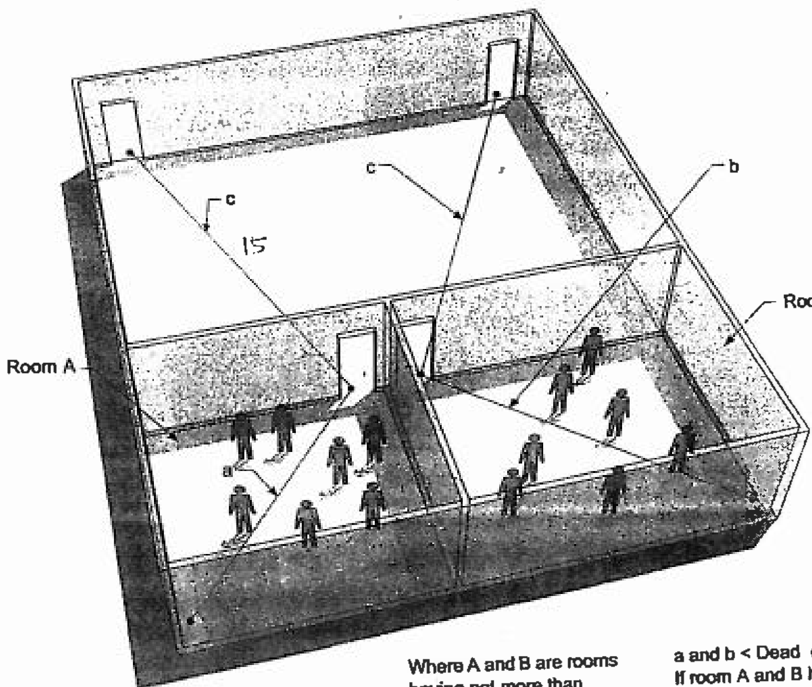


Diagram 4.4.4.2
Travel distance over steps



B is a straight line inclined at the same plane as the staircase (not measured on the flat plane on plan)

Diagram 4.4.4.3
Travel distance from rooms exceeding 6 person occupancy



Where A and B are rooms having not more than six persons c < P

a and b < Dead end travel distance.
If room A and B has an occupancy exceeding 6 persons, then a + c or b + c shall be less than or equal to P.
P = Permitted Travel Distance

Diagram 4.4.4.4.
Measurement of travel distance to exit

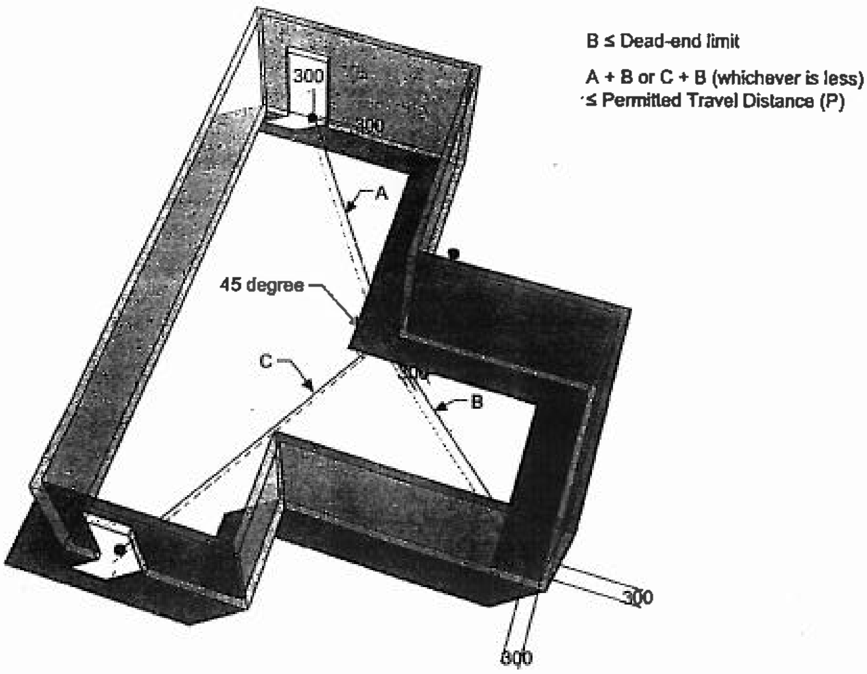


Diagram 4.4.4.5
Dead-end travel distance

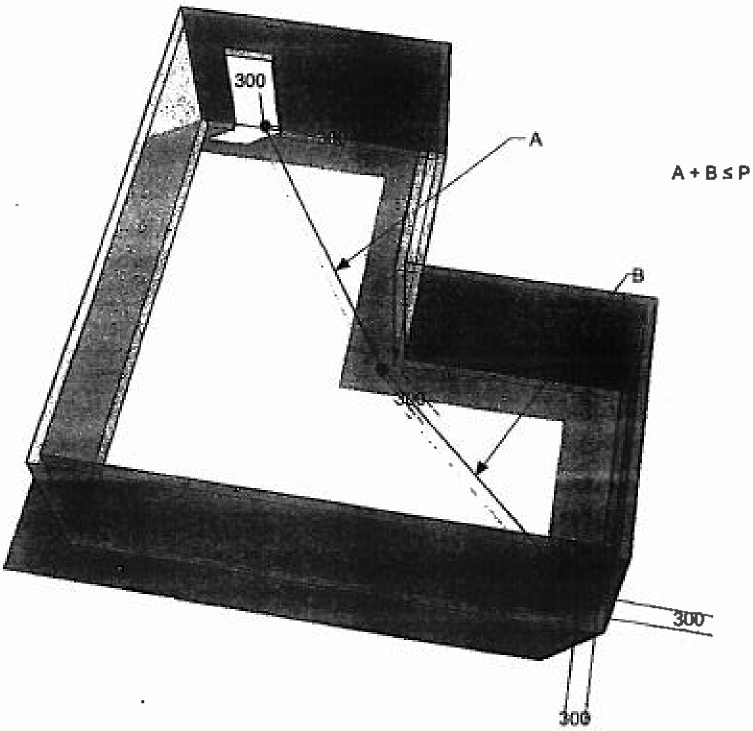


Diagram 4.4.4.6
Dead-end travel distance

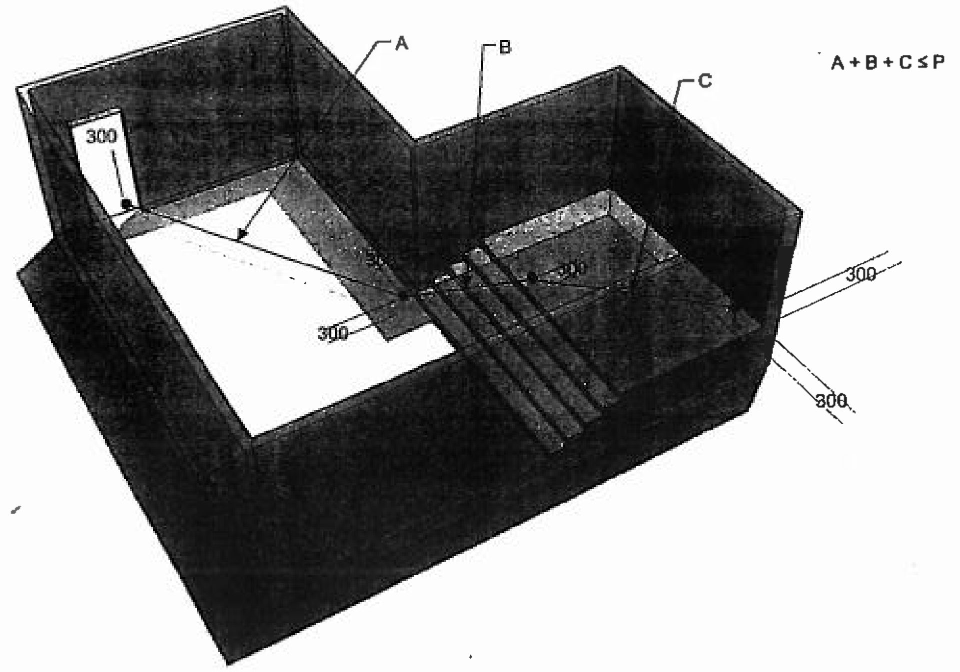


Diagram 4.4.4.7
Dead-end travel distance

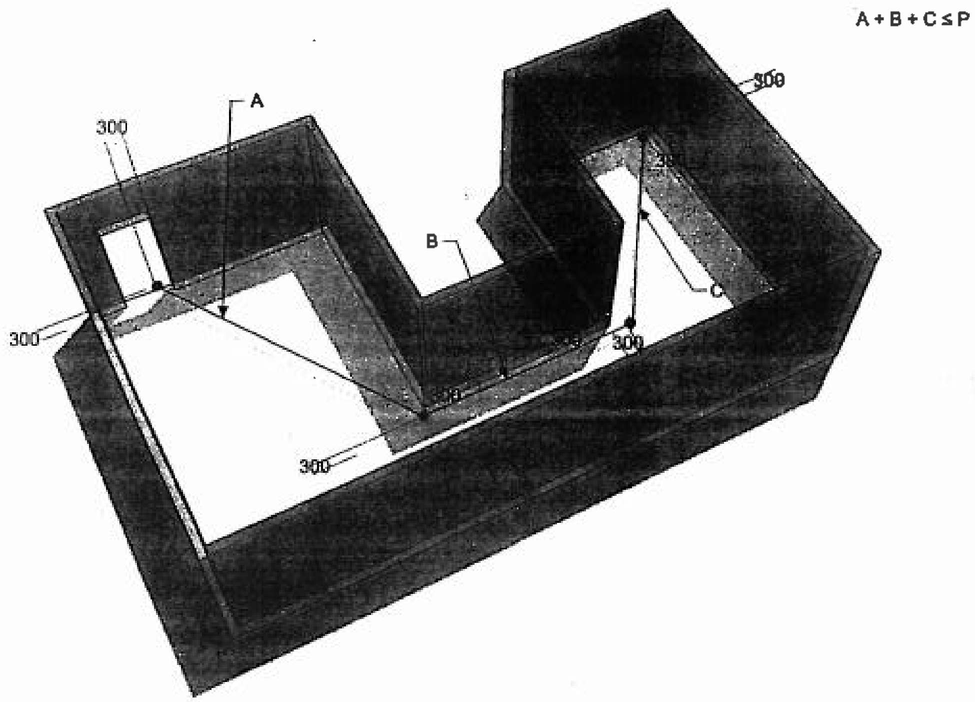


Diagram 4.4.4.8
Exit and travel distance

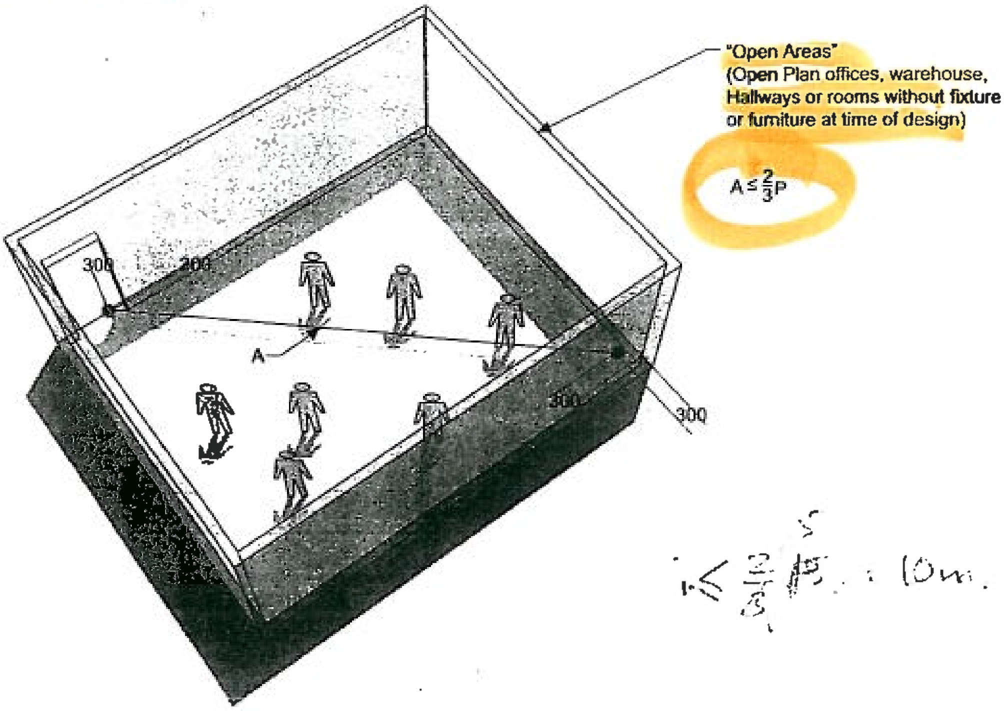


Diagram 4.4.4.9
Travel distance within rooms

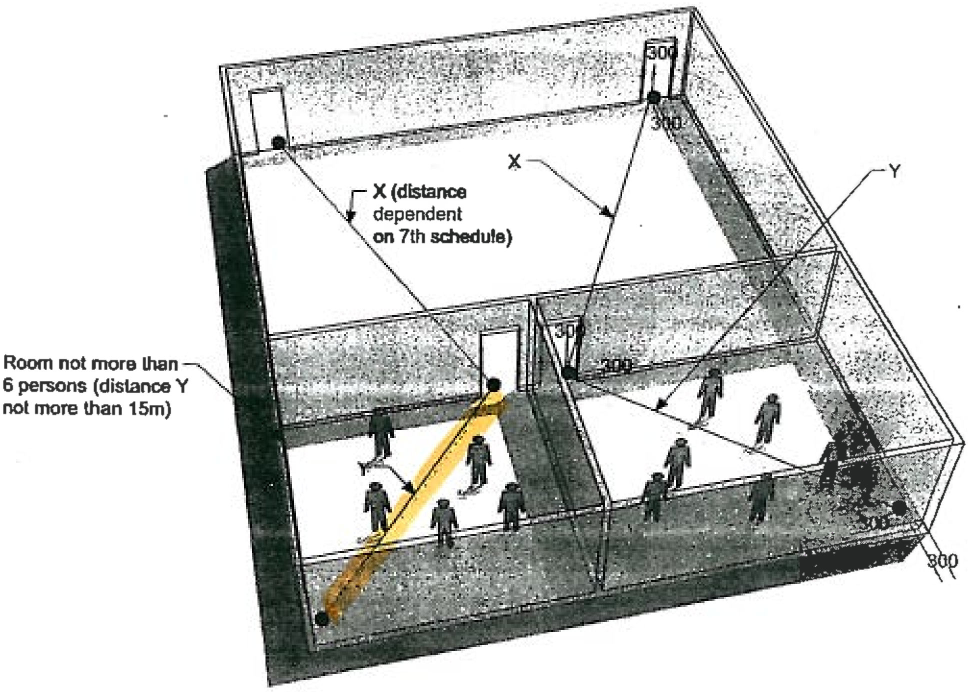


Diagram 4.4.4.10
Measurement of travel distance within rooms

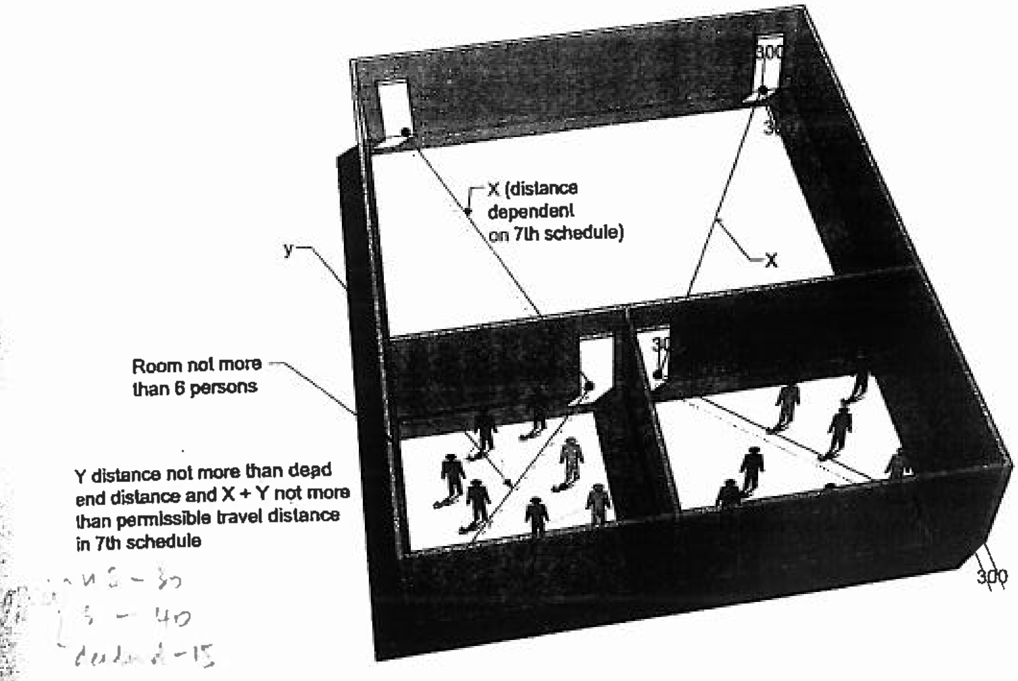


Diagram 4.4.4.11
Measurements of travel distance to exits

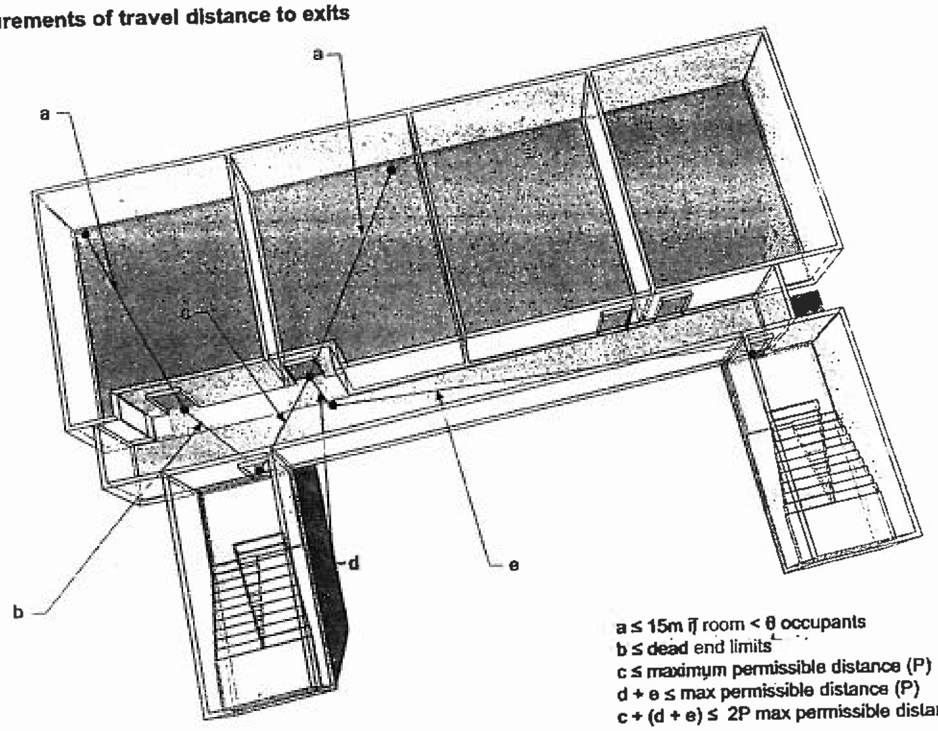
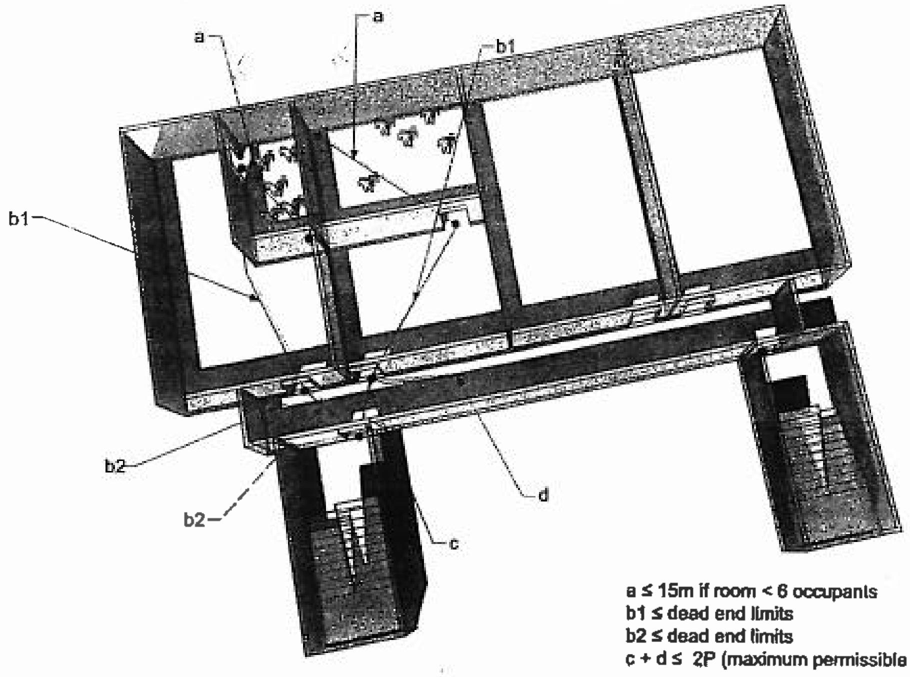


Diagram 4.4.4.12
Travel distance through offices



a ≤ 15m if room < 6 occupants
b1 ≤ dead end limits
b2 ≤ dead end limits
c + d ≤ 2P (maximum permissible distance)

Diagram 4.4.4.13
2 storey exits to be provided

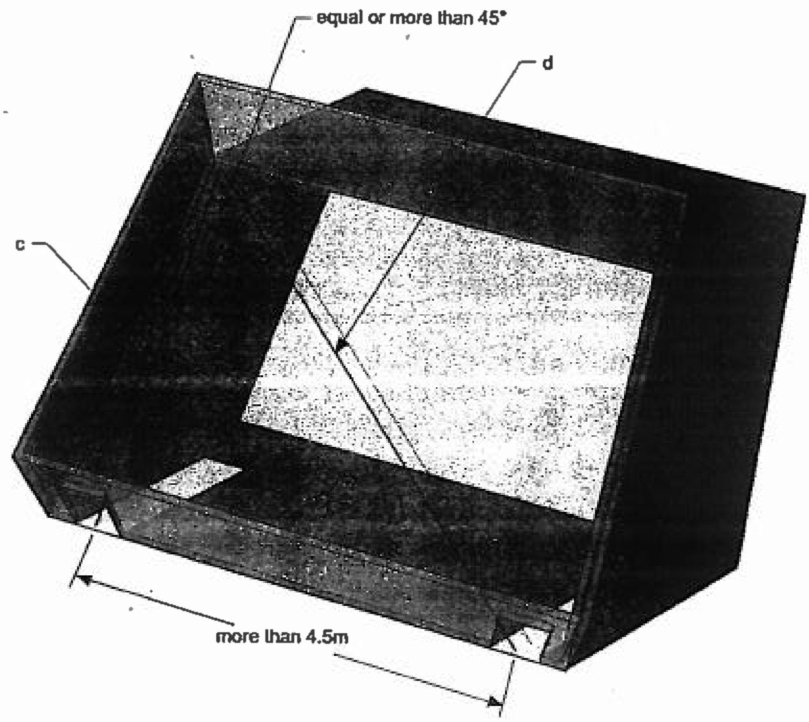


Diagram 4.4.4.14
Compliance with permitted travel distance

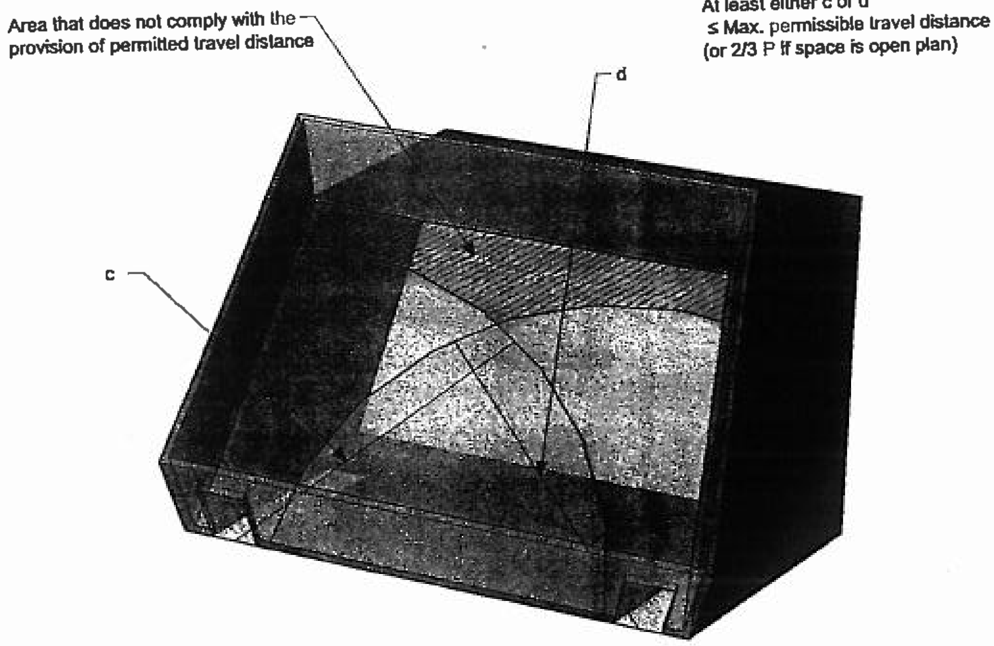
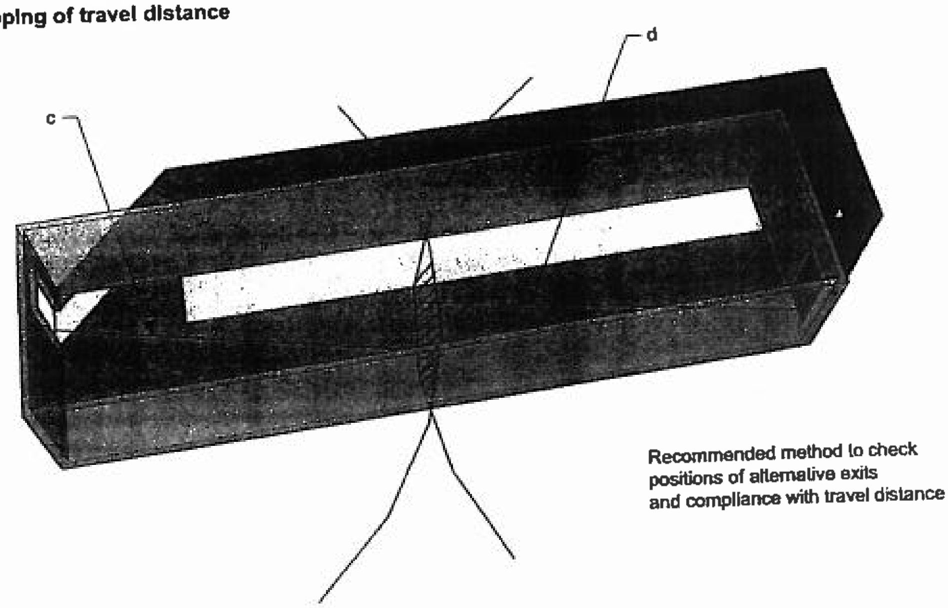


Diagram 4.4.4.15
Overlapping of travel distance



4.4.5 Arrangement of Storey Exits

The principle of this clause is that once the escape route is inside a protected zone, eg. an isolated/ protected staircase, then the route shall remain protected all the way to the final exit, i.e. out of the building. Therefore, the route shall not discharge into an unprotected area (such as open lobby) prior to the final exit. (Refer to By-law 190).

Diagram 4.4.5.1
Final Exits

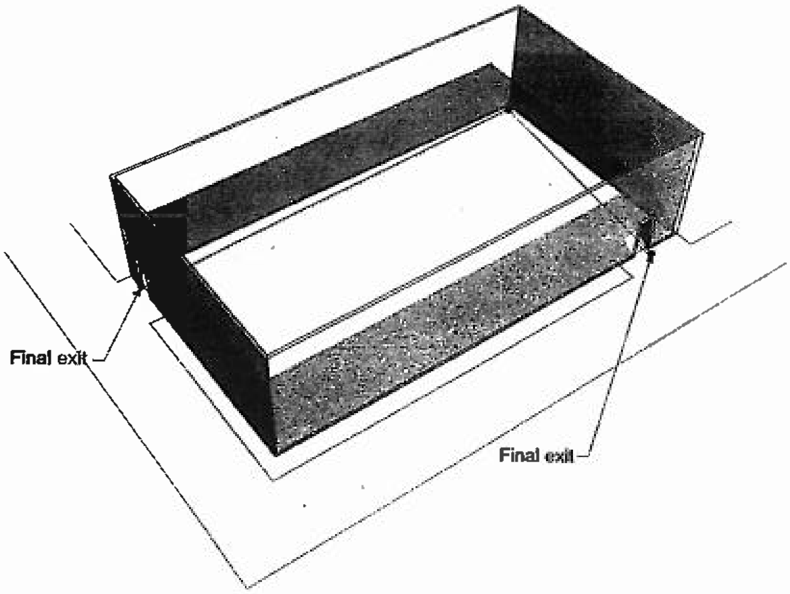


Diagram 4.4.5.2
Final Exits

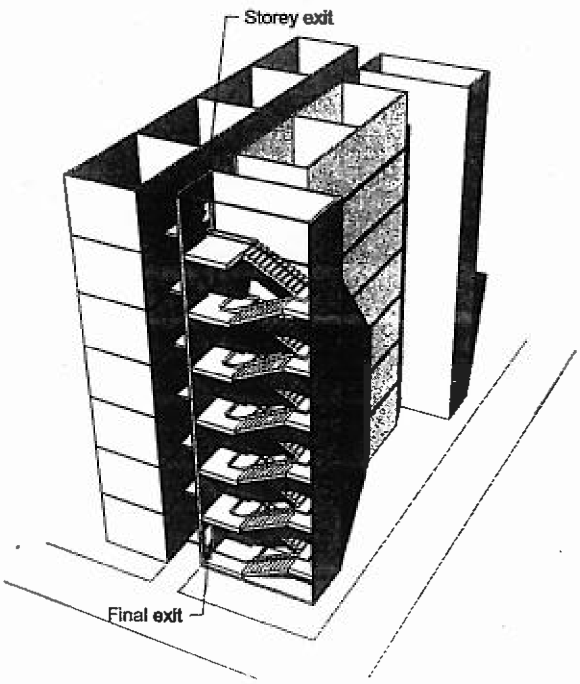


Diagram 4.4.5.3
Minimum distance between exits

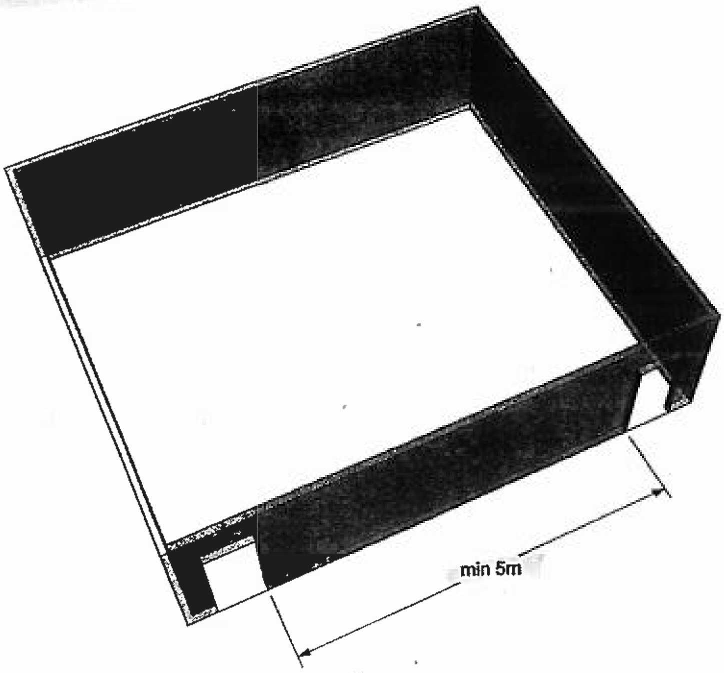


Diagram 4.4.5.4
Minimum distance between storey exits

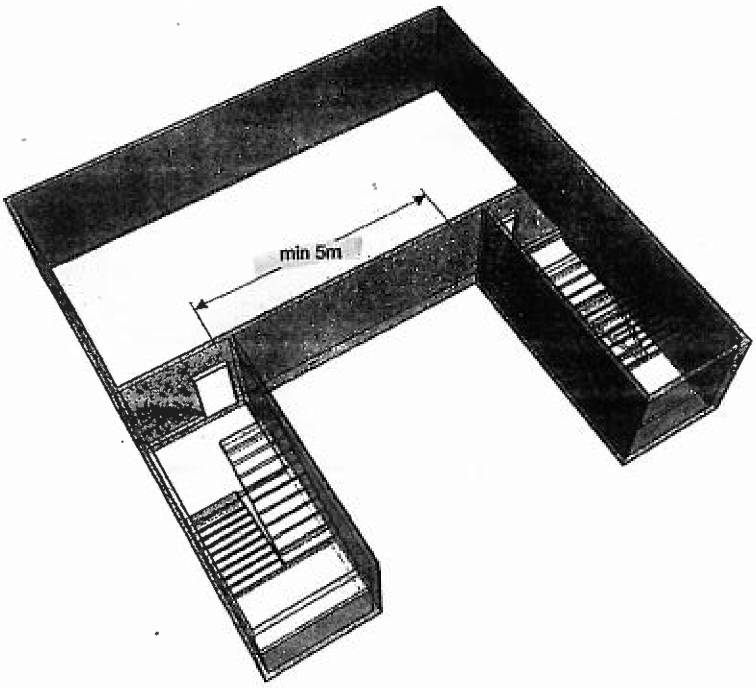


Diagram 4.4.5.5
Minimum distance between exits onto corridor

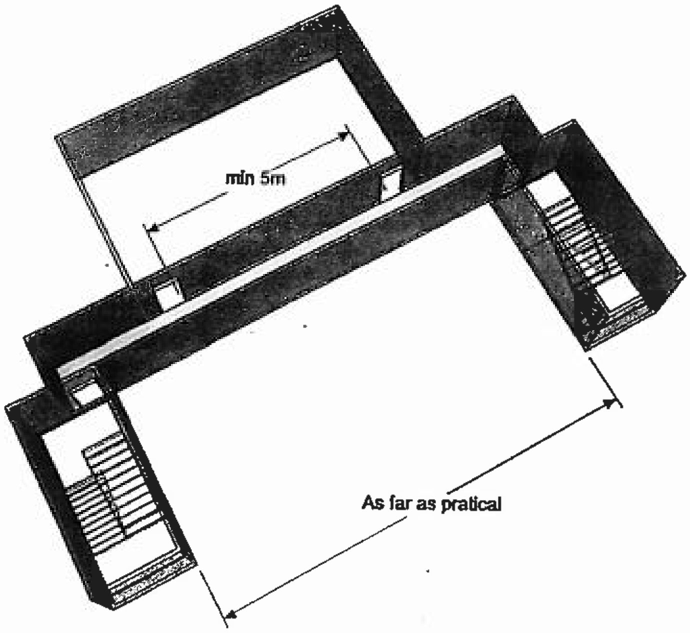


Diagram 4.4.5.6
Storey exits (staircases)

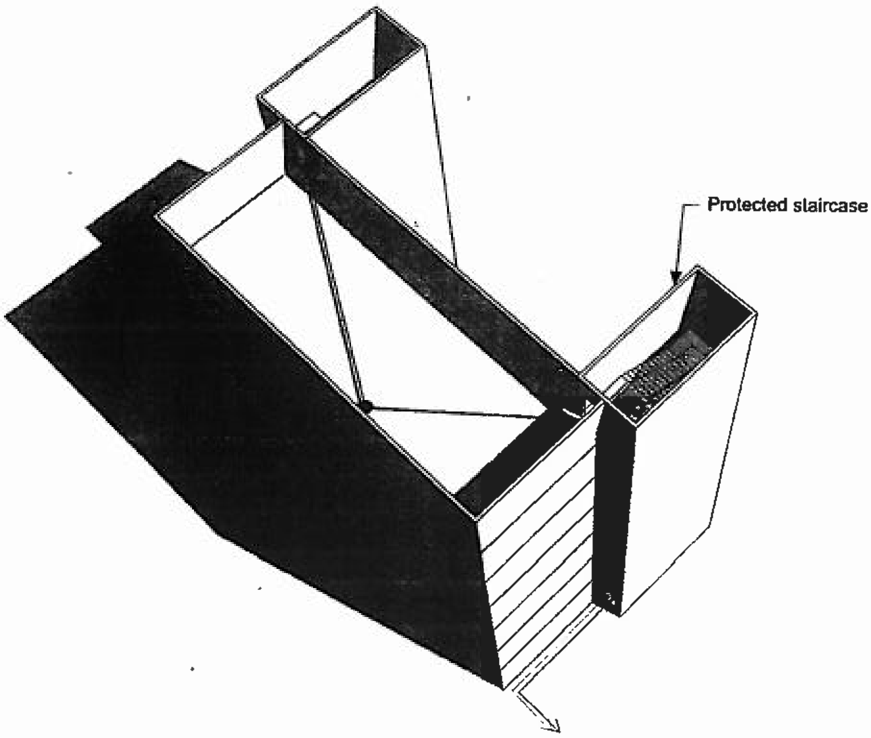


Diagram 4.4.5.7
Storey exits (balcony approach)

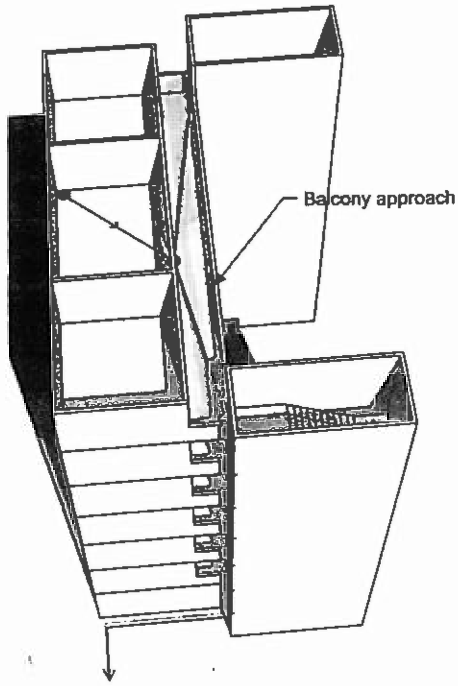


Diagram 4.4.5.8
Exit routes to discharge directly to final exit

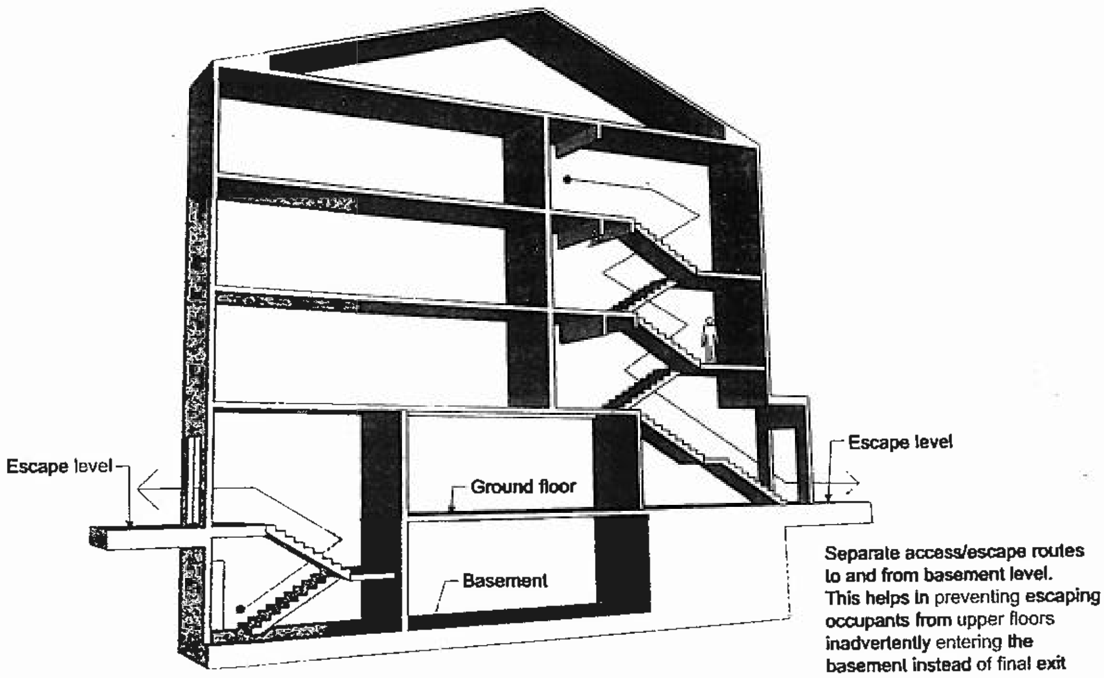


Diagram 4.4.5.9
Egress through unenclosed openings (mezzanine)

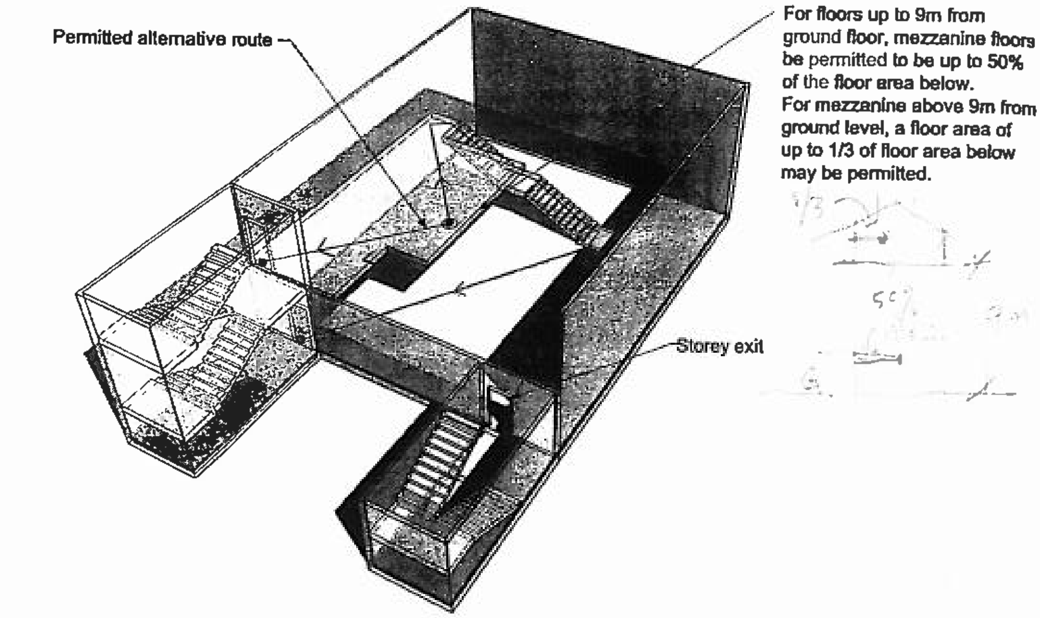
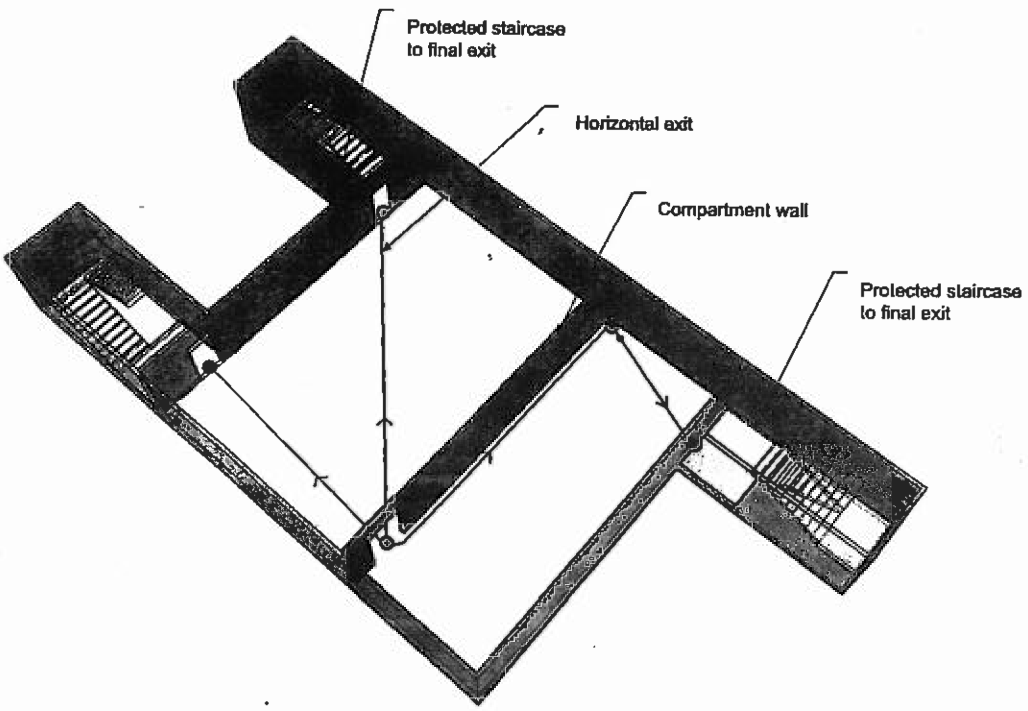


Diagram 4.4.5.10
Horizontal exits



4.4.6 Staircases

Staircases are very important elements which often serve as the primary escape route element in any building containing more than one level. As such it is important in planning and designing staircases that consideration be given to issues like usability, practicality and predictability.

Humans develop a rhythm when climbing or going down stairs. An intuitive fuzzy logic reasoning predicts the next riser or step. It is for this reason that pitch lines (an imaginary line joining all nosings in a flight) have to be made as consistent as possible. Uneven steps in a flight of stairs can confuse one's perception and lead to users stumbling. By the same reason, flights of less than three risers are not allowed. These are called usability considerations. From a practicality point of view, minimum tread dimensions and maximum riser dimensions are used to control designs to ensure that they are physically usable. In England and Wales, a maximum pitch angle of 42 degrees is allowed for staircases. Any steeper and it becomes physically challenging to use, especially for the elderly, very young and physically impaired or unfit.

The following information on steps and stair must be shown on drawings submitted to JBPM:

(i) number of treads (or risers) which shall not exceed 16 in a single flight unless it is for stairs within an individual residential unit (By-law 108[1]).

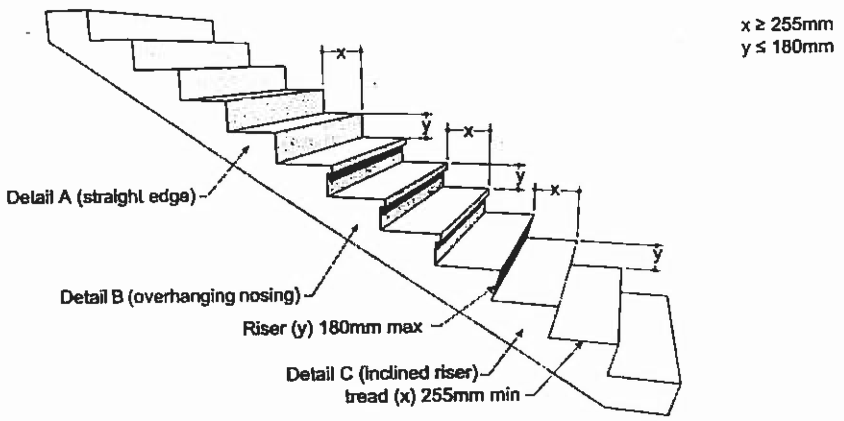
(ii) dimension of treads and risers; treads shall not be less than 255mm, risers shall not be more than 180mm. (By-law 106[1])

(iii) widths of steps or stairs which shall be calculated in accordance with By-law 168.

(iv) depth of landing which shall not be less than the width (By-law 106[3]) of the staircase.

(v) Minimum headroom of not less than 2 metre measured vertically from any point over the full width of the stairs.

Diagram 4.4.6.1.
Measurement of riser and tread



Tread and riser dimensions must be constant within a staircase to prevent users from tripping and falling especially in the event of fire. Dimensions are stipulated for the same reasons.

The width of staircase shall not reduce along its path of travel to the final exit (by-law 169).

Winders are not permitted in fire escape staircase.

Diagram 4.4.6.2
Landing in residential building
(more than 16 risers per flight is not encouraged)

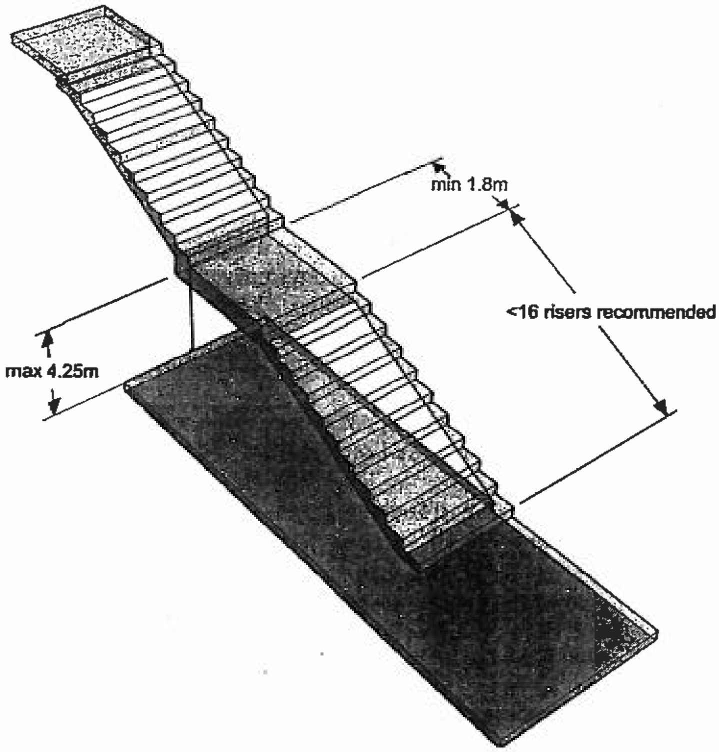


Diagram 4.4.6.3
Single riser in staircase not permitted
(minimum number of risers can be two but it should be regular)

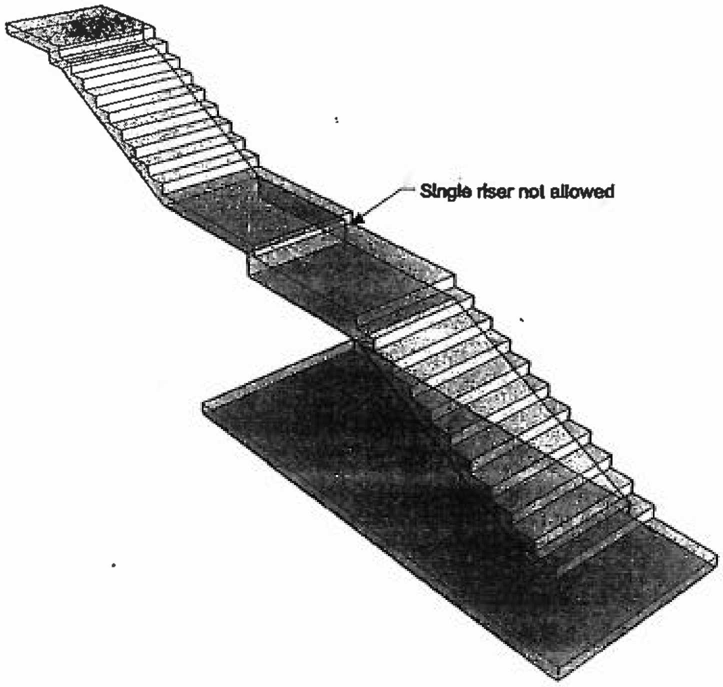
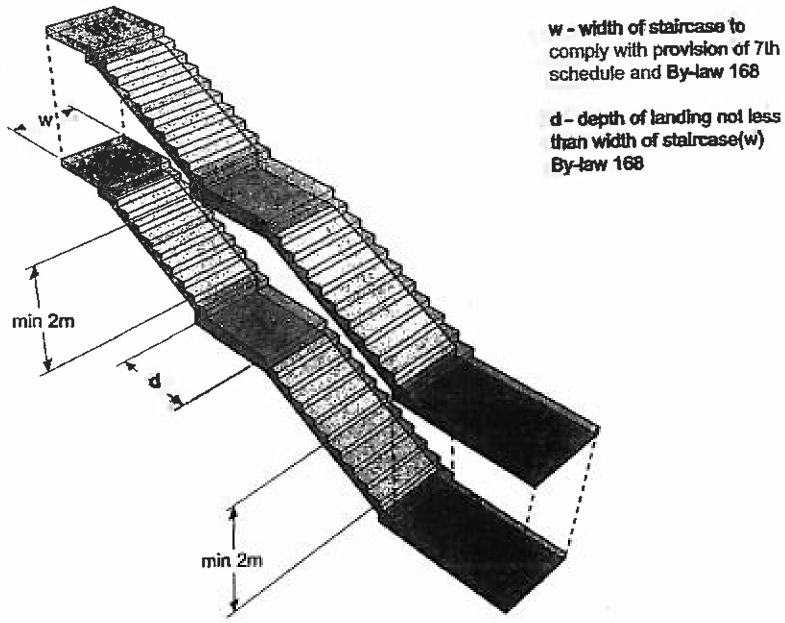
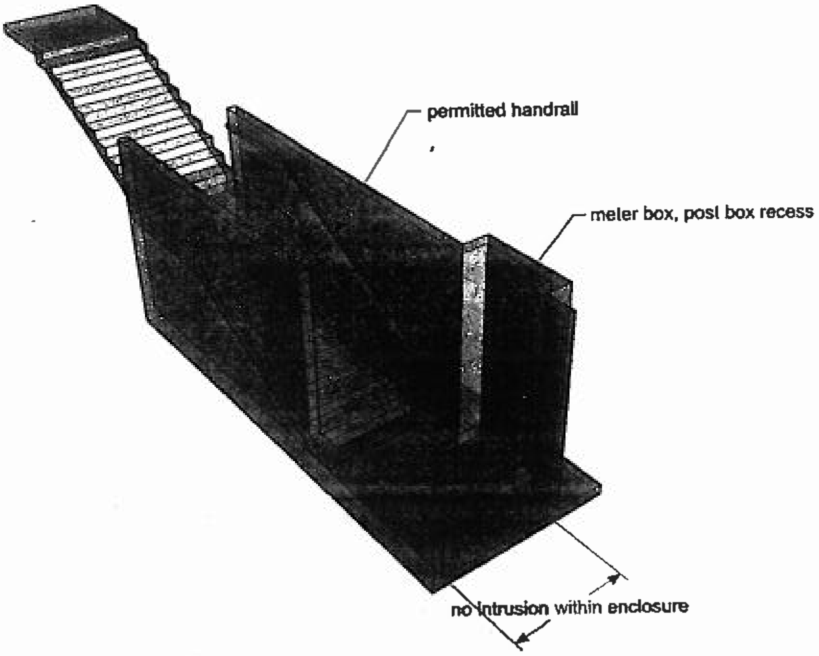


Diagram 4.4.6.4
No obstruction in staircases

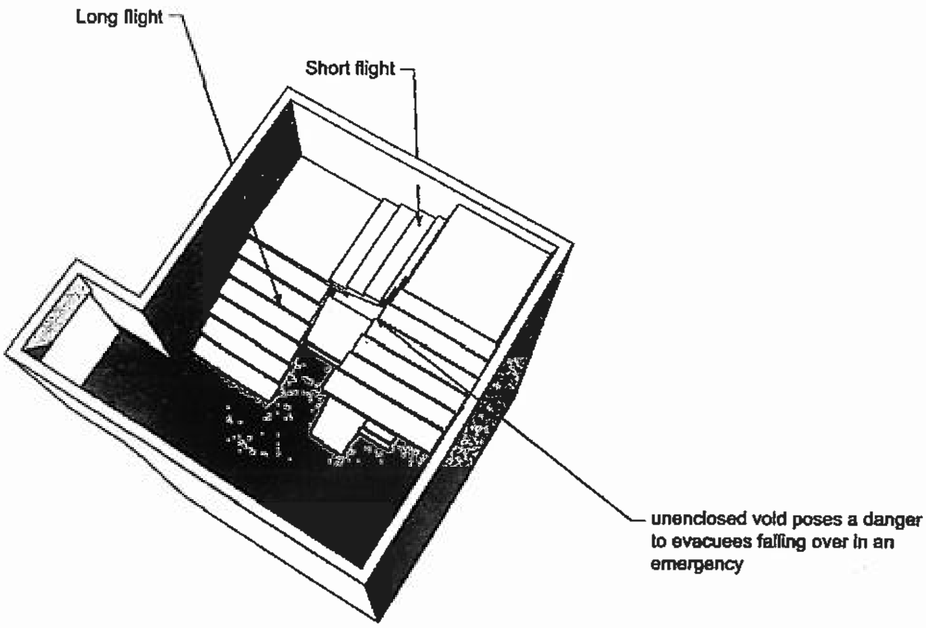




Meter box, post box or other fittings are not to intrude into this enclosure.

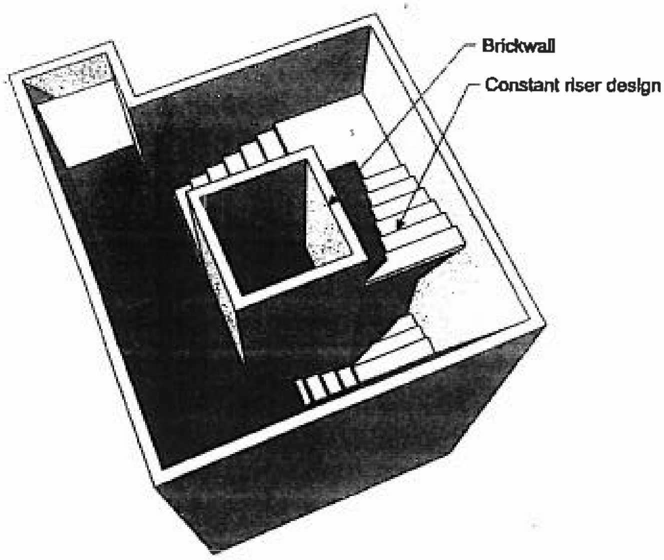
No obstruction or intrusion within this "enclosure" (except permitted handrails).

Diagram 4.4.6.5
Example of bad staircase design



Staircase with long and short flights as shown above are not encouraged by JBPM for an escape staircase because a person's rhythm of walking down steps is broken especially during an evacuation when the staircase is packed with evacuees and one cannot see the steps ahead.

Diagram 4.4.6.6
Example of acceptable staircase design



The above layout is acceptable provided brickwall surround the void and the flight are regular. This to prevent people from falling over the staircase into the void in the event of a rush during evacuation.

Diagram 4.4.6.7
Recommended standard of escape stair

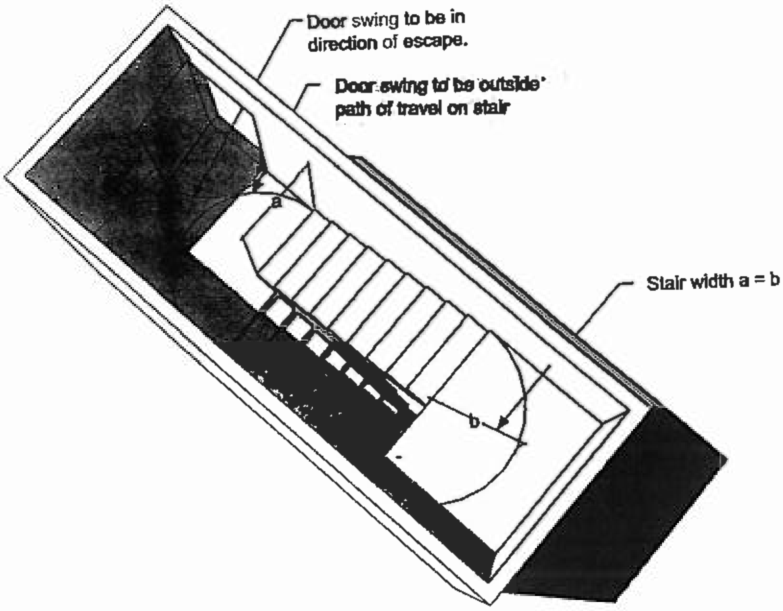
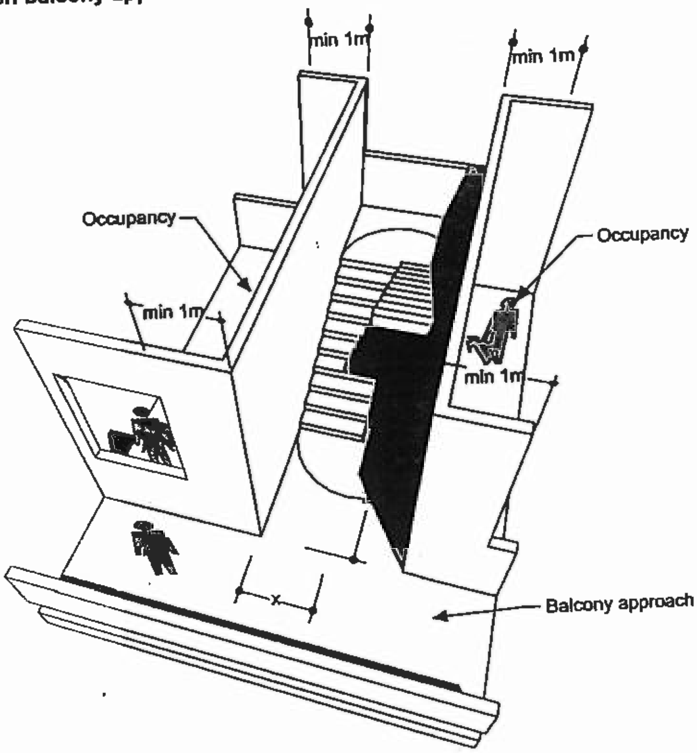


Diagram 4.4.6.8
Staircase serving open balcony approach



4.4.7 Smoke Lobbies

Diagram 4.4.7.1
Smoke lobby to staircases

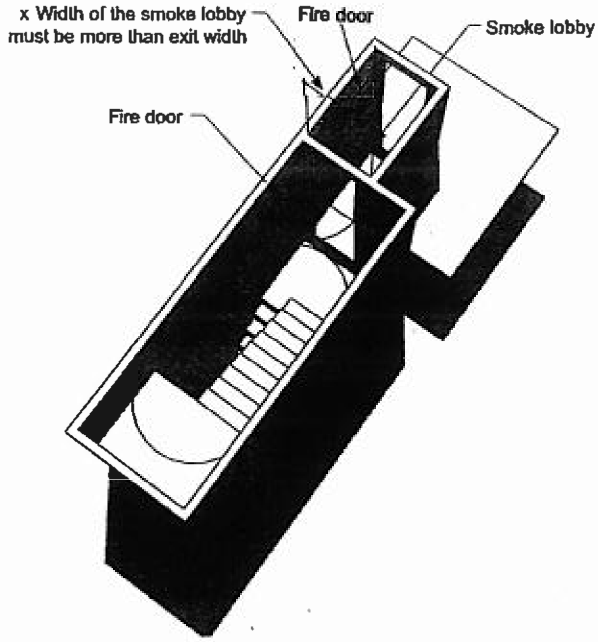
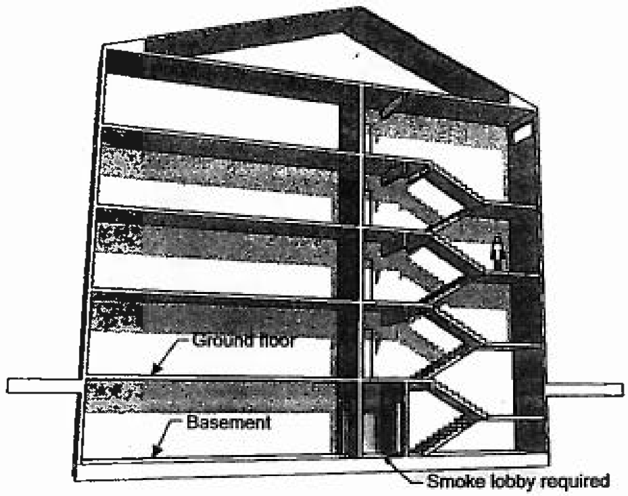


Diagram 4.4.7.2
Smoke lobby for stair extended to basement



Smoke lobbies create a buffer between the actual occupied premises and the escape passage or staircase.

In its simplest form, it prevents ingress of smoke and toxic gases into the escape staircase when the staircase fire door is opened, where required, pressurisation of the staircase can serve the same purpose by creating positive pressure within the stairwell to prevent smoke ingress.

When the smoke lobby doubles as a fire fighting access lobby, it serves as a point for fire and rescue personnel to tackle the source of fire from within the same floor. (Refer By-laws 196-199).

In buildings exceeding 18m above ground level, protected lobbies are required if the staircases are not ventilated or pressurised. (By-law 197).

Diagram 4.4.7.3
Ventilation of smoke lobby

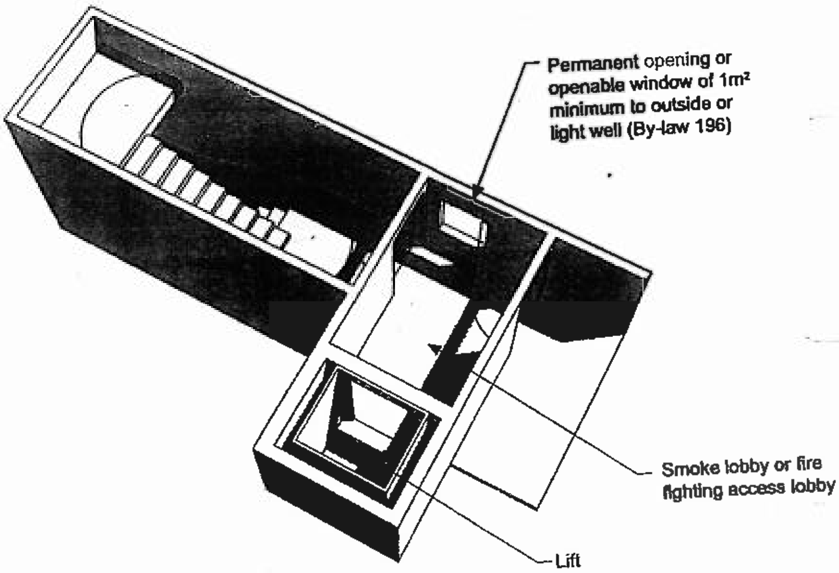
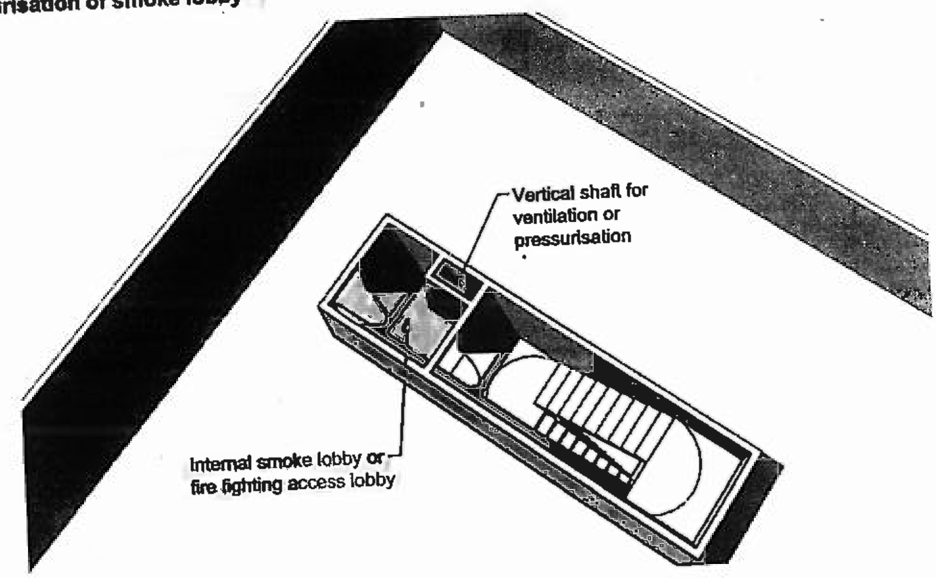


Diagram 4.4.7.4 By law 196
Pressurisation of smoke lobby



18m.

G.L

Diagram 4.4.7.5
Protected lobby requirement for building > 18m height (By-law 197)

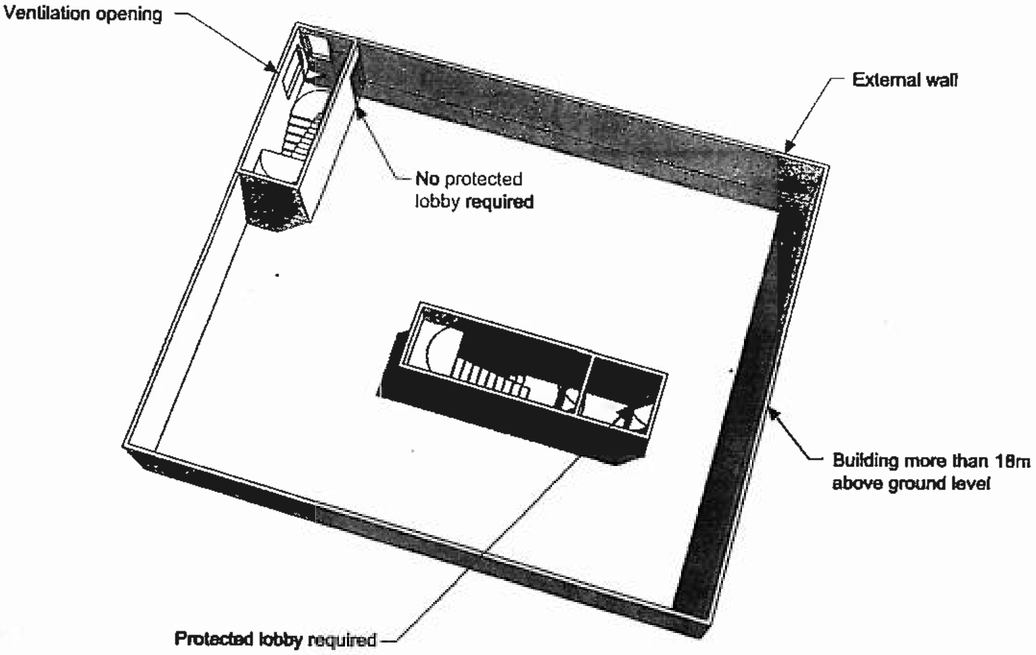


Diagram 4.4.7.6
Protected lobby requirement for building > 45m height (By-law 197[2])

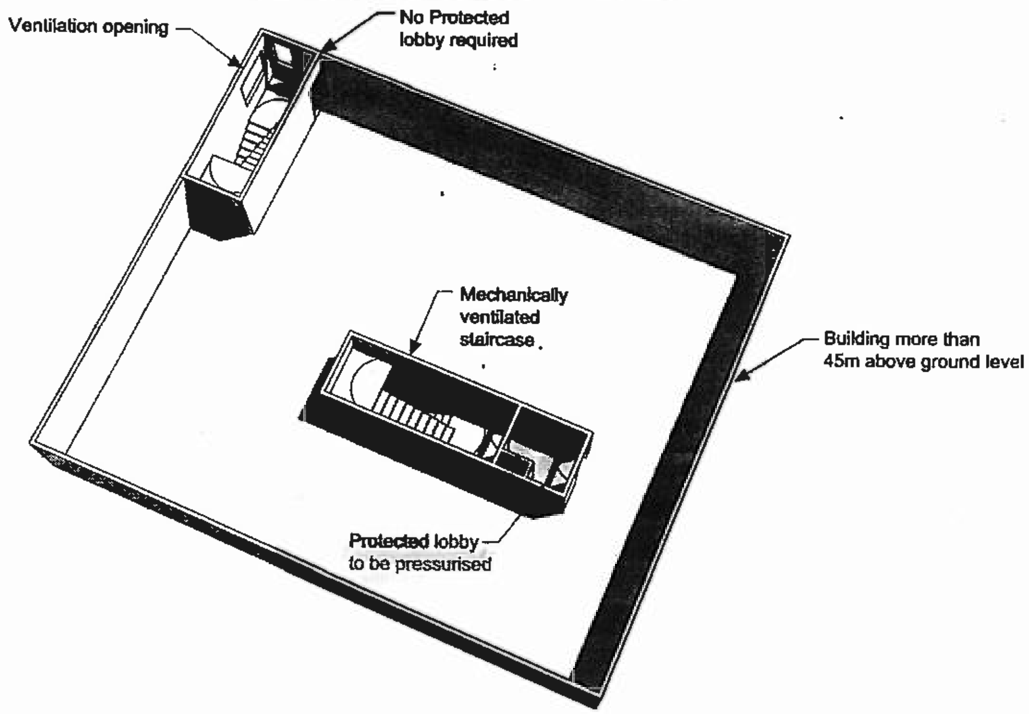


Diagram 4.4.7.7
Omission of protected lobby for pressurised staircase

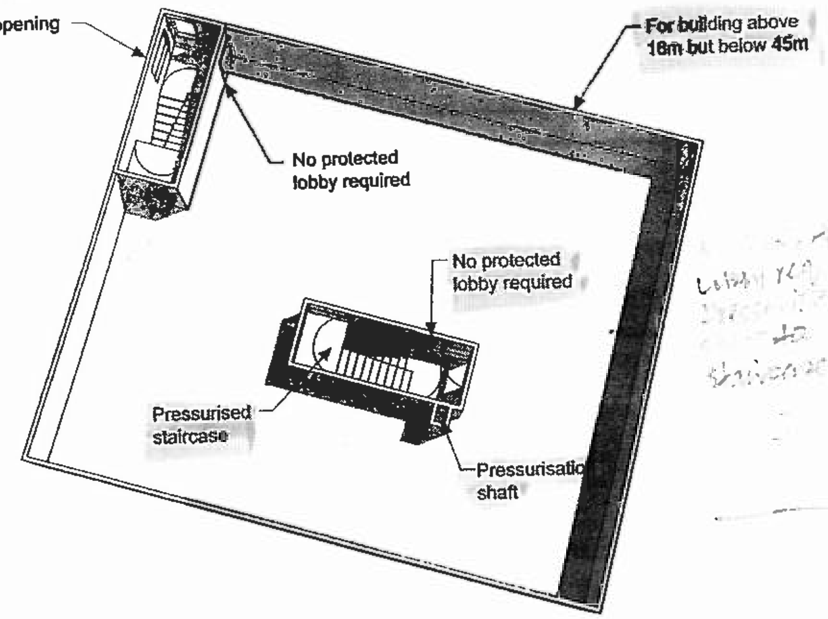
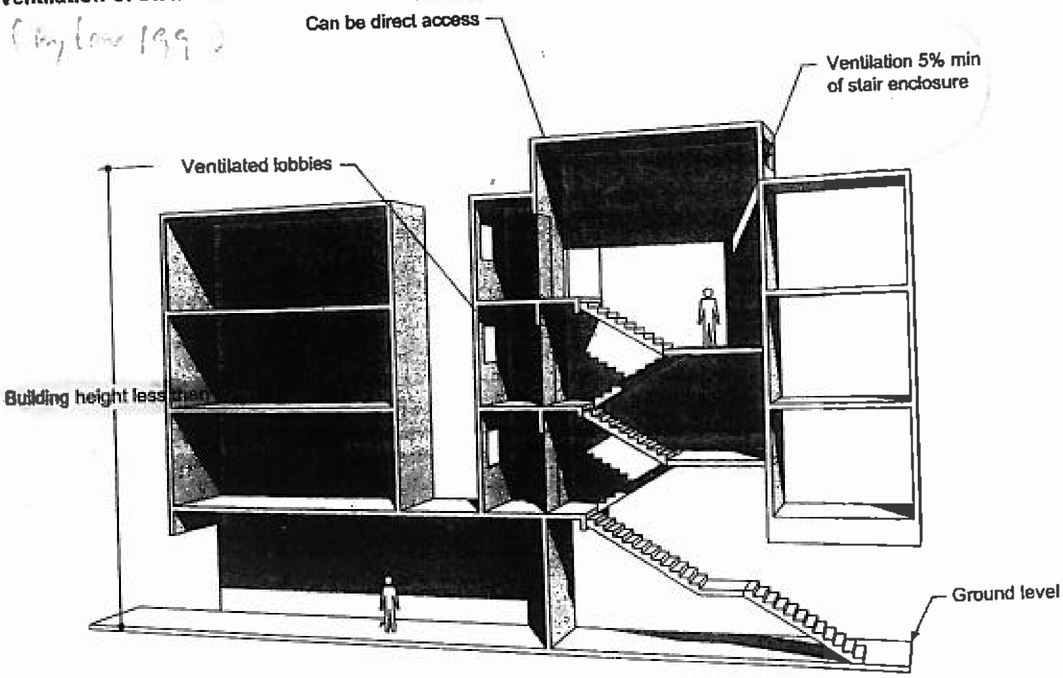


Diagram 4.4.7.8
Ventilation of staircase enclosure in buildings not exceeding 18m



4.4.8 Building with Single Staircase

Diagram 4.4.8.1
Height of topmost floor of building with single staircase

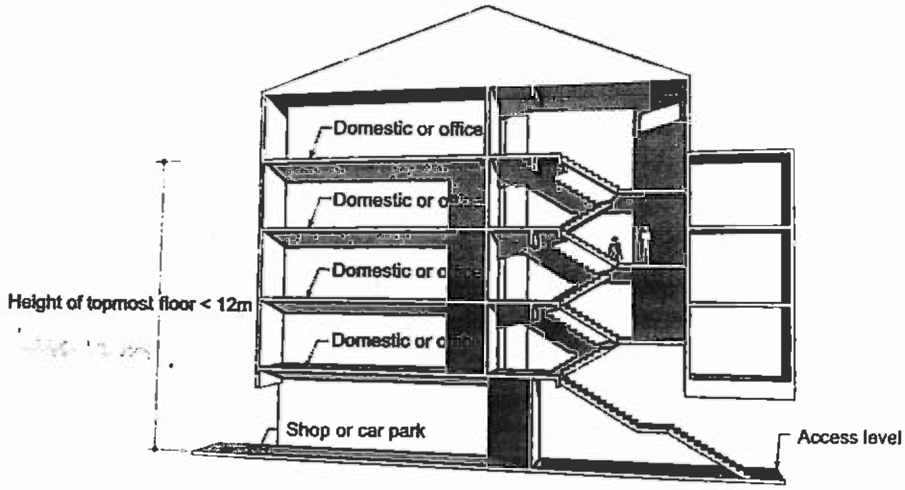
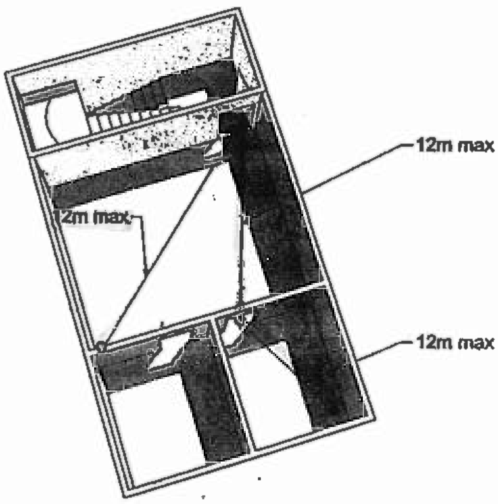


Diagram 4.4.8.2
Maximum travel distance



By-law 194 stipulates when a single staircase may be permitted. Essentially, this is only allowed where the occupancy above ground level is confined to either domestic or office purposes. This presumes a scenario where the occupants are familiar with the layout of the building and floor plates. The ground floor may be used for shops or car parks (shop offices, shop houses).

All elements of structure shall have an FRP of not less than 1 hour except the enclosure for the staircase at the ground floor where the wall shall have an FRP of not less than 2 hours [Refer By-law 216], assuming the ground floor will not be used for residential purposes.

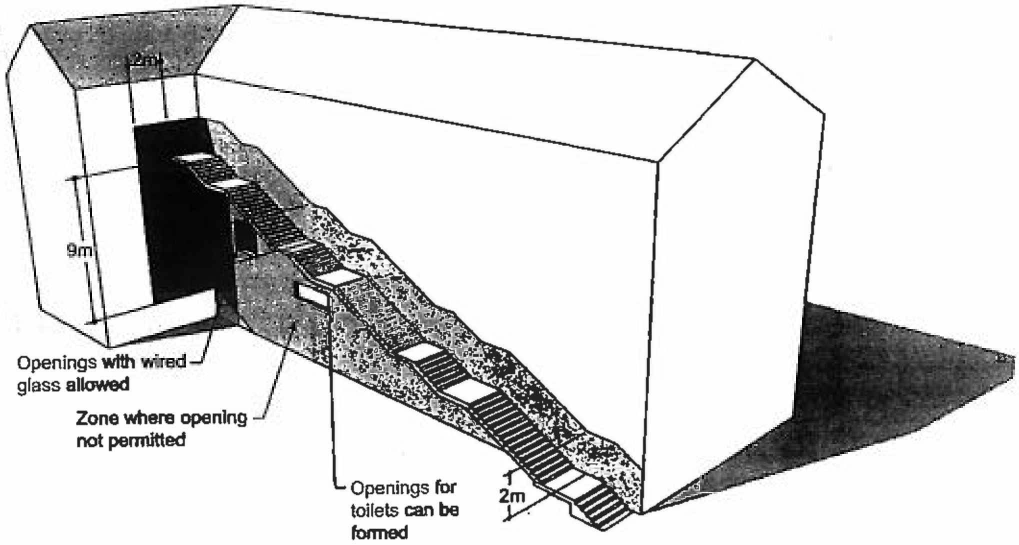
Designers are advised to inform their Clients of the need to anticipate the likelihood of change in use after the issuance of the Certificate of Fitness for Occupation by not electing to use single staircase designs in traditional 4 storey shop/office developments. This is a common problem encountered by JBPM when shop office developments end up being converted into tuition centres, shops and entertainment outlets like bar lounges and cafes.

4.4.9 Protection for External Escape Staircase

By-law 191 ensures that an external staircase used for escape purposes will remain protected from fire exposure originating from the building. Therefore, a zone of protection is extended from the staircase both upwards and downwards to ensure safe passage during a fire.

The illustration shows the zone where no opening shall be formed or only toilets or other protected area openings or openings with wired glass which are kept permanently closed can be allowed to be formed.

Diagram 4.4.9.1
Zone where no opening shall be formed or only toilets or other protected area openings or openings with wired glass and kept permanently closed can be allowed to be formed



4.4.10 Handrails

All flight of stairs with 4 or more risers shall be provided with at least one handrail.

Diagram 4.4.10.1
Staircase exceeding 2225mm width requires intermediate handrails

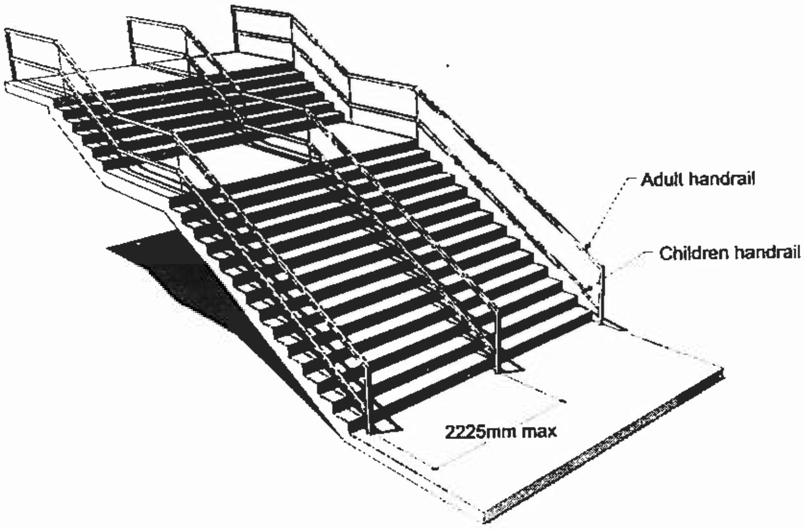


Diagram 4.4.10.2
Wall mounted handrail

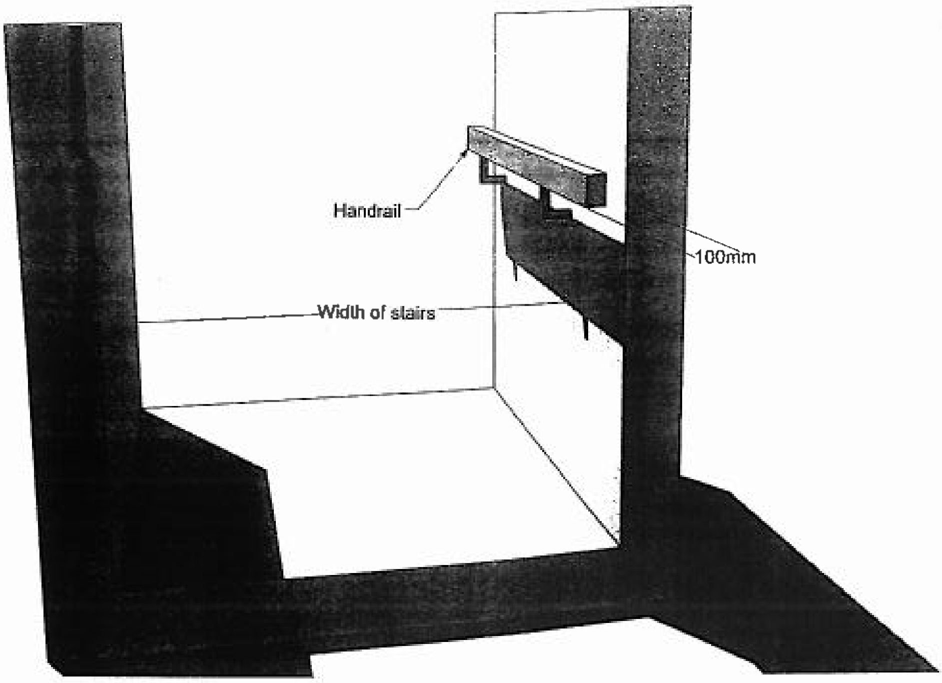
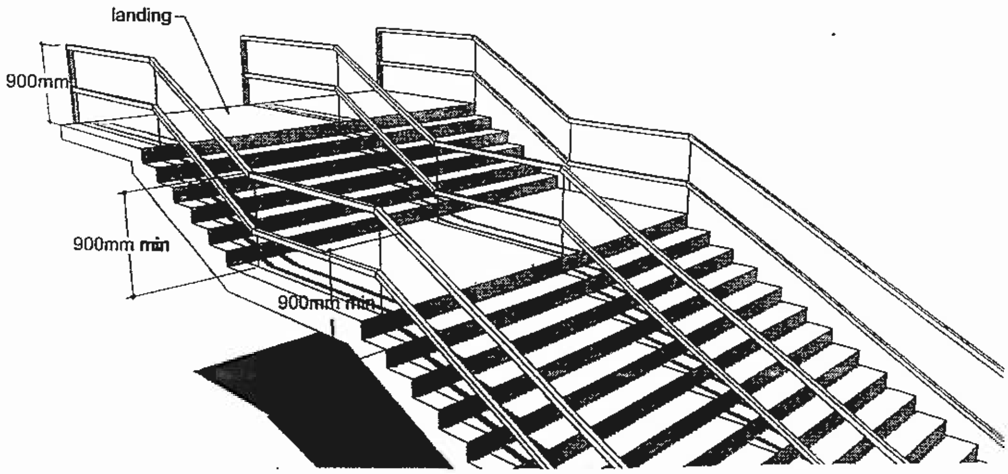


Diagram 4.4.10.3
Handrail detail



4.4.11 Escape Provision Computation

By-law 175 - Calculation of Occupancy Loads

By-law 176 - Computing Storey Exit Width

By-law 177 - Computing Number of Staircases and Staircase Width

Worked example to calculate numbers and width of staircase required using the Seventh Schedule of UBBL 1984

- Office building/Purpose Group IV

- 5 levels, each level designed as a compartment

- Floor areas - Level 1 (Ground) - 1500m^2
  - Level 2 - 1500m^2
  - Level 3 - 1500m^2
  - Level 4 - 1500m^2
  - Level 5 - 1800m^2

Exit Width Calculations Table

A	Level	1	2	3	4	5
B	Purpose Group/Occupancy Load	IV/10	IV/10	IV/10	IV/10	IV/10
C	Floor Area (m^2)	1500	1500	1500	1500	1800
D	C ÷ B = Occupancy	150	150	150	150	180
E	Exit Capacity Required for Stairs (D ÷ 60)	2.5	2.5	2.5	2.5	3.0
F	Minimum Staircase Width (E x 550mm)	1375	1375	1375	1375	[illegible]

Notes
Purpose Group - Refer to Fifth Schedule

Occupant Load - Refer to 2nd Column of Seventh Schedule, check whether areas to be used is nett or gross.

Exit Capacity - Refer to 3rd column of Seventh Schedule, establish type of exit and exit capacity that is appropriate eg. doors outside, ramps or stairs.

(i) Referring to column F in the above table, Level 5 is the largest and the exit width (staircase) required is 1650mm. Staircase provision must cater to this requirement.

(ii) By-laws 168 and 177 stipulate that every upper floor shall have means of egress via at least two separate staircase (with exception of By-law 194), assuming exit distances are com plied with. A minimum of two staircases are therefore required for compliance.

(iii) By-law 199(a) requires the assumption that one of the protected staircases is inaccessible. If two staircase were provided, they would therefore each have to be minimum 1650mm width to cater for the occupant load.

(iv) Three-staircase scenario:
If three staircase were provided say main staircase/fire fighting staircase width of 1200mm (minimum 1100mm) and two secondary staircase of 900mm width each. The check would be as follows:

(a) Total exit width:

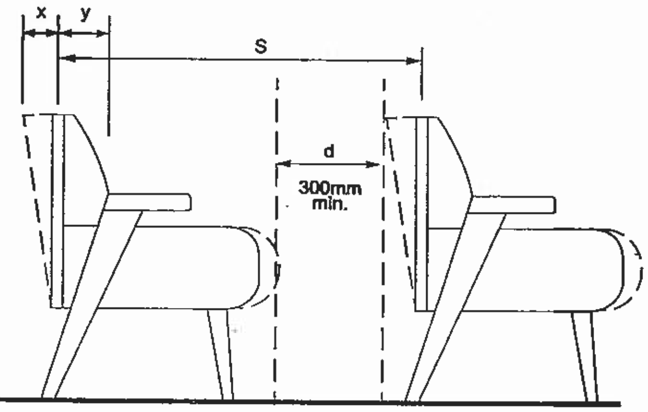
Main Staircase	-	1,200mm
Secondary Staircase 1	-	900mm
Secondary Staircase 2	-	900mm
Total Exit Width	-	3,000mm

(b) Assuming the widest staircase (main staircase) is inaccessible, remaining exit width is 3,000mm - 1,200mm = 1,800mm.

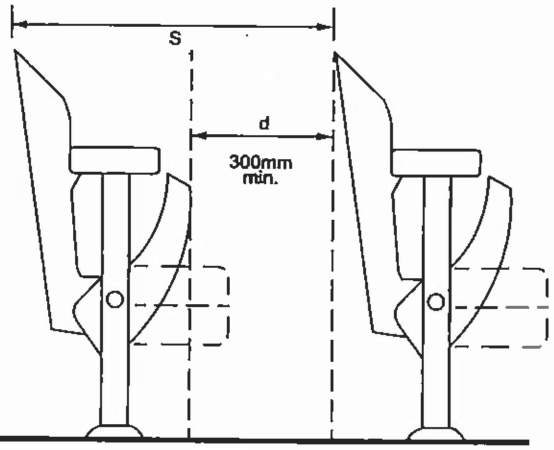
1,800mm > 1,650mm, therefore the provision satisfies the By-laws.

4.4.12 Seating In Places of Assembly

Diagram 4.4.12.1
Spacing between seats (By-law 184)



Non-Self Raising Seats



Back to back spacing, S > 825mm
x + y + 675mm > 825mm

Diagram 4.4.12.2
Maximum number of seating per row (By-law 184)

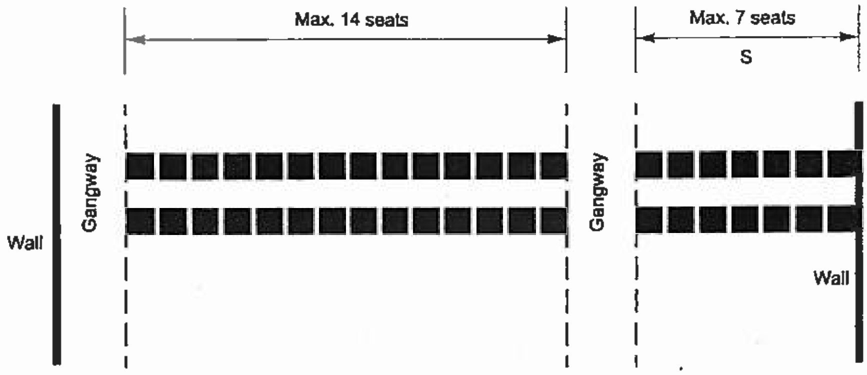


Diagram 4.4.12.3
Seats without dividing arms

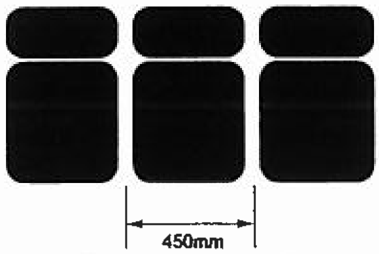


Diagram 4.4.12.4
Continental seating

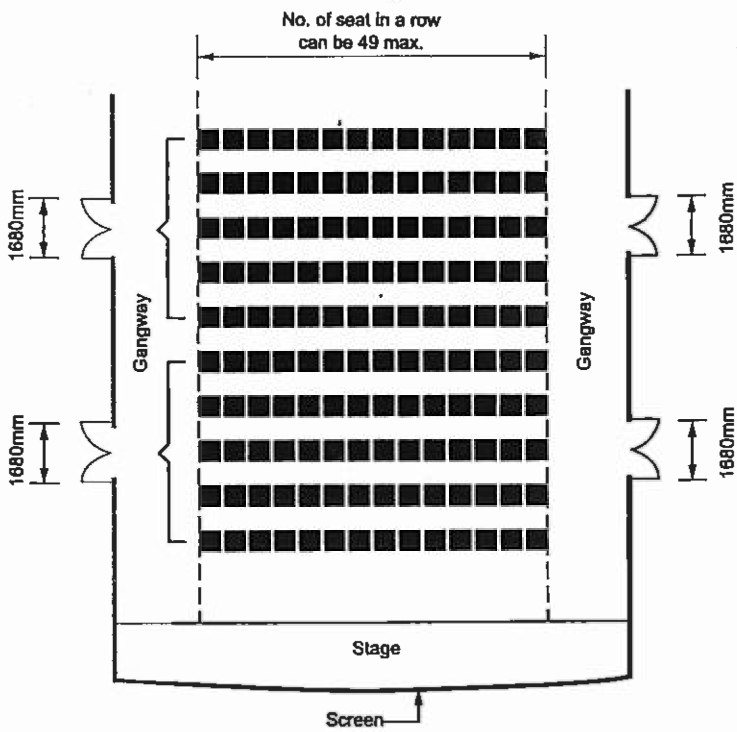


Diagram 4.4.12.5
Gangway all round

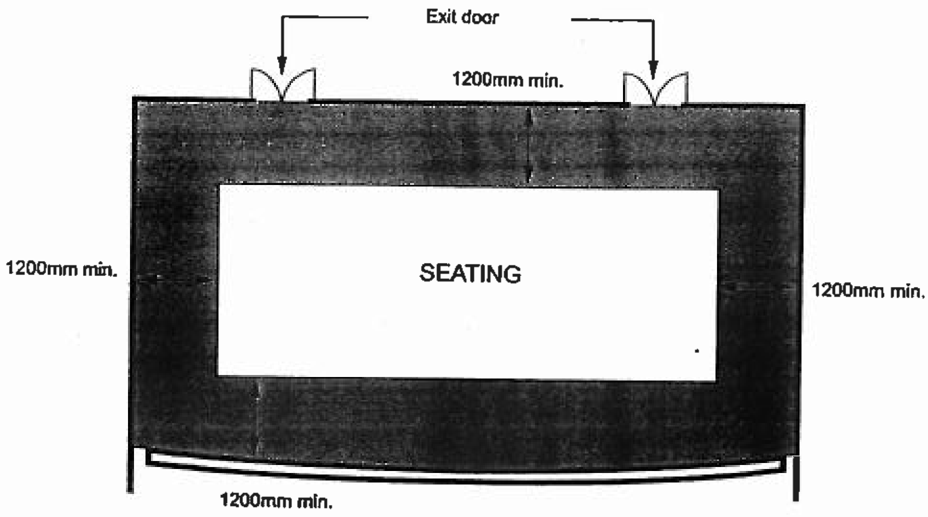


Diagram 4.4.12.6
Gangway on 3 sides

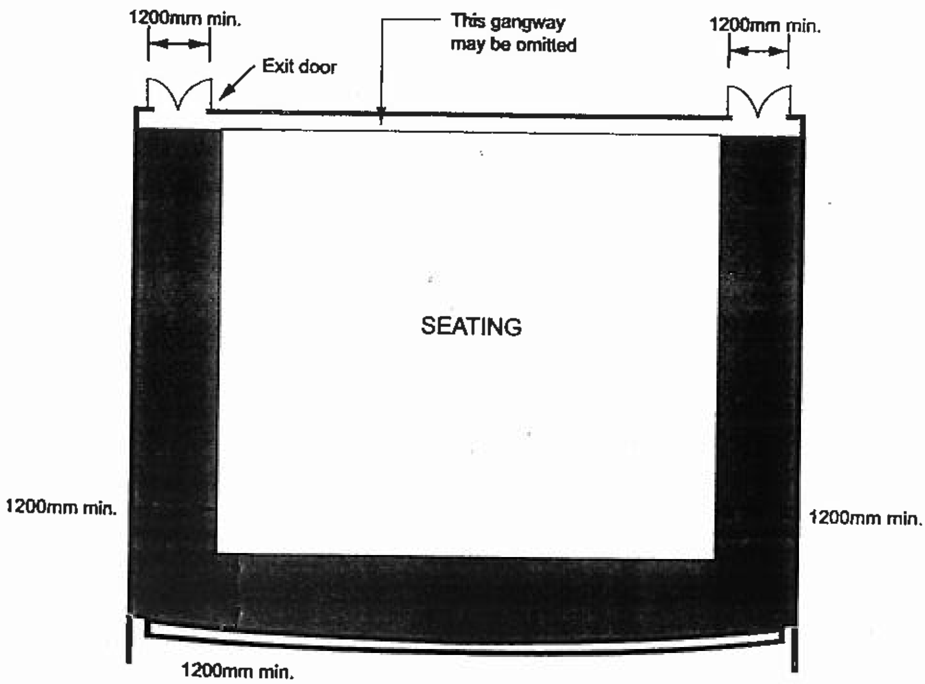


Diagram 4.4.12.7
Parallel gangway required by local authority

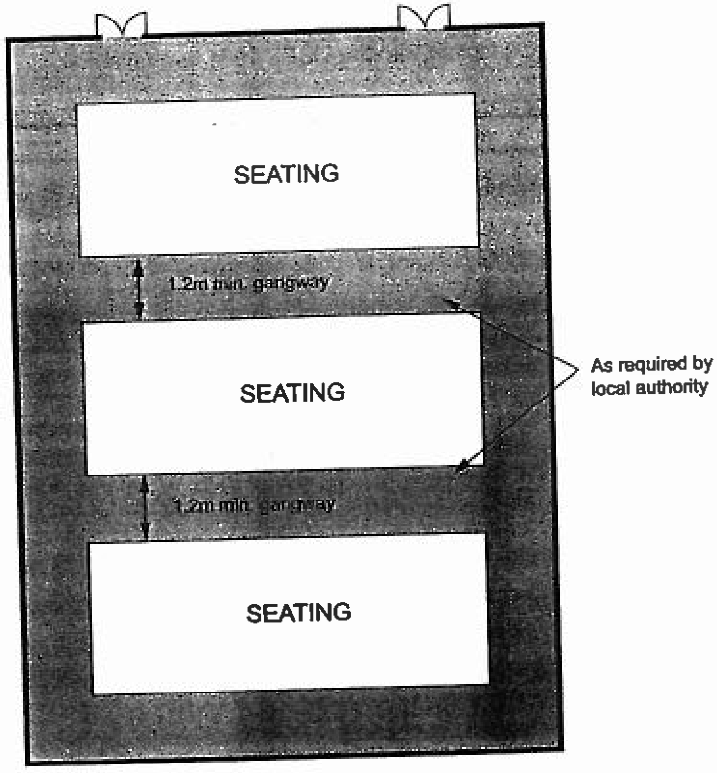
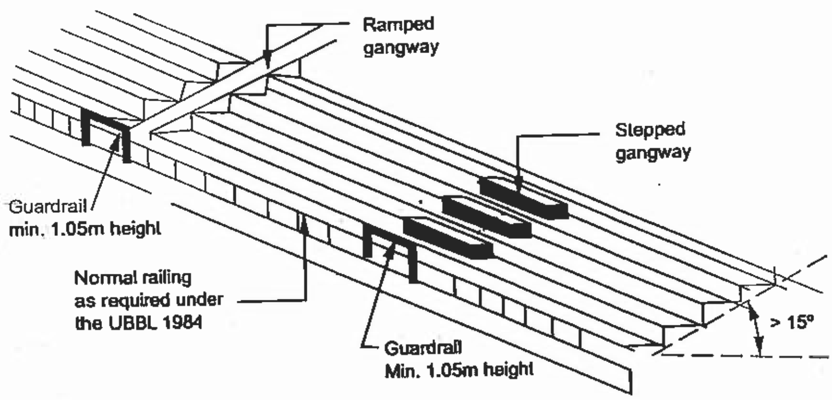


Diagram 4.4.12.8
Guardrails at foot of gangway



4.5 RULES OF MEASUREMENT

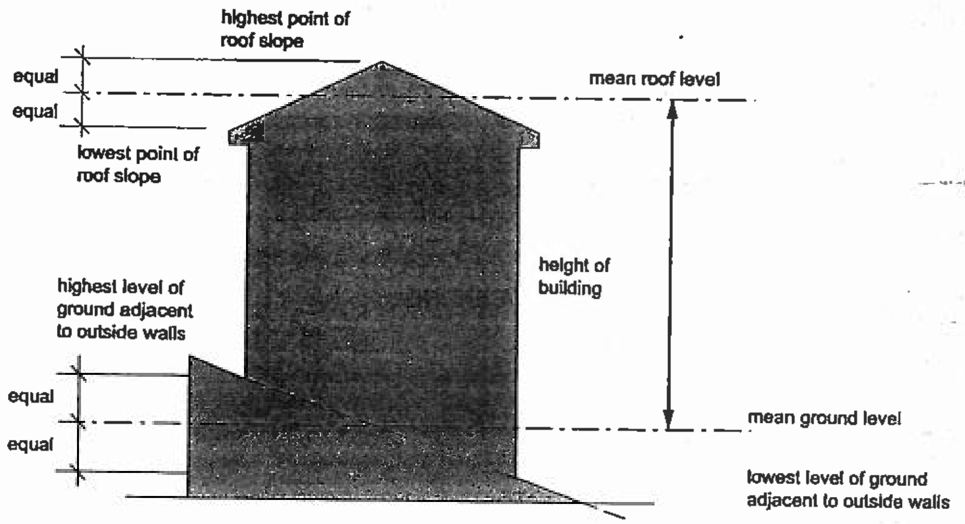
4.5.1 Description

By-law 135 in the UBBL 1984 sets the basis for measuring heights, areas and volumes of buildings/ compartments for use in conjunction with the UBBL 1984 throughout.

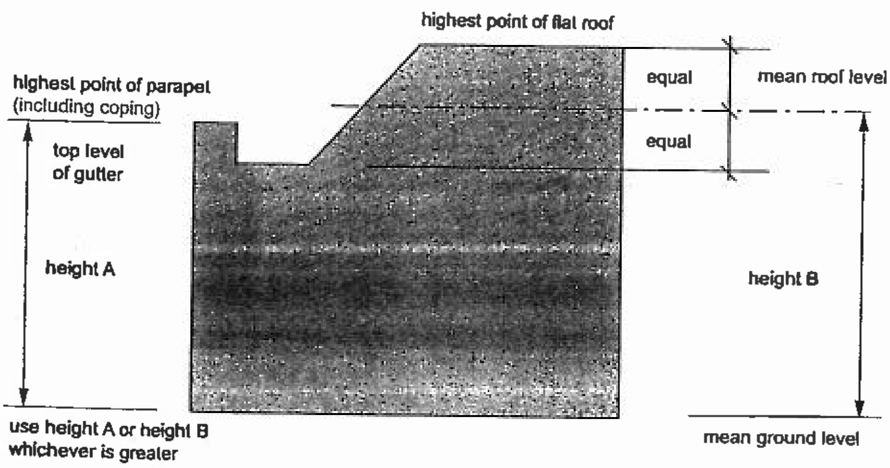
It has to be borne in mind that these measurement methods will differ from the basis for calculating the same dimensions for use with planning guidelines or other applications.

Illustrations A, B and C describes the rules of measurement for heights in various buildings.

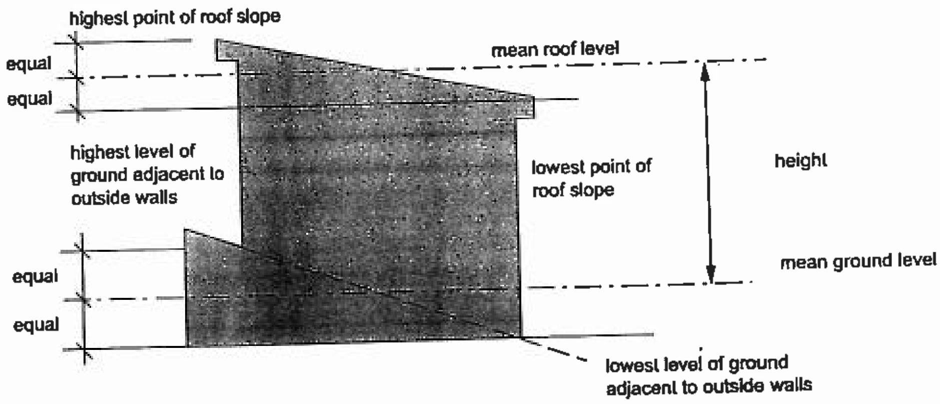
Diagram 4.5.1.1
Height of building



A. Double-pitched roof



B. Mansard type roof

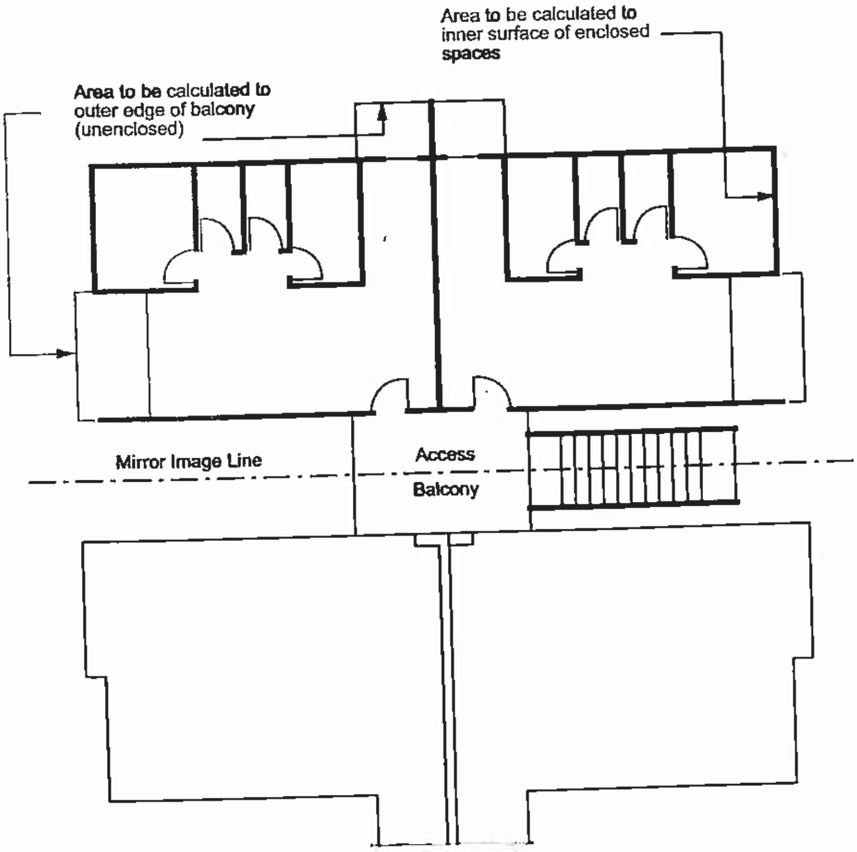


C. Flat or monopitch roof

Calculation of area of any storey or compartment to be taken to finished inner surfaces of enclosing walls or to outermost edge of the floor on the side that has no enclosing walls eg. balconies.

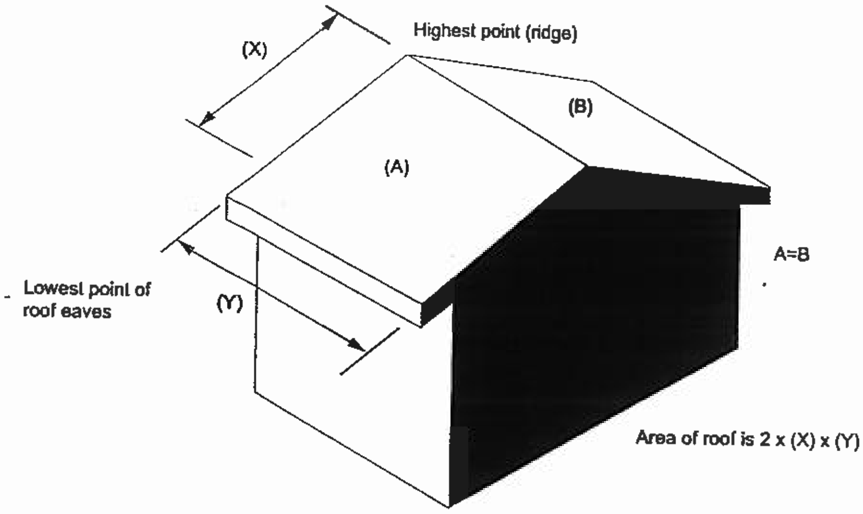
The area measured would include all internal walls and partitions enclosed by the inner surfaces up to external walls or edges (as in balconies).

Diagram 4.5.1.2
Area of building



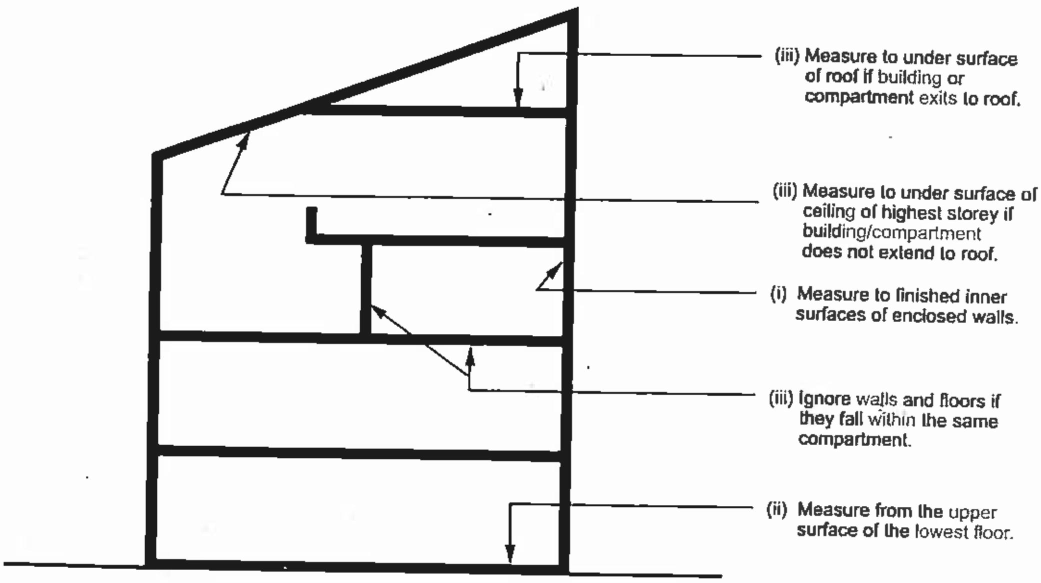
The area of any part of a roof shall be taken to be the actual visible area of such part measured on a plane parallel to pitch.

Diagram 4.5.1.3
Area of roof



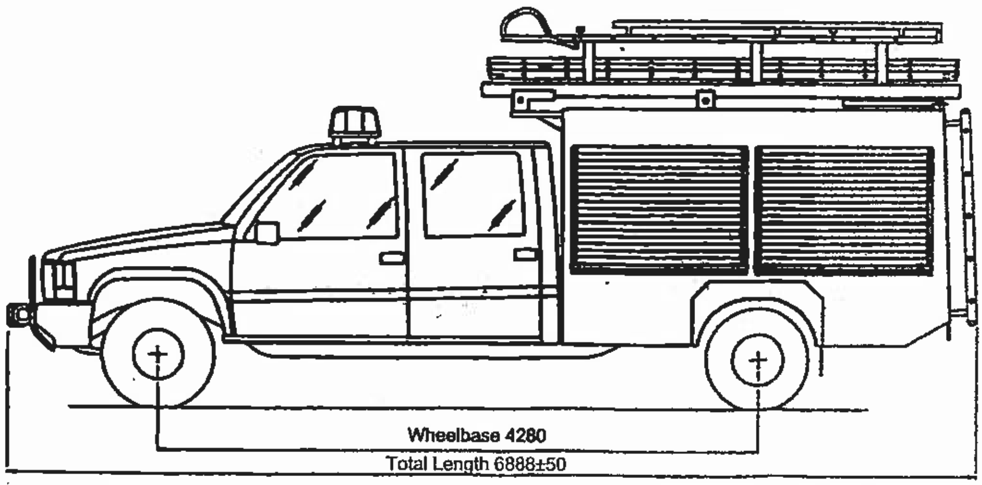
Calculations of cubic capacity of a building or compartment

Diagram 4.5.1.4
Volume of build compartment



APPENDIX 1

Specifications of Fire Appliances for the Purpose of Designing for Fire Access for Fire Rescue Vehicles

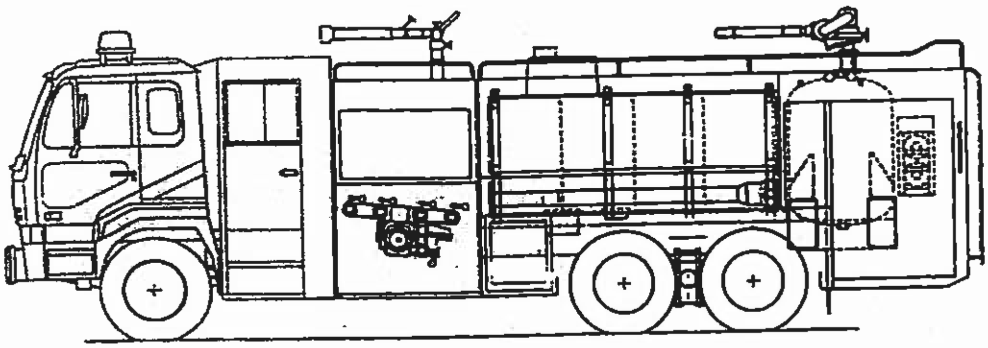


DIMENSIONS

OVERALL LENGTH	:	6,800mm
OVERALL WIDTH	:	2,100mm
OVERALL HEIGHT	:	2,400mm
WHEEL BASE	:	4,280mm
TRACK - FRONT	:	1,757mm
- REAR	:	1,853mm
TURNING CIRCLE	:	18,000mm
GROUND CLEARANCE	:	200mm
OVERHANG - FRONT	:	1,070mm
- REAR	:	1,450mm
ANGLE - APPROACH	:	35°
- DEPARTURE	:	30°

DESIGN RATINGS

FULLY LADEN	:	4,700kg
GROSS VEHICLE WEIGHT	:	5,000kg

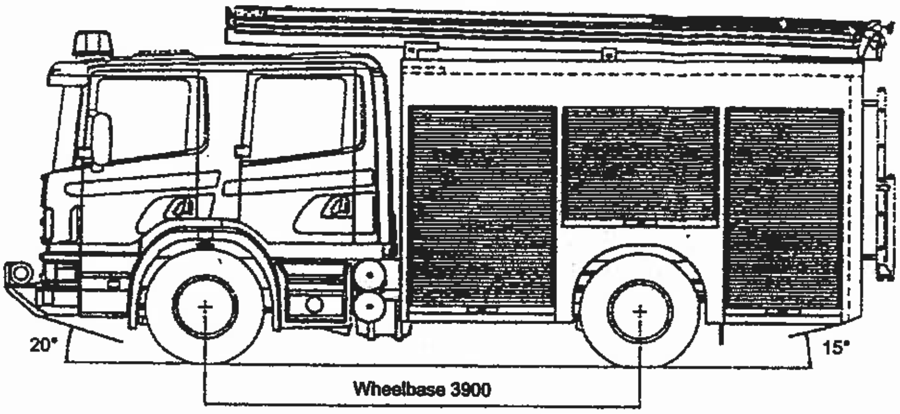


DIMENSIONS

OVERALL LENGTH	:	10,800mm
OVERALL WIDTH	:	2,500mm
OVERALL HEIGHT	:	3,300mm
WHEEL BASE	:	5,265mm
TRACK - FRONT	:	2,045mm
- REAR	:	1860mm
TURNING CIRCLE	:	
GROUND CLEARANCE	:	295mm
OVERHANG - FRONT	:	1,400mm
- REAR	:	2,750mm
ANGLE - APPROACH	:	25°
- DEPARTURE	:	12°

DESIGN RATINGS

FULLY LADEN	:	21,000kg
GROSS VEHICLE WEIGHT	:	26,000kg



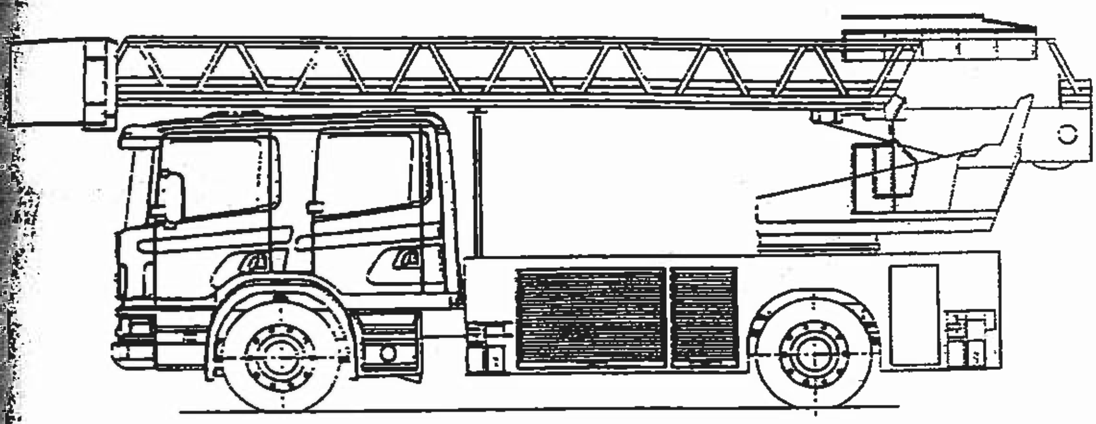
DIMENSIONS

OVERALL LENGTH	:	7,800mm
OVERALL WIDTH	:	2,500mm
OVERALL HEIGHT	:	3,400mm
WHEEL BASE	:	3,900mm
TRACK - FRONT	:	2,100mm
- REAR	:	1,752mm
TURNING CIRCLE	:	14,000mm
GROUND CLEARANCE	:	250mm
OVERHANG - FRONT	:	1,000mm
- REAR	:	1,450mm
ANGLE - APPROACH	:	20°
- DEPARTURE	:	15°

DESIGN RATINGS

FULLY LADEN	:	13,000kg
GROSS VEHICLE WEIGHT	:	18,000kg

TURNABLE LADDER (MAGIRUS)



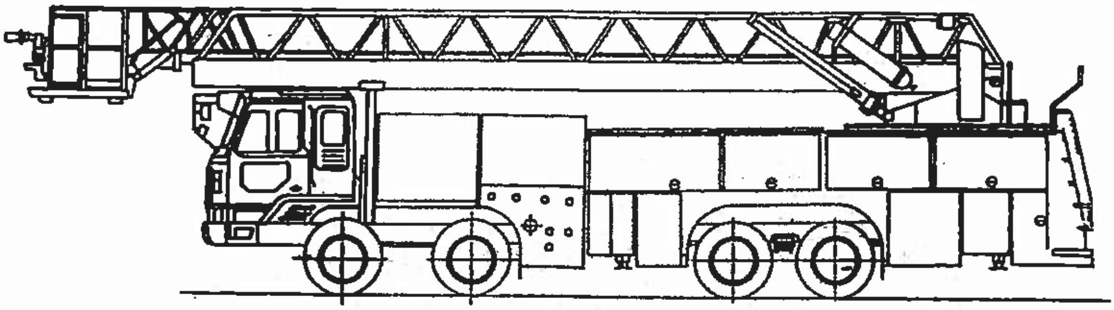
DIMENSIONS

OVERALL LENGTH	:	10,000mm
OVERALL WIDTH	:	2,500mm
OVERALL HEIGHT	:	3,600mm
WHEEL BASE	:	4,900mm
TRACK - FRONT	:	2,100mm
- REAR	:	1,752mm
TURNING CIRCLE	:	17,200mm
GROUND CLEARANCE	:	250mm
OVERHANG - FRONT	:	2,600mm
- REAR	:	2,600mm
ANGLE - APPROACH	:	14°
- DEPARTURE	:	10°

DESIGN RATINGS

FULLY LADEN	:	17,000kg
GROSS VEHICLE WEIGHT	:	18,200kg

TURNABLE LADDER (SIMON)

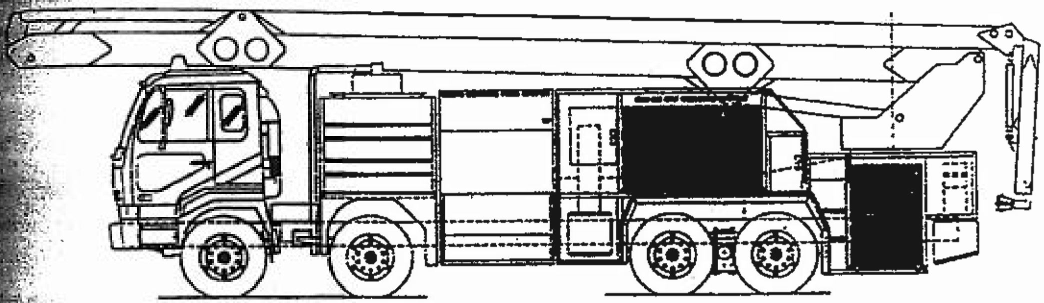


DIMENSIONS

OVERALL LENGTH	:	14,000mm
OVERALL WIDTH	:	2,500mm
OVERALL HEIGHT	:	3,900mm
WHEEL BASE	:	5,900mm
TRACK - FRONT	:	2,045mm
- REAR	:	1,860mm
TURNING CIRCLE	:	
GROUND CLEARANCE	:	265mm
OVERHANG - FRONT	:	4,000mm
- REAR	:	4,000mm
ANGLE - APPROACH	:	20°
- DEPARTURE	:	10°

DESIGN RATINGS

FULLY LADEN	:	28,000kg
GROSS VEHICLE WEIGHT	:	31,000kg



DIMENSIONS

OVERALL LENGTH	:	13,060mm
OVERALL WIDTH	:	2,500mm
OVERALL HEIGHT	:	3,600mm
WHEEL BASE	:	5,900mm
TRACK - FRONT	:	2,045mm
- REAR	:	1,860mm
TURNING CIRCLE	:	
GROUND CLEARANCE	:	260mm
OVERHANG - FRONT	:	4,000mm
- REAR	:	4,000mm
ANGLE - APPROACH	:	20°
- DEPARTURE	:	10°

DESIGN RATINGS

FULLY LADEN	:	28,000kg
GROSS VEHICLE WEIGHT	:	31,000kg

ACTIVE FIRE PROTECTION SYSTEM

5.1 DESCRIPTION

Portable Fire Extinguishers are elementary fire fighting equipment intended for first-aid fire fighting during the initial outbreak of fire incident to prevent escalation into a full scale fire. Proper usage of portable fire extinguishers often effectively control and extinguisher a fire even before fire authorities is summoned. However they are not suppose to be used against a large scale fire.

Portable fire extinguishers should be suitably selected for the type of fire in accordance to the classification and the fire size and sited in suitable locations in close proximity to the potential fire hazards

Portable fire extinguishers should have minimum gross weight but with higher fire rating in order to be user friendly and shall be able to be carried and operated by one person.

Portable fire extinguishers should be maintained and serviced annually for their effectiveness.

5.2 DESIGN REQUIREMENTS

5.2.1 Codes and Standards

(a) Under the Uniform Building By-laws 1984, portable fire extinguisher requirement is described under By-law 227.

(b) Portable fire extinguishers shall be designed, tested, select, install and maintain in accordance to:

- M.S.1539 – Specification for portable fire extinguishers :
  Part 1 : Construction and test methodology
- M.S.1539 – Specification for portable fire extinguishers :
  Part 3 : Selection and Application – Code of Practice
- M.S.1539 – Specification for portable fire extinguishers :
  Part 4 : Maintenance of portable fire extinguishers – Code of practice

(c) Portable fire extinguishers shall be manufactured with the following requirements :

- SIRIM quality certification scheme

5.2.2 Classes of Fire

Portable fire extinguishers should be provided for dealing with the following potential classes of fire identified in the risk assessment : (see Figure 5.2.2.1)

- Class A : Fires involving solid materials of organic nature with the formation of glowing ambers, eg. paper, wood, etc
- Class B : Fires involving liquids or liquefiable solids, eg. petrol, kerosene, diesel, etc
- Class C : Fires involving gases, eg. oxygen, LNG, LPG, etc
- Class D : Fires involving metals, eg. sodium, potassium, magnesium, etc
- Class E : Fires involving electrical equipment
- Class F : Fires involving fats and cooking oils

5.2.3 Selection and Application

The typical medium for portable fire extinguishers are as follows:

- Water - Suitable for Class A fires
- Foam - Suitable for Class A and Class B fires
- Dry Chemical Powder - Suitable for Class A, B, C and E fires
- Carbon Dioxide - Suitable for Class B and E fires

5.2.4 Color Coding

Colour of extinguisher cylinder/body shall be signal red to RAL 3000. All wordings, diagram, pictogram shall be white in colour and all extinguishing medium shall be colour coded as follows: (see Figure 5.2.4.1)

Water - Red
Foam - Cream
Dry Chemical Powder - Blue
Carbon Dioxide - Black
Halon - Golden Yellow

Note : Halon portable fire extinguishers are only allowed for military, aviation or special applications only where permitted by Department of Environment Malaysia.

5.2.5 Label Marking

All portable fire extinguishers shall be marked as per labels attached. All label markings shall be fully visible from the front (see Figure 5.2.5.1 and 5.2.5.2)

5.2.6 Installation

- Generally, portable fire extinguishers should be located in conspicuous position where they can be easily spotted by person following an escape route.

- Siting position near to room exits, corridors, stairways, lobbies and landings are most suitable. They should not be sited where a potential fire might prevent access to them.

- Extinguishers should be located preferably within recessed closets if they be sited along protected corridors to avoid obstruction during evacuation.

- They should be sited not more than 20 metres from a potential fire hazard

5.2.7 Performance Design

Fire classes, fire hazard location, extinguisher distribution, extinguisher performance as well as application should be the criteria for determining the size and quantities of portable fire extinguishers.

For dry chemical powder extinguisher, vast improvement in chemical content has increased the performance of the extinguisher. Weight is hence no longer the criteria for selection but fire rating determines the performances eg. minimum fire performance rating of a 9kg extinguisher of 30% chemical powder is 27A and 144B. A 6kg extinguisher of 50% chemical powder can achieve a fire rating of 27A and 183B.

Gross weight of portable fire extinguishers should be kept to a minimum (recommended to be below 12kg) to ensure portability. Current weight rating of portable fire extinguishers is net weight of fire extinguishing medium excluding the weight of the cylinder, valve body, metre and hose; e.g. gross weight of 5kg CO_2 extinguisher is 21kg.

It is recommend to design for 2 smaller extinguishers to achieve the same rating instead of 1 extinguisher to increase the effectiveness of fire extinguishment.

Example 1

For a single storey building of floor area 1,600m², the minimum aggregated class A rating is

$$0.065 \times 1{,}600 = 104A$$

The total fire rating can be provided by:

8 x 13A PFE	=	104A	8 x 4 kg PFE of 13A
4 x 27A PFE	=	108A	4 x 6 kg PFE of 27A

* PFE – Portable fire extinguisher

Note – Portable fire extinguishers of smaller capacity but higher fire rating is preferred for portability and effectiveness

5.3 VISUAL INSPECTION CHECKLIST

5.3.1 Portable fire extinguisher

- ❑ Cylinder body should be red with medium colour coded in respective colour
- ❑ All label marking wordings, diagrams and pictograms shall be in white colour and shall be fully visible from the front
- ❑ Label should carry SIRIM product certification logo
- ❑ Extinguishers shall have valid Fire and Rescue Department Approval Letter
- ❑ Each Extinguisher shall have a valid Fire and Rescue Department H13 certificate
- ❑ Extinguisher meter indication should indicate adequate pressure (Green Zone) within the cylinder
- ❑ Cylinder body and valve should be rust free
- ❑ Safety pin should be in place and secured
- ❑ Discharge Hose should have no cracks

Figure 5.2.2.1

Classes and Nature of Fire in Relation to Fire Rating and Test Fire Sizes

Class of Fire	Nature of Fire	Fire Rating	Test Fire Size
A	Fire involving solids, organic in nature, combustion normally leads to formation of glowing embers, carbonaceous fires	5A 8A 13A 21A 27A	0.25 m² 0.40 m² 0.65 m² 1.05 m² 1.35 m²
B	Fires involving liquids or liquefiable solids	13B 21B 34B 55B 70B 89B 144B 183B	0.41 m² 0.66 m² 1.07 m² 1.73 m² 2.20 m² 2.80 m² 3.55 m² 5.75 m²
C	Fire involving gases Note : 1. Must turn off the gas valve or plug the leak before putting out the fire 2. Preferably to be handled by trained fire fighters 3. May require : protective clothing and/or SCBA (Self Contained Breathing Apparatus)	N.A	N.A
D	Fire involving metals Note : 1. To refer to material safety data sheet of types of metals used 2. Preferably to be handled by trained fire fighters 3. Special application and technique required 4. May require : protective clothing and/or SCBA (Self Contained Breathing Apparatus)	N.A	N.A
E	Fire involving electrical equipments Note : 1. Extinguisher must pass dielectric test of 35 kva to carry Class E marking 2. Shall not be used on live electrical equipment	N.A	N.A
F	Fire involving fats and cooking oils	5F 15F 25F 75F	0.015 m² 0.02 m² 0.04 m² 0.11 m²

Figure 5.2.4.1

Colour coding of medium to MS 1539 : Part 1 : 2002

Extinguishing Medium	Cylinder Body Colour		Medium Indentification Colour		Any Other Markings Colour	
	Body Colour	Ref. Code	Extinguishing Medium	BS 381C Ref. Colour Code	Wordings & Diagrams	BS 381C Ref. Colour Code
WATER	SIGNAL RED	RAL 3000	Red	537	White	-
FOAM			Cream	352		
DRY POWDER (all types)			Blue	166		
CO_2			Black	-		
HALON			Golden Yellow	356		

NOTE: For RAL colour, see: Farbregister RAL 841-GL, RAL Deutsches Institut für Gütesicherung und Kennzeichnung, Siegburger Strasse 39, D-53757 Sankt Augustin, Germany

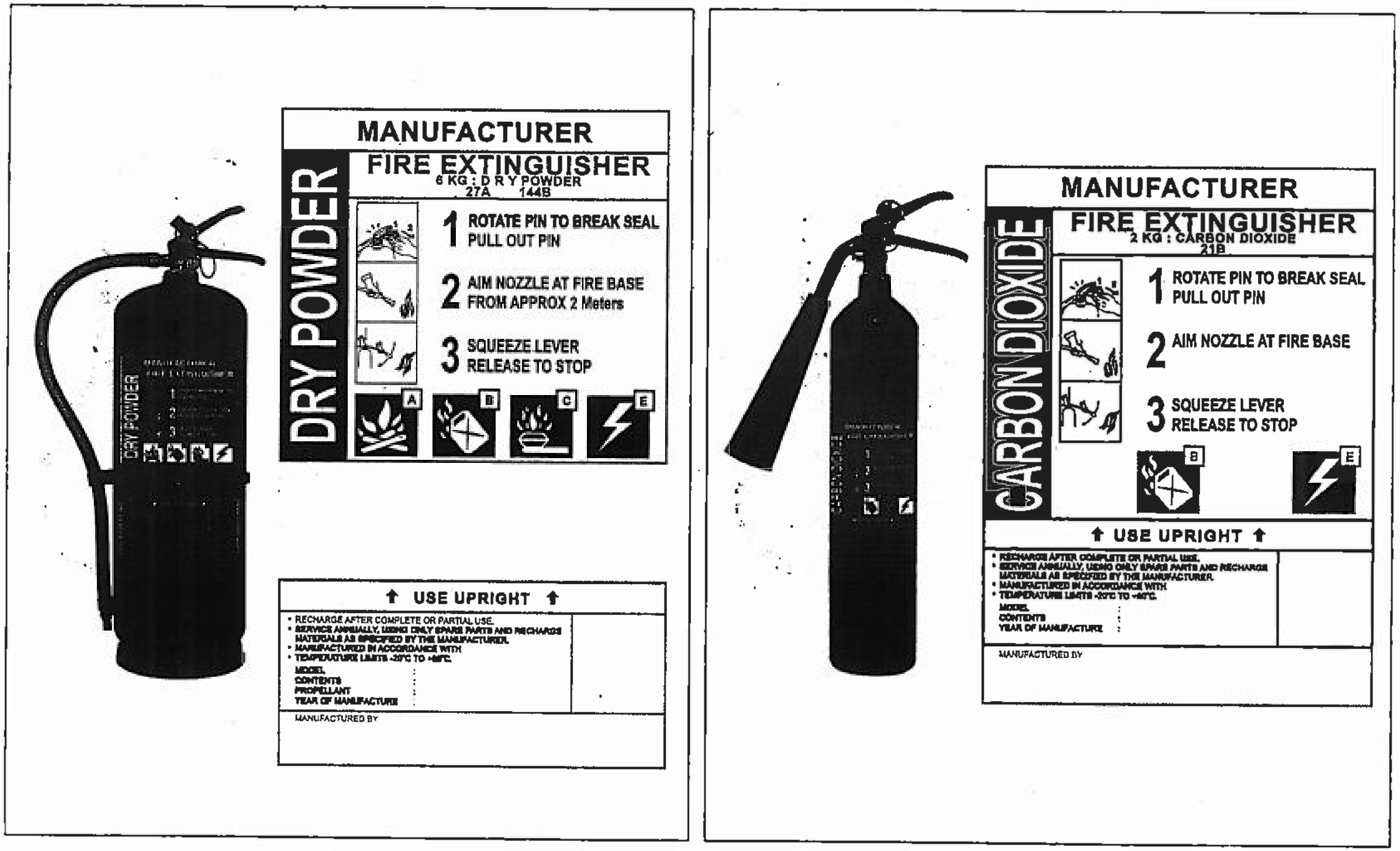
Figure 52

MANUFACTURER
FIRE EXTINGUISHER
9 LITER : WATER
13A
WATER
1 ROTATE PIN TO BREAK SEAL
PULL OUT PIN
2 AIM NOZZLE AT FIRE BASE
FROM APPROX 2 Meters
3 SQUEEZE LEVER
RELEASE TO STOP
A
USE UPRIGHT
• RECHARGE AFTER COMPLETE OR PARTIAL USE.
• SERVICE ANNUALLY, USING ONLY SPARE PARTS AND RECHARGE MATERIALS AS SPECIFIED BY THE MANUFACTURER.
• MANUFACTURED IN ACCORDANCE WITH
• TEMPERATURE LIMITS +5°C TO +60°C.
• PROTECT FROM FROST.
MODEL :
CONTENTS :
PROPELLANT :
YEAR OF MANUFACTURE :
MANUFACTURED BY

MANUFACTURER
FIRE EXTINGUISHER
9 LITER : AFFF FOAM
13A 183B
FOAM
1 ROTATE PIN TO BREAK SEAL
PULL OUT PIN
2 AIM NOZZLE AT FIRE BASE
FROM APPROX 2 Meters
3 SQUEEZE LEVER
RELEASE TO STOP
A
B
USE UPRIGHT
• RECHARGE AFTER COMPLETE OR PARTIAL USE.
• SERVICE ANNUALLY, USING ONLY SPARE PARTS AND RECHARGE MATERIALS AS SPECIFIED BY THE MANUFACTURER.
• MANUFACTURED IN ACCORDANCE WITH
• TEMPERATURE LIMITS +5OC TO +60OC.
• PROTECT FROM FROST.
MODEL
CONTENTS
PROPELLANT
YEAR OF MANUFACTURE
MANUFACTURED BY

Figure 5.2.5.2 Label Marking

Figure 5.2.5.2 Label Marking



6.1 DESCRIPTION

Fire hydrant installation consists of a system of pipework connected directly to the water supply mains to provide water to each and every hydrant outlet and is intended to provide water for the firemen to fight a fire. The water is discharged into the fire engine from which it is then pumped and sprayed over the fire. Where the water supply is not reliable or inadequate, hydrant pumps should be provided to pressurise the fire mains.

A typical hydrant installation feed directly from the public water mains is shown in Figure 6.1 and Figure 6.2 shows a typical installation pressurised by fire pumps.

6.2 DESIGN REQUIREMENTS

6.2.1 Design Standards

The requirement for fire hydrants is described under By-laws 225(2) and 225(3) of the Uniform Building By-laws 1984, and the relevant standards are as follows:

- M.S.1489 Part 1 : Hydrant Systems, Hose Reels and Foam Inlets;
- M.S.1395 : Specification for pillar hydrant.

6m MIN. breeching inlet
30m MAX.

6.2.2 Hydrant Outlets

Pillar hydrants should comply with M.S.1395 and located at not more than 30 metres away from the breeching inlet for the building. The hydrant should be not less than 6 metres from the building if it is a high rise building so as to allow firemen to operate the hydrant safely, away from the burning building or falling debris. Generally, hydrants are spaced at not more than 90 metres apart along access roads of minimum 6 metres in width and capable of withstanding a load of 26 tons from fire brigade vehicles.

Hydrant outlets are typically of the twin outlet pillar type with an underground sluice valve. Where these are installed within the owner's boundary, each should be provided with 30 metres of 65mm dia. canvas hose, instantaneous couplings and nozzles, all housed within a steel cabinet beside the hydrant. Hydrants located along public roads need not be provided with hose stations. Underground hydrants are not encouraged due to the difficulty of access.

For pressurised installations, hydrants with twin outlets should be capable of providing 1000 l/min of water at a minimum running pressure of 4 bars but not exceeding 7 bars for instantaneous coupling. Where threaded type of hydrant outlets are permitted by the Fire Authority, the outlet pressure may exceed 7 bars. The 1,000 l/min is based on each 65mm diameter outlet of a double outlet pillar hydrant discharging 500 l/min from each outlet simultaneously. Pressure regulating type of outlet valves should be used where the pressure from the fire mains exceed 7 bars. Where the hydrant outlet is located within the owner's premise, hydrant hose usually of canvas should be provided complete with nozzles at each outlet.

The hydrant mains are usually laid underground although they can also be installed above ground except where it crosses a road. The piping is usually of cement lined steel pipe. However, piping of Acrylonitrile Butadiene Styrene (ABS) material may also been used especially where corrosion is a major concern.

6.2.3 Hydrant Pumps

The hydrant pumps draw water from the fire water storage tank and two sets of pumps, one on duty and the other on standby, are provided. The pump capacity is usually sized to deliver a flow rate of 3000 l/min at a running pressure of not less than 4 bars for any three hydrant outlets operating at the same time. This flowrate will have to be increased if the number of outlets to be operating at the same time is more than three.

The standby hydrant pumpset should be supplied with power from the emergency generator if this is available. Otherwise, the standby pumpset should be diesel engine driven. Where diesel driven pumpsets are used, the diesel engine shall be capable of operating continuously for 2 hours at full load. The diesel engine should be provided with an integral constant speed governor to control the engine speed at the rated pump speed under any load condition up to the full load rating of the engine. The starter motor and battery capacity shall be capable of providing 6 cycles each of not less than 15 seconds cranking with not more than 10 second of rest in between. At the 7th cycle, the starter motor and battery should be able to start the diesel engine. Batteries for the diesel engine should be of the maintenance free type. Fuel supply should be adequate for minimum 2 hours of full load operation.

Electrical cabling to supply power to the hydrant pumps should be of fire rated type of cable.

In addition to the duty and standby pumpsets, a jockey pump is normally provided to maintain system pressure and avoid having to start up the duty pumps to maintain system pressure. Jockey pumps are usually electric motor driven with a capacity of around 120 litres/min.

The hydrant pumpsets should be protected from the weather and away from locations likely to be flooded. Pump rooms should be ventilated by natural or mechanical means and provided with the necessary signage.

6.2.4 Hydrant Tanks

The fire water storage tank should be sized for a minimum effective capacity of 135,000 litres and should be refilled automatically from a water supply pipe capable of providing a minimum flowrate of 1,200 l/min. For hydrant pumps larger than 3000 l/min, the make up water flowrate should be such that together with the water stored, the hydrant pump will be able to operate for 1 hour. A 4-way breeching inlet should also be provided to enable the fire brigade to help refill the tank.

The effective capacity of the storage tank is the volume of water between the normal water level and the low water level. The low water level shall be taken as 600mm above the highest point of the pump suction pipe inlet opening. Where an approved vortex inhibitor is used, the low water level shall be taken as the top of the vertex inhibitor's upper flange.

Hydrant tanks are usually separate from other water storage tanks but may be combined with water storage tanks for other fire fighting systems. In such cases, the tank capacity should be the sum total of the water storage for both hydrant as well as the other fire fighting system.

The tank may be of pressed steel, fibreglass reinforced polyester (FRP) or concrete. Pressed steel tanks if used should be hot dipped galvanized and coated internally with bituminous paint for corrosion protection. The tank should be compartmented unless they are of reinforced concrete and water level indicator should be provided to show the amount of water available. The external surface of the tank should be painted red or where this is not desirable, a red band of minimum 200mm should be painted to indicate that this is a fire tank.

6.2.5 Pump Starter Panels and Controls

Pump starter panel should be complete with indicator lights as shown in the Figure 6.3. Ventilation slots should be provided with insect screen to prevent entry of vermin.

Hydrant pumps shall start automatically upon actuation of the pressure switches but should only be stopped manually. Usually three pressure switches are provided with the following suggested pressure settings:

- starting the duty pumpset set at 80% of the system pressure;
- starting the standby pumpset set at 60% of the system pressure; and
- starting and stopping the jockey pumpset set at 90% and 110% of the system pressure respectively.

The pressure switches are normally installed in the test and drain line on the pump discharge side. The pressure settings should be clearly labeled on tags attached to each pressure switch.

6.3 TEST REQUIREMENTS

6.3.1 Static Pressure Test

The system should first be flushed to clear all debris from the inside of the riser. The Hydrant pipes are hydranlically tested to a pressure of 14 bars or 150% working pressure, whichever is the higher for 2 hours, measured at the furthest hydrant and a check is carried out for leakage at the joints and landing valve connections.

6.4 MAINTENANCE REQUIREMENTS

6.4.1 Inspection And Testing

A flow test should be carried out to ensure that the pumps are in proper working condition. The pipework should be checked for leakage and the hydrants, valves, hoses, drain valve and cabinets should be inspected as recommended in the checklist attached.

6.5 DESIGN CHECKLIST

(a) At least one hydrant is provided at location not more than 91.5m from the nearest point of fire brigade access.

(b) A minimum flow rate of 500 litres/minute at running pressure of 4 to 7 bars is maintained at each of the hydrant outlet when three numbers of the furthest hydrant are in used.

(c) Water source :
- ❑ Pump suction tank.
- ❑ Public water main.
- ❑ Others : ______________.

(d) Water tank capacity :______________ m^3.

(e) Water supply duration : __________ hours.

(f) Hydrant type : ______________ ; size : ______________ ;

(g) Total number of hydrant : ______ nos.

(h) Hydrant spacing : ______________ m.

(j) Hydrant main nominal size : ________mm.

(k) Number of fire hose provided : _____nos.

(l) Hose size : ________ mm ; length : ________ m.

(m) Pipe material : ______________________.

(n) Level of underground pipe:
- ❑ Under drive way (at least 0.9m depth) :__________m depth.
- ❑ Other location (at least 0.8m depth) :___________m depth.

(o) To provide fire brigade breeching inlet.

(p) To provide sectional isolation valves at hydrant ring main.

(q) Hydraulic calculation.

(r) Hydrant pump:
- ❑ Rated flow rate : _________ litres/min at __________ m head.
- ❑ Rated power : _________kW.
- ❑ Pipe nominal size : Suction : _________mm ; Delivery : ______mm.

6.6 VISUAL INSPECTION CHECKLIST

6.6.1 Visual Inspection of Water Supplies
Incoming water supply connection.

Capacity of water available.

Compartmentation of water tanks, where applicable.

Priming tank (if any).

Monitoring of water tank level.

Vortex inhibitors for water tanks, where applicable.

Breeching inlet.

6.6.2 Visual Inspection of Hydrant and Accessories
Spacing of hydrants.

Physical condition of hydrants, hoses and accessories.

6.6.3 Visual Inspection of Pipework

Type of pipes used.

Protection of underground pipework.

Painting of pipework.

Supports for pipework.

6.6.4 Visual Inspection of Pumps

Protection of rotating parts.

Mounting of pumps.

6.7 TESTING AND COMMISSIONING CHECKLIST

6.7.1 Testing and Commissioning of Water Supplies

Pump operating current and voltage.

Pump operating pressure and flow rate.

Pump operating RPM.

Pump not overheating.

Vibration and noise level.

Testing of electrical wiring system.

Alternative power supply for electric pumps.

Batteries for diesel pumps.

Fuel for diesel pumps.

Automatic operation of pumps.

6.7.2 Testing and Commissioning of Pipework

Hydrostatic testing of pipework.

Flushing of pipework.

6.7.3 Testing and Commissioning of Hydrant Outlet

Pressure and flow characteristics.

Figure 6.1 Hydrant System Typical Arrangement Drawing
SCALE: N.T.S

COMPONENT / EQUIPMENT
1 Sluice Valve
2 Strainer
3 Water Metre
4 Non Return Valve
5 Hydrant cabinet c/w Hoses, Nozzles & Accessories
6 Pillar Hydrant
7 Sluice Valve in Concrete Chamber

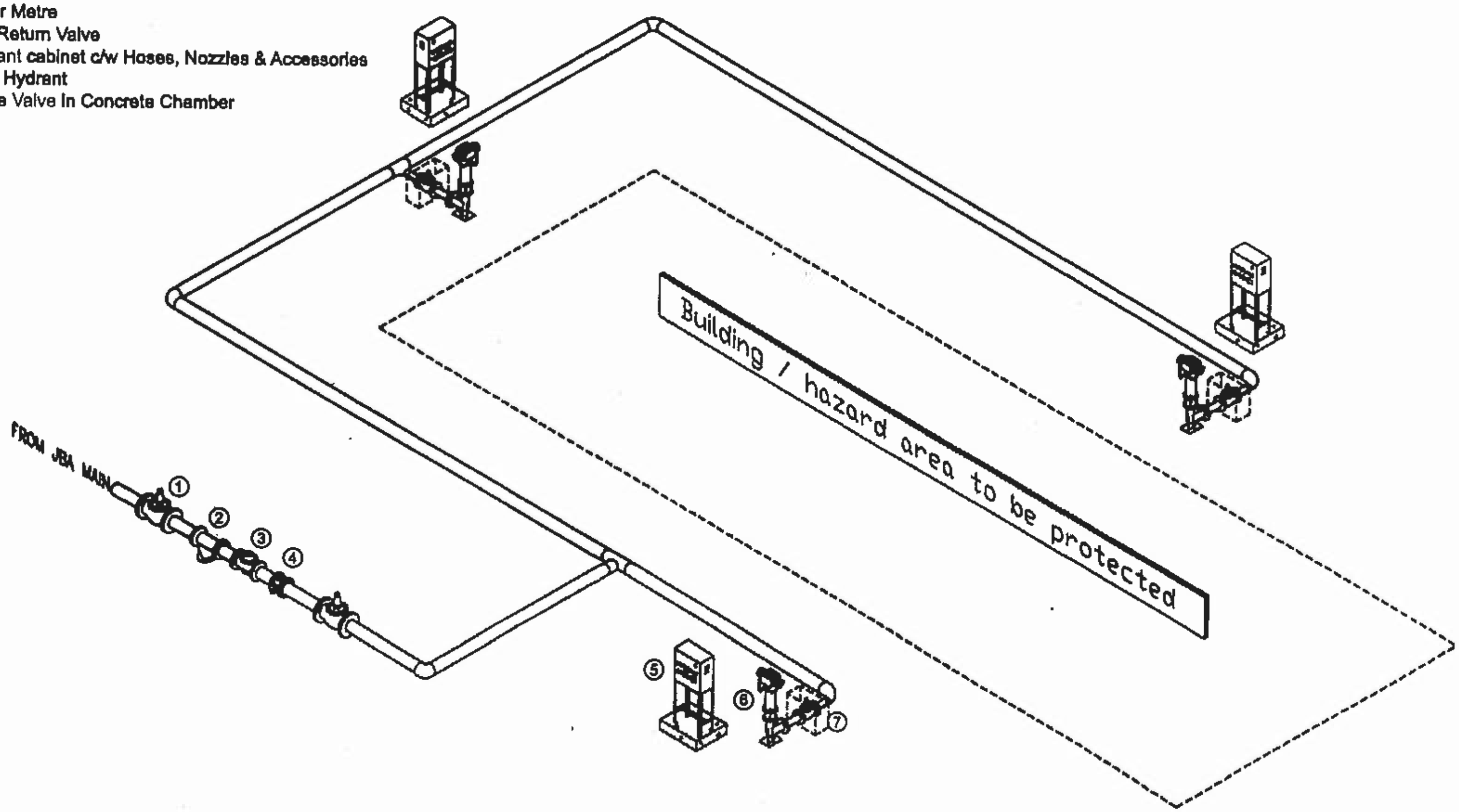


Figure 6.2 Pressurised Hydrant System Typical Arrangement Drawing
SCALE: N.T.S

1 Water Tank
2 4-Way Breeching Inlet
3 Vent Pipe c/w Mosquito Net
4 Access Manhole
5 Level Indicator
6 External Cat Ladder
7 Overflow Pipe
8 Warning Pipe
9 Expansion Joint
10 Y-Strainer
11 Gate Valve
12 Check Valve
13 Concentric Reducer
14 Eccentric Reducer
15 Duty Pump
16 Jockey Pump
17 Standby Pump
18 Pump Start Test Pipe
19 Pump Starter Panel
20 Hydrant cabinet c/w Hoses, Nozzles & Accessories
21 Pillar Hydrant
22 Sluice Valve in Concrete Chamber

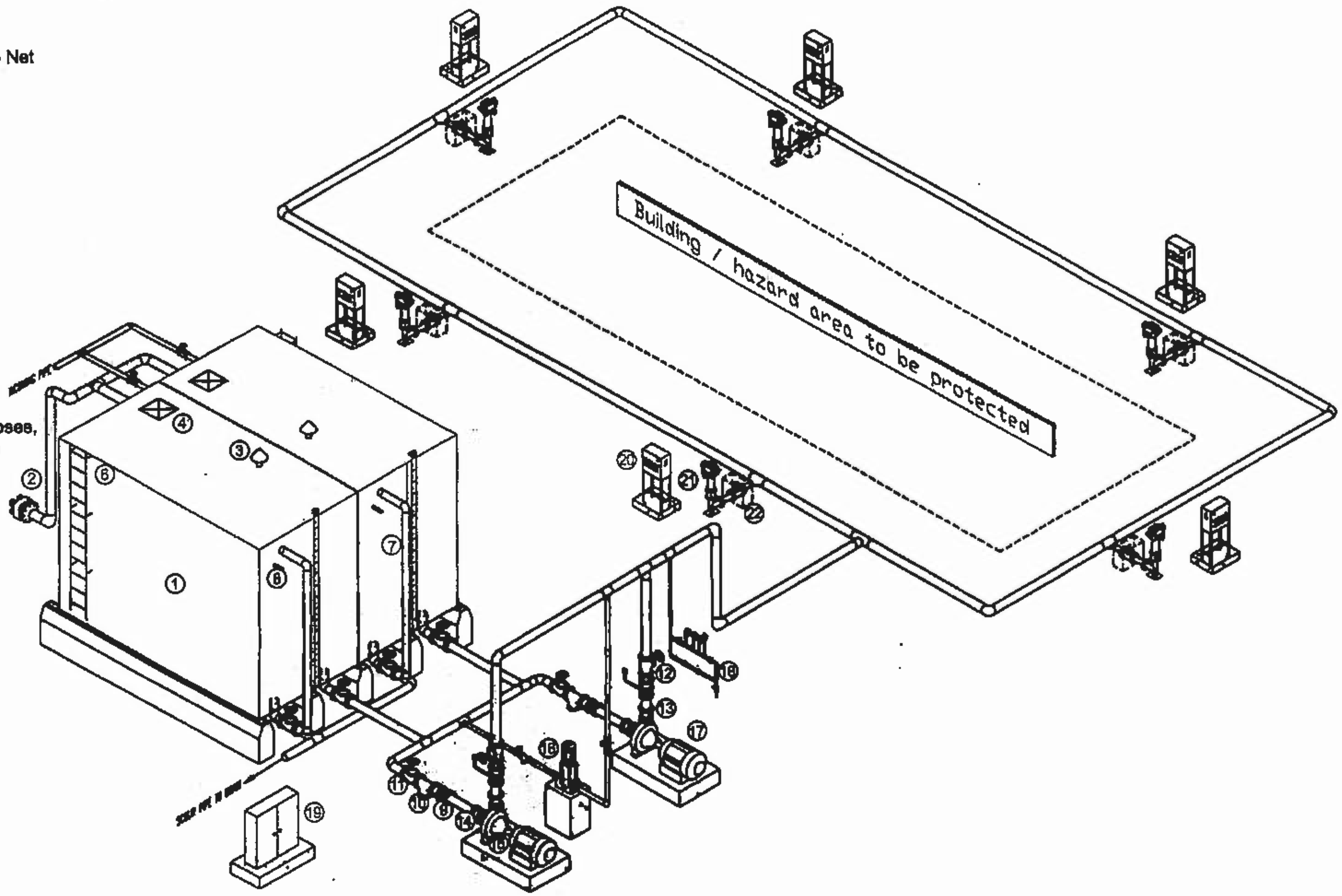
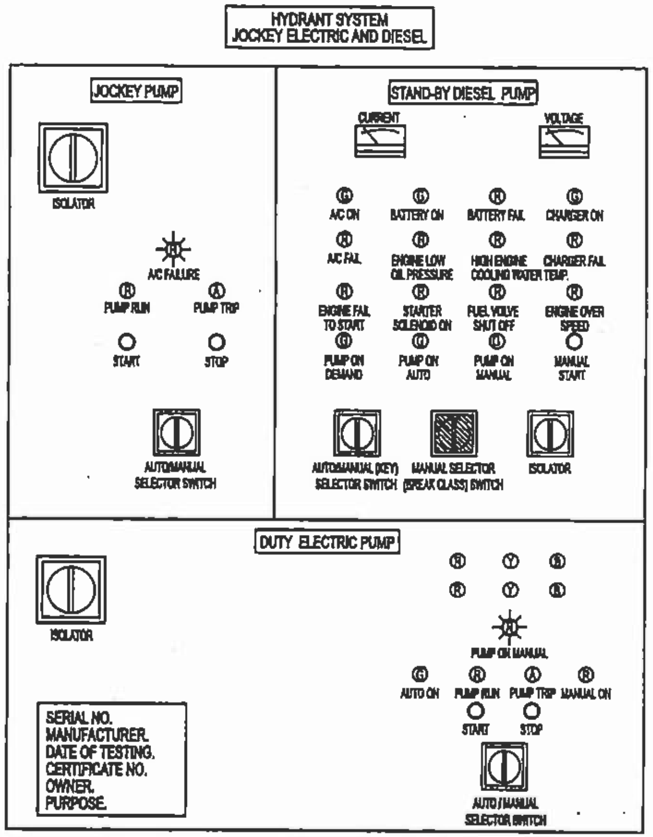


Figure 6.3 Hydrant Pump Starter Panel

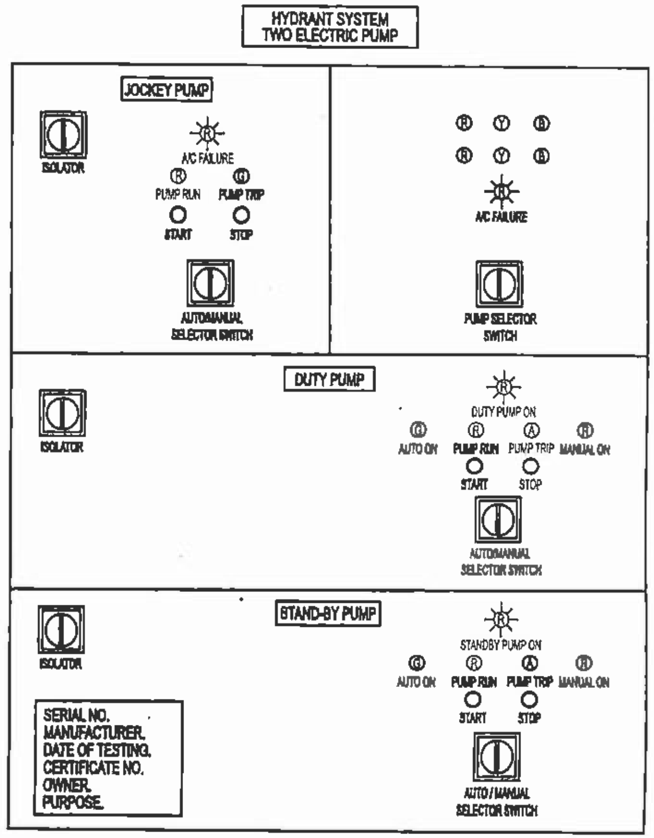


Note:

1. **Phase indicator shall be shown in duplicate (double filament bulbs with a single alignment is acceptable as a alternate)**
2. A/C failure indicator shall be monitored on to the fire alarm indicator panel.

Legend

- (R) :- Red light
- (Y) :- Yellow light
- (B) :- Blue light
- (G) :- Green light
- (A) :- Amber light
- (R, flashing symbol) :- Red flashing light



7 HOSE REEL SYSTEM

7.1 DESCRIPTION

Hose reel system is intended for the occupant to use during the early stages of a fire and comprises hose reel pumps, fire water storage tank, hose reels, pipe work and valves. A typical hose reel installation is shown in Figure 7.1.

7.2 DESIGN REQUIREMENTS

7.2.1 Design Standards

The requirement for hose reel systems is detailed under the 10th Schedule of the Uniform Building By-laws 1984. The applicable standards for hose reel systems are as follows:

- M.S.1489 Part 1 : Hydrant Systems, Hose Reels and Foam Inlets;
- M.S.1447 - Hose reels with semi-rigid hose;
- M.S.1488 : Semi-rigid hoses for first aid fixed installations.

7.2.2 Hose Reels

Hose reels should comply with M.S.1447 and are usually placed such that all areas are within 30 metre hose coverage of each hose reel. One hose reel should be provided for every 800 sq. metres of usable floor space. Hose reels are usually located in prominent positions at each floor level along escape routes or besides exit doors or staircases, preferably within recessed closets.

Each hose reel outlet is to discharge a minimum of 30 l/min of water within 6 metres of all parts of the space protected. The rubber hoses should be to M.S.1488 and are typically 30 metres in length and 25mm in diameter. Nozzles should be of the jet and spray adjustable type of different diameters but 8mm is a recommended size.

Pipework for hose reel system is generally 50mm nominal diameter and the feed to individual hose reel should be not less than 25mm diameter. The piping should be of galvanised steel medium grade (Class B) minimum for above ground piping and heavy grade (Class C) for underground pipes. The pipes shall be painted with primer and finished with red paint or the hose reel pipe may be identified with red bands painted at elbows and tees.

7.2.3 Hose Reel Pumps

The hose reel pumps draw water from the fire water storage tank and two sets of pumps, one on duty and the other on standby, are provided. The pump capacity is usually sized to deliver a flow rate of 120 l/min at a running pressure of not less than 2 bars for any four hose reels operating at the same time.

The standby hose reel pumpset should be supplied with power from the emergency generator if this is available. Otherwise, the standby pumpset should be diesel engine driven. Fuel supply should be adequate for minimum 1 hour of operation. Electrical cabling to supply power to the hose reel pumps should be run in galvanised steel conduit or alternatively, may be of fire rated type of cable. Batteries for the diesel engine should be maintenance-free type.

Where the total number of hose reels in the building does not exceed four (4), the standby pumpset may be electrically driven and need not be provided with emergency power.

each HR
Draw 800 m²

The hose reel pumpsets should be protected from the weather and away from locations likely to be flooded. Pump rooms may be located anywhere in the building or on the roof but should be ventilated by natural or mechanical means and provided with the necessary signage.

7.2.4 Hose Reel Tanks

The fire water storage tank should be sized based on 2275 litres for the first hose reel and 1137.5 litres for every additional hose reel up to a maximum of 9100 litres for each system.

The tank may be of pressed steel, fibreglass reinforced polyester (FRP) or concrete. Pressed steel tanks where used should be hot dipped galvanized and coated internally with bituminous paint for corrosion protection. The tank should be compartmented and water level indicator should be provided to show the amount of water available. The external surface of the tank should be painted red or where this is not desirable, a red band of minimum 200mm should be painted to indicate that this is a fire tank.

The hose reel tank should be refilled automatically from a water supply pipe of minimum 50mm diameter to provide a minimum flowrate of 150 l/min.

Although hose reel tanks are usually separated from domestic water storage tanks, the two can be combined. In such cases, the tank capacity should be the sum total of the water storage for both domestic as well as for hose reels and the tap off point for the domestic use must be above the tap off point for the hose reel system such that the minimum fire reserve for hose reel is always maintained.

7.2.5 Pump Starter Panels and Controls

Pump starter panel should be complete with indicator lights as shown in the Figure 7.2. Ventilation slots should be provided with insect screen to prevent entry of vermin.

Hose reel pumps shall start automatically upon actuation of the pressure switches. Usually two pressure switches are provided with the following suggested settings:

- starting and stopping the duty pumpset set at 80% and 100% of system pressure respectively; and
- starting and stopping the standby pumpset set at 60% and 100% of system pressure respectively.

For diesel pumpsets, these should be capable of automatic starting but should only be stopped manually.

7.2.6 Gravity Feed Hose Reel System

Where the tank is located on the roof or upper floors and the static pressure is adequate to achieve the required pressure, the hose reels may be fed directly from the hose reel tank. If pumps are required for the upper floors, a bypass pipe is usually provided. Where excessive pressure is encountered, pressure reducing valves should be installed with a manual bypass in case the pressure reducing valve fails.

7.2.7 Hose Reel Systems Fed from Other Sources

The hose reel system may be tapped off from pressurized hydrant provided pressure reducing valves are incorporated to reduce the pressure to the appropriate level. However, hose reels shall not be tapped off from automatic sprinkler systems.

7.3 DESIGN CHECKLIST

(a) Design flow rate at each hose reel shall be 30 litres/min based on the top most four numbers of hose reels in use simultaneously.

(b) Minimum design static pressure at entry of each hose reel : __________ bar.

(c) Hose reel type : ___________________.

(d) Hose length : ___________ metres.

(e) Water source :
- ☐ Pump suction tank.
- ☐ Gravity tank.
- ☐ Fire water main
- ☐ Others : ______________.

(f) Water tank capacity : ____________ litres.
*(2,275 litres for the first hose reel, each additional hose reel require extra 1,137.5 litres up to 9,100 litres.)

(g) Pressure reducing valve set :
- ☐ Yes. Pressure reducing range : _____ bar to _____ bar.
- ☐ No.

(h) Hose reel spacing : _____________ m.

(i) Total number of hose reel : _______ nos.

(j) Nozzles are adjustable and spray type. Size : _________mm nom diameter.

(k) Riser size (minimum nominal size 50mm) : ____________mm.

(l) Pipe material : ____________________.

(m) Hose reel pump :
Rated flow rate : ____________litres/min at __________ metre head.

(n) Pipe nominal size : Suction : ____________mm ; Delivery : __________ mm

7.4 VISUAL INSPECTION CHECKLIST

7.4.1 Visual Inspection of Water Supplies

Capacity of water available.

Compartmentation of water tanks.

7.4.2 Visual Inspection of Pipework

Type of pipes used.

Protection of underground pipework.

Painting of pipework.

Pipe support.

Pipe sleeves.

Fire seal.

7.4.3 Visual Inspection of Hose Reels and Accessories

Isolating valve for hose reel.

Physical condition of hose reel drum, hose, nozzles, etc.

7.4.4 Visual Inspection of Pumps

Protection of rotating parts of pump sets.

Mounting of pumps.

7.5 TESTING AND COMMISSIONING CHECKLIST

7.5.1 Testing and Commissioning of Pipework

Pump operating current and voltage.

Pump operating pressure and flow rate.

Pump operating RPM.

Pump not overheating.

Vibration and noise level.

Testing of electrical wiring system.

Alternative power supply for electric pumps.

7.5.2 Testing and Commissioning of Pipework

Hydrostatic testing of pipework.

Flushing of pipework.

7.5.3 Testing and Commissioning of Hose Reel

Hose reel performance test.

Figure 7.1 Hose Reel System Typical Arrangement Drawing
SCALE: N.T.S

COMPONENT / EQUIPMENT
1 Water Tank
2 Vent Pipe c/w Mosquito Net
3 Access Opening
4 Level Indicator
5 External Cat Ladder
6 Overflow Pipe
7 Warning Pipe
8 Standby Pump
9 Eccentric Reducer
10 Expansion Joint
11 Y-Strainer
12 Gate Valve
13 Concentric Reducer
14 Check Valve
15 Duty Pump
16 Pump Start Test Pipe
17 Pump Starter Panel
18 Hose reel c/w Hoses, Nozzles & Accessories
19 Air Release Valve c/w Ball Valve
20 Stop Valve

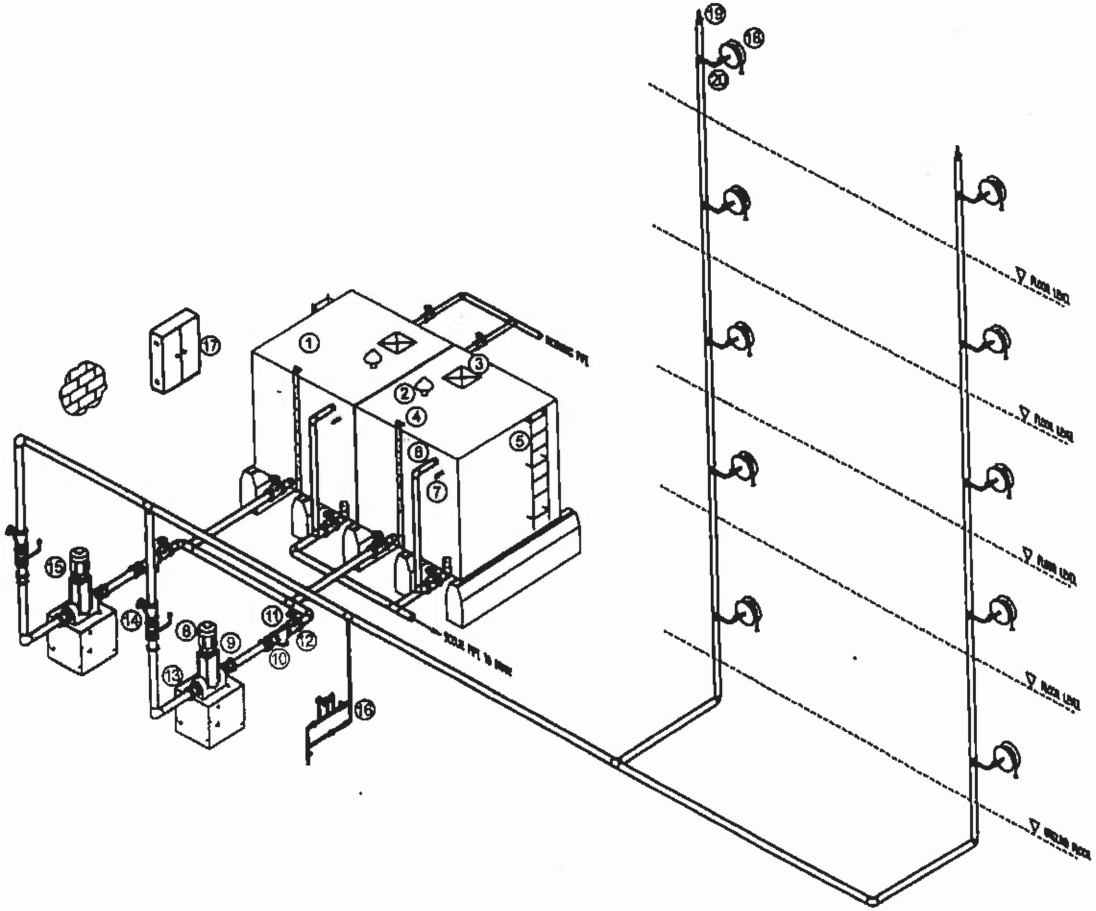
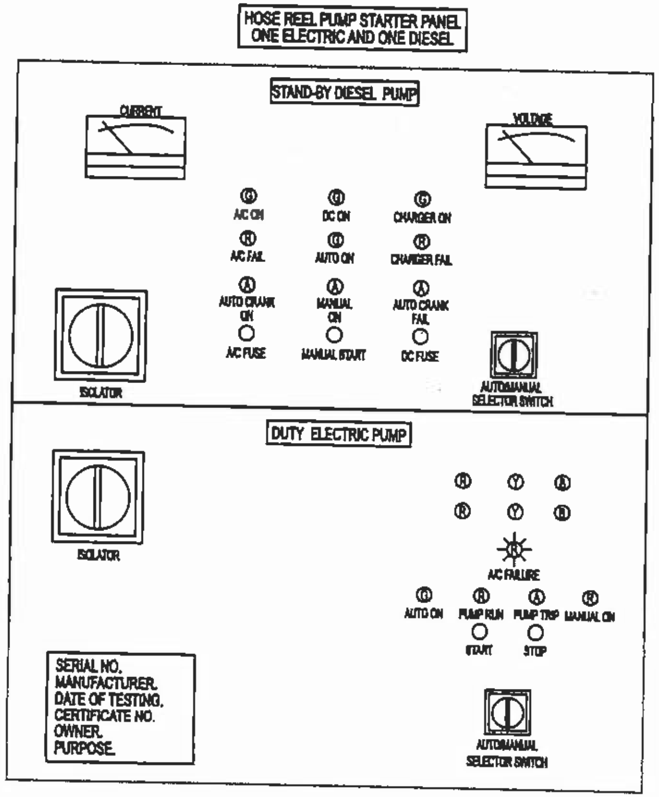
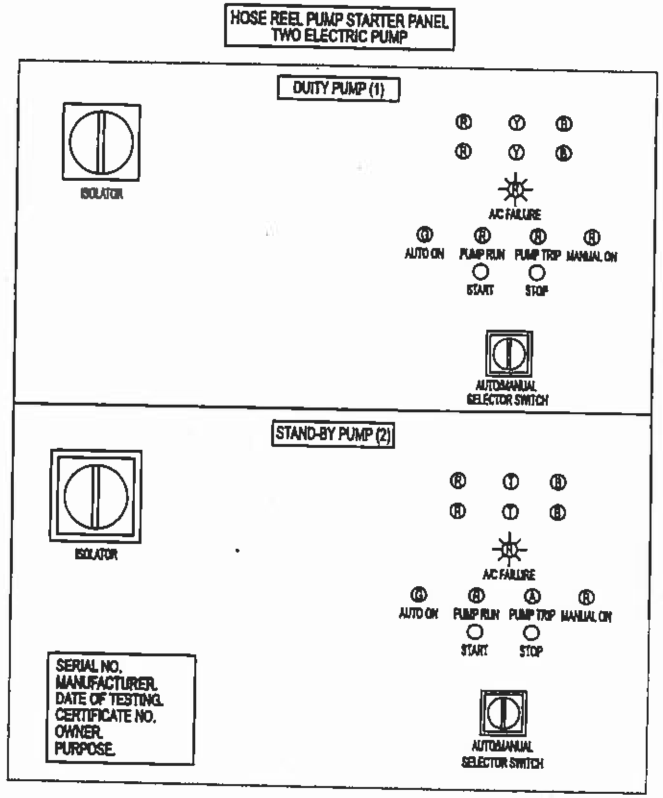


Figure 7.2 Hose Reel Pump Starter Panel



Note:
1. Phase indicator shall be shown in duplicate (double filament bulbs with a single alignment is acceptable as an alternative.)
2. A/C failure indicator shall be monitored on to the fire alarm indicator panel.

Legend
- (R) :- Red light
- (Y) :- Yellow light
- (B) :- Blue light
- (G) :- Green light
- (A) :- Amber light
- (R, flashing symbol) :- Red flashing light



8.1 DESCRIPTION

Dry risers are a form of internal hydrant for the firemen to use and are only required for buildings where the topmost floor is higher than 18.3 metres and less than 30.5 metres above the fire appliance access level. Dry risers are normally dry and depend on the fire engine to pump water into the system. Dry riser system comprises a riser pipe with landing valves at each floor and to which canvas hose with nozzles can be connected to direct the water jet at the fire. Breeching inlets into which the firemen pumps water are provided at ground level and are connected to the bottom of the dry risers.

A typical dry riser installation is shown in Figure 8.1.

8.2 DESIGN REQUIREMENTS

8.2.1 Design Standards

In the Uniform Building By-laws 1984, the By-laws pertaining to dry risers are By-laws 230 and 232. The relevant standards for dry risers are:

- M.S.1489 : Part 1 - Hydrant Systems, Hose Reels and Foam Inlets;
- M.S.1210 : Part 2 - Landing Valves for Dry Risers;
- M.S.1210 : Part 3 - Inlet Breeching for Riser Inlets;
- M.S.1210 : Part 4 - Boxes for Landing Valves for Dry Risers.

8.2.2 Landing Valve

Landing valves are provided on each floor and should comply with M.S.1210 : Part 2. They are usually located within fire access lobbies, protected staircases or other protected lobbies, and installed at not more than 0.75 metres above the floor level. To protect the landing valves, boxes may be provided and these should comply with M.S.1210 Part 4.

Fire hose of not less than 38mm diameter, 30 metres in length, complete with 65mm dia. quick coupling and nozzle should be provided at each landing valve.

8.2.3 Breeching Inlet

The fire brigade breeching inlet installed at the bottom of the riser should comply with M.S.1210 : Part 3. Where the breeching inlet is enclosed within a box, the enclosure should comply with M.S.1210 Part 5 and labeled 'Dry Riser Inlet'. A drain should be provided at the bottom of the riser to drain the system after use.

A two-way breeching inlet should be provided for a 100mm dia. dry riser while a 150mm dia. dry riser should be installed with a 4-way breeching inlet. Breeching inlets should be located no more than 18 metres from the fire appliance access road and not more than 30 metres from the nearest external hydrant outlet.

8.2.4 Riser Pipe

The riser pipe diameter usually located within the fire access lobby or staircase should be 150mm if the highest outlet is more than 22.875 metres above the breeching inlet. Otherwise, the riser pipe can be 100mm in diameter. The riser pipe shall be of galvanised iron to B.S.1387 (Heavy gauge) or Class C, tested to 21 bars.

Horizontal runs of pipework feeding the risers should be sloped to enable proper draining after use. An air release valve should be installed at the top of the riser to relief air trapped in the system.

The riser pipe should be electrically earthed or connected to the building earth to achieve equipotential.

8.3 TEST REQUIREMENTS

8.3.1 Static Pressure Test
The system should first be flushed to clear all debris from the inside of the riser. The riser is then hydraulically tested to a pressure of 14 bars for 2 hours, measured at the breeching inlet and a check is carried out for leakage at the joints and landing valve connections.

8.4 MAINTENANCE REQUIREMENTS

8.4.1 Inspection and Testing
The breeching inlets, landing valves and hoses, dry riser pipe, drain valves and cabinets should be inspected regularly to ensure that they are in good operating condition.

8.5 DESIGN CHECKLIST

(a) Dry riser is required for building which the topmost floor is more than 18.3 metres but less than 30.5 metres above fire appliance access.

(b) Total number of landing valve _______ nos per riser.

(c) Rising main location :
❑ In stairway enclosure.
❑ Within a fire fighting lobby.
❑ Other : ________________.

(d) Riser diameter : _____________ mm.

(e) Pipe material : __________________.

(f) Lowest point of landing valve at about 750mm above floor level.

(g) Fire brigade breeching inlet :
❑ Two-way pumping inlet
❑ Four-way pumping inlet

8.6 VISUAL INSPECTION CHECKLIST

8.6.1 Visual Inspection of Water Supplies
Breeching inlet.

8.6.2 Visual Inspection of Landing Valves
Location of valves.

Caps for outlet of landing valves.

8.6.3 Visual Inspection of Pipework

Isolating valve for hose reel.

Physical condition of hose reel drum, hose, nozzles, etc.

8.6.4 Visual Inspection of Pumps

Type of pipes used.

Protection of underground pipework.

Painting of pipework.

Pipe supports.

Pipe sleeves.

Fire seal.

8.7 TESTING AND COMMISSIONING CHECKLIST

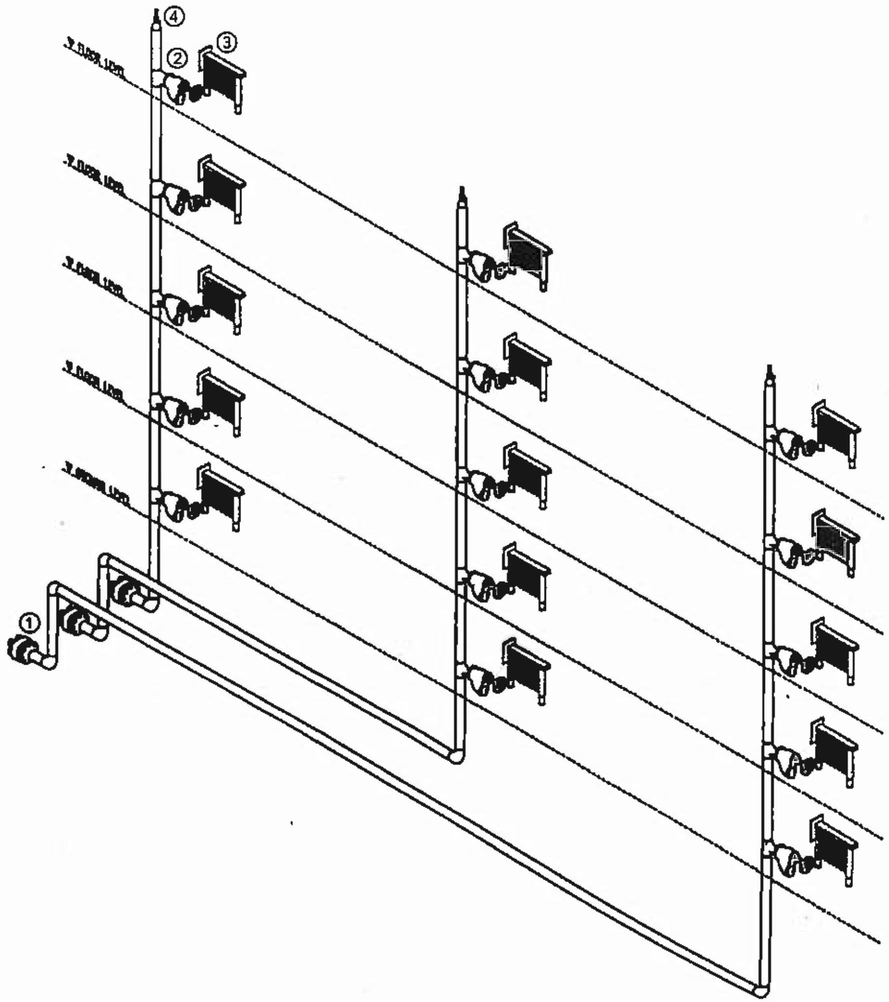
8.7.1 Testing and Commissioning of Pipework

Hydrostatic testing of pipework.

Flushing of pipework.

Figure 8.1 Dry Riser System Typical Arrangement Drawing
SCALE: N.T.S

COMPONENT / EQUIPMENT
1 4-way Breeching Inlet
2 Landing Valve
3 Hose Cradle
4 Air Release Valve c/w Ball Valve



9 WET RISER SYSTEM

9.1 DESCRIPTION

Wet risers are a form of internal hydrant for the firemen to use and are always charged with water. Wet risers are only required for buildings where the topmost floor is higher than 30.5 metres above the fire appliance access level.

Wet riser system comprises duty fire pump with standby pump discharging into a 150mm diameter riser pipe with landing valves at each floor and to which canvas hose with nozzles can be connected to direct the water jet at the fire. A jockey pump is usually provided to maintain system pressure. For high rise buildings, each stage of the wet riser should not exceed 70.15 metres.

A typical wet riser installation is shown in Figure 9.1.

9.2 DESIGN REQUIREMENTS

9.2.1 Design Standards

The requirements for wet riser systems is described under By-law 231, 232 and 248 of the Uniform Building By-Laws, 1984 and the applicable standards are:

- M.S.1489 : Part 1 - Hydrant Systems, Hose Reels and Foam Inlets;
- M.S.1210 : Part 1 - Landing Valves for Wet Risers;
- M.S.1210 : Part 3 - Inlet Breeching for Riser Inlets;
- M.S.1210 : Part 4 - Boxes for Landing Valves for Dry Risers.

9.2.2 Wet Riser Landing Valve

Landing valves are provided on each floor and should comply with M.S.1210 : Part 1. They are usually located within fire fighting access lobbies, protected staircases or other protected lobbies, and installed at not more than 0.75 metres from the floor. To protect the landing valves, boxes can be provided and these should comply with M.S.1210 : Part 4.

The pressure at the landing valve should be no less than 4 bars and not more than 7 bars. To achieve this, there are two types of landing valves i.e. pressure reducing type with or without relief outlet. Those with relief outlets require a wet riser return pipe.

Fire hose of the canvas type of not less than 38mm dia. 30 metres in length, complete with 65mm dia. quick coupling and jet and spray nozzle should be provided in a hose cradle beside each landing valve.

9.2.3 Breeching Inlet

With the fire brigade breeching inlets the firemen can pump water into the wet riser storage tank to make up for water used. The breeching inlet should be a 4-way type complying with M.S.1210 : Part 3. Where the breeching inlet is enclosed within a box, the enclosure should comply with M.S.1210 Part 5 and labelled 'Wet Riser Inlet'. A drain should be provided at the bottom of the riser to drain the system after use.

Breeching inlets should be located no more than 18 metres from the fire appliance access road and not more than 30 metres from the nearest external hydrant.

9.2.4 Wet Riser Pipe

The wet riser mains are usually located within smoke free lobby or protected areas and such that all spaces are to be within a 45 metres coverage from a landing valve. Where more than one riser is required for each floor, the distance apart between the risers should not exceed 60 metres. The distance between the lowest and topmost landing valve in any upper stage riser should not exceed 60 metres. The riser pipe diameter should be 150mm galvanised iron to B.S.1387 (Heavy gauge) or Class C. Where a relief pipe is required, this return pipe shall be minimum 100mm dia. galvanised iron to B.S.1387 (Medium gauge) or Class B, discharging back to the wet riser tank wherever possible. An air release valve should be installed at the top of the riser to relief air trapped in the system.

All wet riser pipes should be coated with primer and finished with red gloss paint. Alternatively, the pipe can be colour coded with red bands of 100mm width and the elbows and tees painted red. The riser pipe should be electrically earthed to achieve equipotential with the building.

9.2.5 Wet Riser Pumps

The wet riser pumps draw water from wet riser storage tank and two sets of pumps, one on duty and the other on standby, are provided. The pump capacity is usually sized to deliver a flow rate of 1500 l/min at a running pressure of not less than 4 bars but not more than 7 bars, when any three landing valves are in use at the same time.

The standby wet riser pumpset should be supplied with power from the emergency generator if this is available. Otherwise, the standby pumpset should be diesel engine driven. Fuel supply should be adequate for minimum 2 hours of continuous operation. Electrical cabling to supply power to the wet riser pumps should be of MICC or fire rated type. Batteries for the diesel engine should be maintenance-free type.

The wet riser pumpsets should be protected from fire and away from locations likely to be flooded. Sump pumps shall be installed where the fire pump room is located in the basement below external drainage levels. It should also be ventilated by natural or mechanical means and provided with the necessary signage. A carbon dioxide type portable extinguisher should be provided as well.

9.2.6 Wet Riser Tanks

The fire water storage tank should be sized for a minimum effective capacity of 45,500 litres with automatic refill rate of 455 l/min. The intermediate break tank for upper stages of the wet riser should be not less than 11,375 litres with an automatic make-up flow of 1365 l/min.

Wet riser tanks may be of pressed steel, fibre reinforced polyester (FRP) or concrete. Pressed steel tanks where used should be hot dipped galvanized and coated internally with bituminous paint for corrosion protection. The water tanks should be compartmented unless they are of reinforced concrete. Ball float valves, overflow pipes, drain pipes and water level indicators should be provided for each compartment. The external surface of the tank should be painted red or where this is not desirable, a red band of minimum 200mm should be painted to Indicate that this is a fire tank.

The wet riser tanks may be located on the ground floor, first or second basement. The wet riser tanks are usually separated from other water storage tanks. However, it may be combined with hose reel tank, in which cases the tank capacity should be the sum total of the water storage for both wet riser as well as for hose reel system. The hose reel tap off level should be above the wet riser tap off level such that the wet riser reserve is maintained.

9.2.7 Pump Starter Panels and Controls

Pump starter panel should be complete with indicator lights as shown in the Figure 9.2. Ventilation slots should be provided with insect screen to prevent entry of vermin. Power supply cables to the panel should be of mineral insulated copper cable (MICC) or fire rated type routed within areas with low fire risk. The pump starter panel should be placed within the same room as the fire pumps it controls.

Wet riser pumps are automatically started upon actuation of the pressure switches but should only be stopped manually. Usually three pressure switches are provided with the following suggested pressure settings:

- starting the duty pumpset set at 80% of the system pressure;
- starting the standby pumpset set at 60% of the system pressure; and
- starting and stopping the jockey pumpset set at 90% and 110% of the system pressure respectively.

The pressure switches are normally installed in the test and drain line on the pump discharge side. The pressure settings should be clearly labelled on tags attached to each pressure switch.

9.3 TEST REQUIREMENTS

9.3.1 Static Pressure Test

The system should first be flushed to clear all debris from the inside of the riser. The riser is then hydraulically tested to a pressure of 14 bars or 150% the working pressure, whichever is the higher for 2 hours, measured at the lowest landing valve and a check is carried out for leakage at the joints and landing valve connections.

9.3.2 Flow Test

A three way landing valve should be provided on the roof or topmost floor for testing purposes. Means should be provided to measure the water flowrate.

9.4 MAINTENANCE REQUIREMENTS

9.4.1 Inspection and Testing

A flow test should be carried out to ensure that the pumps are in proper working condition. The pipework should be checked for leakage and the breeching inlets, landing valves and hoses, drain valves and cabinets should be inspected as recommended in the checklist attached.

9.5 DESIGN CHECKLIST

(a) Wet riser is required for building where the topmost floor is more than 30.5 metres above fire appliance access.

(b) A minimum flow rate of 500 litres/minute at running pressure of 4 to 7 bars is maintained at each landing valve when three numbers of the furthest landing valves are fully opened.

(c) Water source :
- ☐ Pump suction tank.
- ☐ Fire water main.
- ☐ Other : ____________.

(d) Multi-stage system shall be installed for highest outlet more than 70.15 metres above pump level.

(e) Each stage of riser does not exceed 60 metres.

(f) Landing valves shall be pressure regulating / reducing type.

(g) Total number of landing valve per stage:
- Stage 1 : __________ nos.
- Stage 2 : __________ nos.

(h) Three way 63.5mm outlets are provided at location above the roof line.

(j) Riser spacing : __________metres.

(k) Rising main location :
- ☐ In stairway enclosure.
- ☐ Within fire fighting lobby.
- ☐ Other : ______________.

(l) Number of fire hose provided : ______nos.

(m) Hose size : _________ mm ; length : _____________ m.

(n) Break tank capacity : 11,375 litres.

(o) Water tank capacity : 45,500 litres

(p) Minimum nominal diameter of riser shall be 150mm.

(q) Pipe material : ______________________________.

(r) Lowest point of landing valve at about 750mm above floor level.

(s) To provide fire brigade breeching inlet.

(t) Wet riser pump :
- Rated flow rate : _____________litres/min at _________ metre head.
- Rated power : ___________kW.

(u) Pipe nominal size : Suction : ___________mm ; Delivery : __________ mm

(v) For diesel engine :
- Fuel capacity sufficient to run engine at full load for ________ hours.
- Reserve supply of fuel for _______ hours of engine full load running.

9.6 VISUAL INSPECTION CHECKLIST

9.6.1 Visual Inspection of Water Supplies
Capacity of water available.

Compartmentation of water tanks.

Priming tank (if any).

Monitoring of water tank level.

Vortex inhibitors for water tanks.

Breeching inlet.

9.6.2 Visual Inspection of Landing Valves and Accessories
Location of landing valve.

Storage of canvas hose and accessories.

Physical condition of canvas hose, accessories and landing valve.

Caps for outlet of landing valves.

9.6.3 Visual Inspection of Pipework
Type of pipes used.

Protection of underground pipework.

Painting of pipework.

Pipe supports.

Pipe sleeves.

Fire seal.

9.6.4 Visual Inspection of Pumps
Protection of rotating parts of pump sets.

Mounting of pump sets.

9.7 TESTING AND COMMISSIONING CHECKLIST

9.7.1 Testing and Commissioning of Water Supplies
Pump operating current and voltage.

Pump operating pressure and flow rate.

Pump operating RPM.

Pump not overheating.

Vibration and noise level.

Testing of electrical wiring system.

Alternative power supply for electric pumps.

Batteries for diesel pumps.

Fuel for diesel pumps.

Automatic operation of pumps.

9.7.2 Testing and Commissioning of Pipework
Hydrostatic testing of pipework.

Flushing of pipework.

9.7.3 Testing and Commissioning of Landing Valves
Pressure at landing valve outlet.

Flow rate of water.

Figure 9.1 Wet Riser System Typical Arrangement Drawing
SCALE: N.T.S

COMPONENT/ EQUIPMENT
1 Water Tank
2 4-Way Breeching Inlet
3 Vent Pipe c/w Mosquito Net
4 Access Opening
5 Level Indicator
6 External Cat Ladder
7 Overflow Pipe
8 Warning Pipe
9 Standby Pump
10 Eccentric Reducer
11 Expansion Joint
12 Y-Strainer
13 Gate Valve
14 Duty Pump
15 Concentric Reducer
16 Check Valve
17 Jockey Pump
18 Pump Start Test Pipe
19 Pump Starter Panel
20 Landing Valve
21 Hose Cradle
22 Air Release Valve c/w Ball Valve

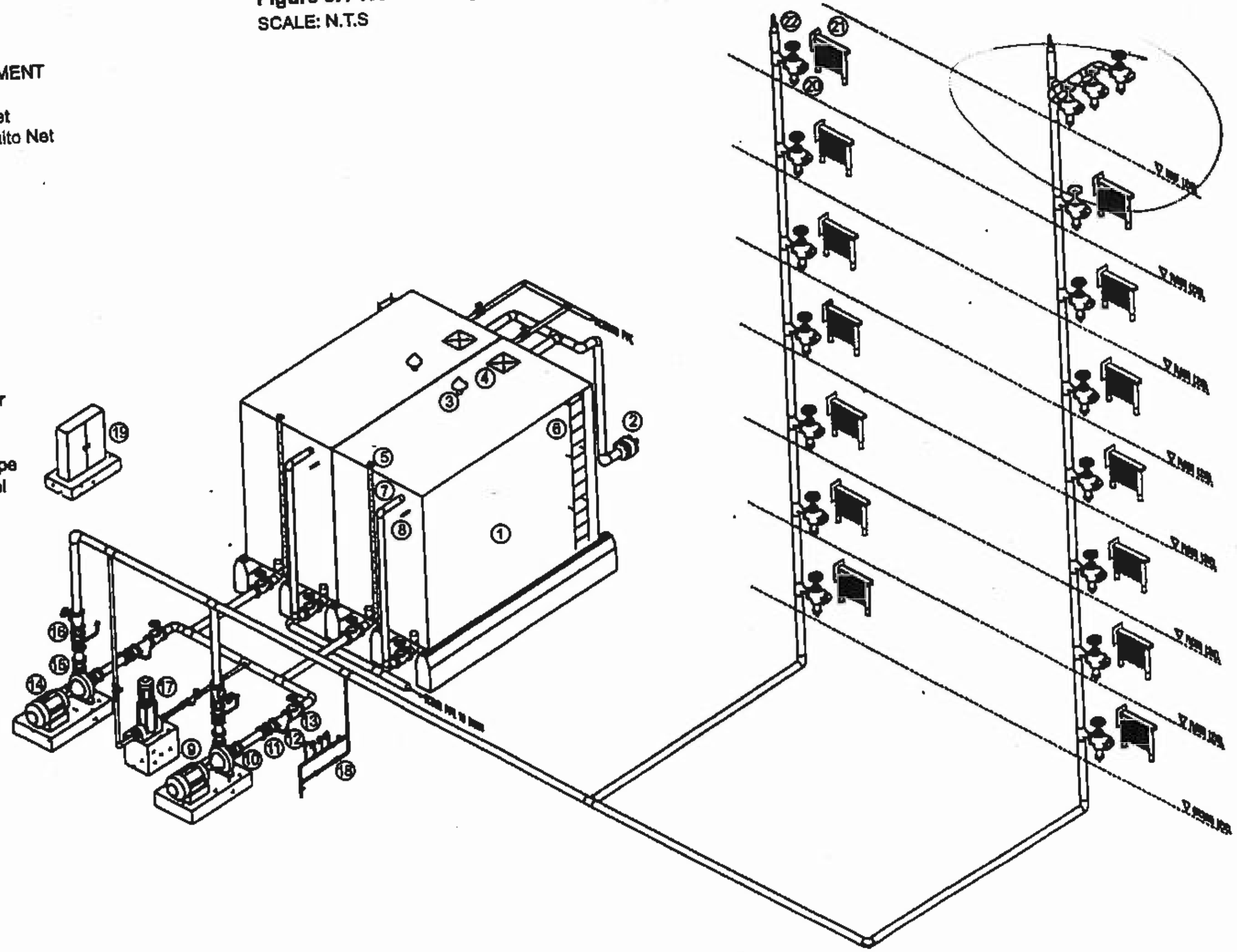
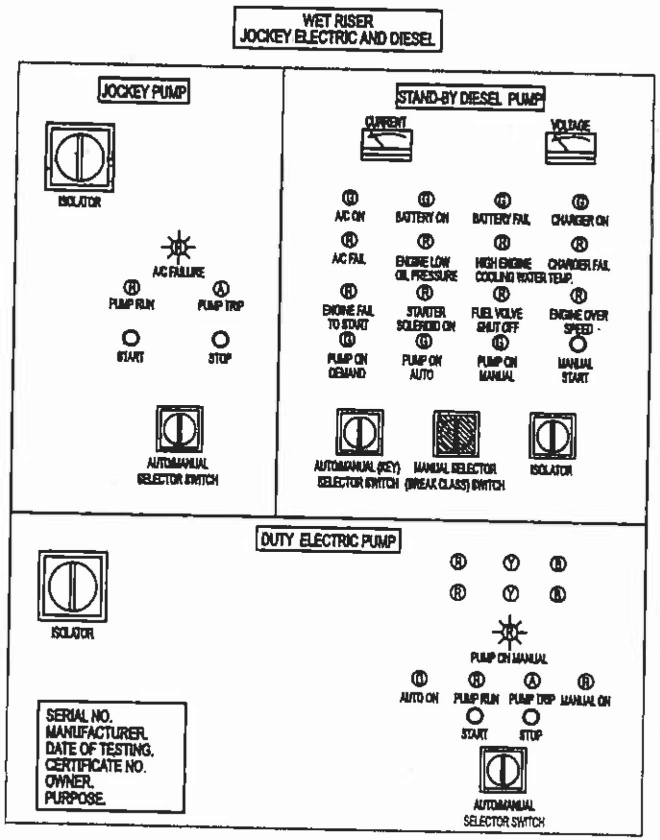


Figure 9.2 Wet Riser Pump Starter Panel

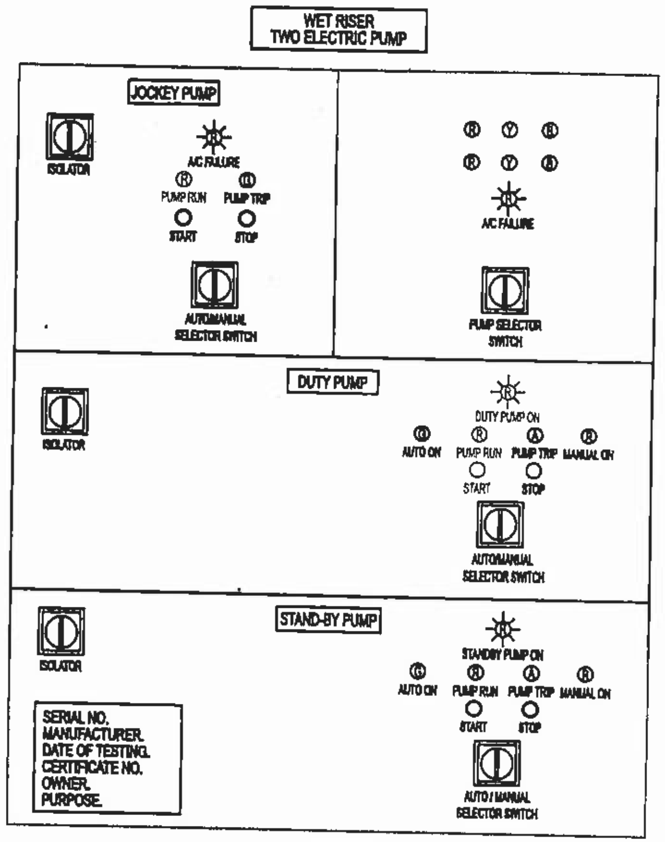


Note:

1. Phase indicator shall be shown in duplicate (double filament bulbs with a single alignment is acceptable as a alternate)
2. A/C failure indicator shall be monitored on to the fire alarm indicator panel.

Legend

- Ⓡ :- Red light
- Ⓨ :- Yellow light
- Ⓑ :- Blue light
- Ⓖ :- Green light
- Ⓐ :- Amber light
- ✳Ⓡ :- Red flashing light



A check valve is installed between the topmost landing valve and the tank to prevent back flow of water from the downcomer into the tank.

10.2.4 Downcomer Pipe

The downcomer mains are usually located within smoke free lobby or protected areas and that all spaces are to be within a 45 metres coverage from a landing valve. Where more than one riser is required for each floor, the distance apart between the risers should not exceed 60 metres. The riser pipe diameter should be 150mm galvanised iron to B.S.1387 (Heavy gauge) or Class C. An air release valve should be installed at the top of the riser to relief air trapped in the system.

All downcomer pipes should be coated with primer and finished with red gloss paint. Alternatively, the pipe can be colour coded with red bands of 100mm width and the elbows and tees painted red. The riser pipe should be electrically earthed.

10.2.5 Fire Water Tanks

The fire water storage tank should be sized for a minimum effective capacity of 45,500 litres with automatic refill rate of 455 l/min.

The tanks may be of pressed steel, fibre reinforced polyester (FRP) or concrete. Pressed steel tanks where used should be hot dipped galvanized and coated internally with bituminous paint for corrosion protection. The water tanks should be compartmented unless they are of reinforced concrete and ball float valves, overflow pipes, drain pipes and water level indicators should be provided for each compartment. The external surface of the tank should be painted red or where this is not desirable, a red band of minimum 200mm should be painted to indicate that this is a fire tank.

The tanks are usually located on the roof to provide the maximum static pressure possible. The tank is usually separated from other water storage tanks. However, it may be combined with hose reel tank, in which cases the tank capacity should be the sum total of the water storage for both the downcomer as well as for hose reel system. The hose reel tap off level should be above the downcomer tap off level such that the water is reserved for the downcomer.

10.3 TEST REQUIREMENTS

10.3.1 Static Pressure Test

The system should first be flushed to clear all debris from the inside of the riser. The riser is then hydraulically tested to a pressure of 14 bars or 150% the working pressure, whichever is the higher for 2 hours, measured at the breeching inlet and a check is carried out for leakage at the joints and landing valve connections.

10.4 MAINTENANCE REQUIREMENTS

10.4.1 Inspection and Testing

The pipework should be checked for leakage and the breeching inlets, landing valves and hoses, drain valves and cabinets should be inspected as recommended in the checklist attached.

10.5 DESIGN CHECKLIST

(a) Downcomer system (modified requirement by UBBL) is only applicable for flats which the topmost floor is less than 60 metres above fire appliance access but exceed the maximum height requirement of dry riser system.

(b) Total number of landing valve : _______ nos per stack.

(c) Number of fire hose provided : ______nos.

(d) Hose size : _________ mm ; length : _________ m.

(e) Stack main location :
- ☐ In stairway enclosure.
- ☐ Within a ventilated lobby.
- ☐ Other : ________________

(f) Stack diameter : _____________ mm.

(g) Pipe material : ____

(h) Lowest point of landing valve at about 750mm above floor level.

(i) To provide fire brigade breeching inlet.

10.6 VISUAL INSPECTION CHECKLIST

10.6.1 Visual Inspection of Water Supplies

Capacity of water available.

Compartmentation of water tanks.

Breeching inlet.

10.6.2 Visual Inspection of Landing Valves and Accessories

Location of landing valves.

Storage of canvas hose and accessories.

Physical condition of canvas hose, accessories and landing valve.

Caps for outlet of landing valves.

10.6.3 Visual Inspection of Pipework

Type of pipes used.

Painting of pipework.

Pipe supports.

10.7 TESTING AND COMMISSIONING CHECKLIST

10.7.1 Testing and Commissioning of Water Supplies
Flow rate and pressure of water supplies.

10.7.2 Testing and Commissioning of Pipework
Hydrostatic testing of pipework.

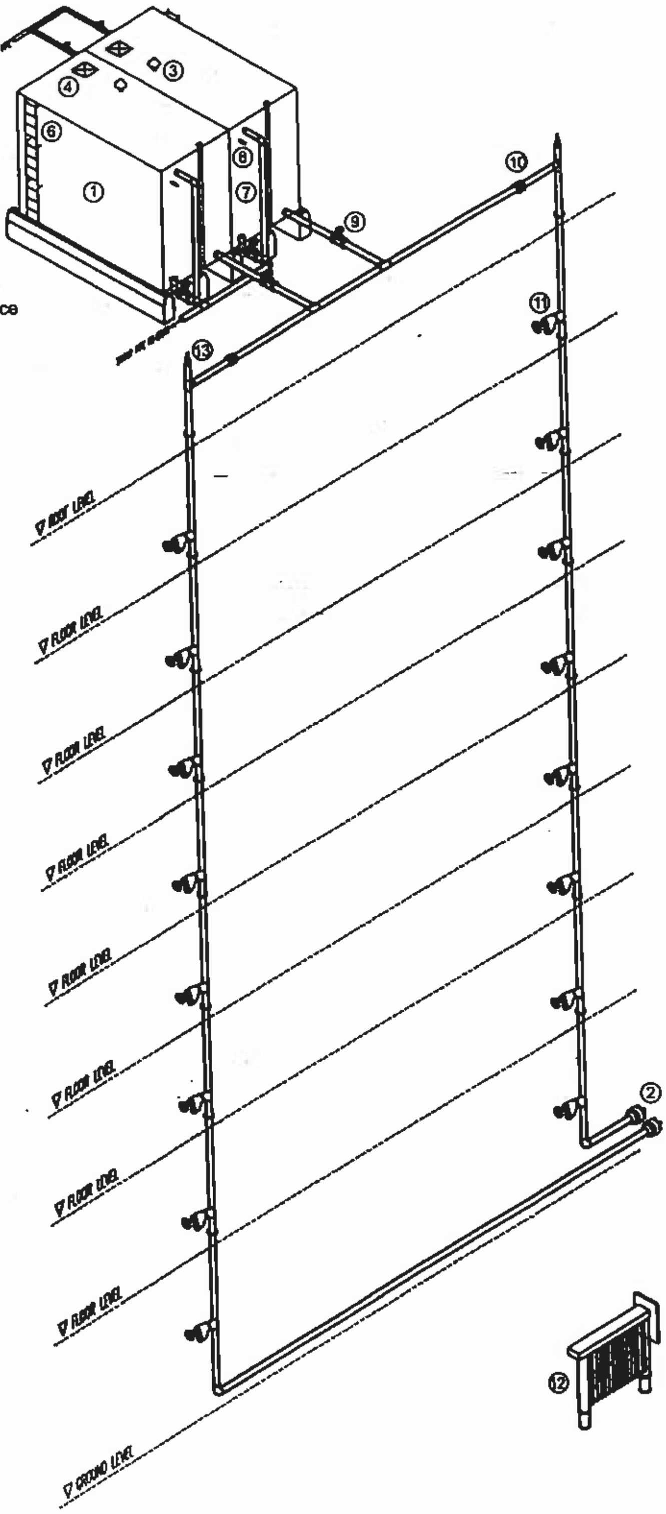
Flushing of pipework.

Figure 10.1 Down Comer System Typical Arrangement Drawing

SCALE: N.T.S

COMPONENT / EQUIPMENT

1 Water Tank
2 4-Way Breeching Inlet
3 Vent Pipe c/w Mosquito Net
4 Access Opening
5 Level Indicator
6 External Cat Ladder
7 Overflow Pipe
8 Warning Pipe
9 Gate Valve
10 Check Valve
11 Landing Valve
12 Hose with Nozzle at Management Office
13 Air Release Valve c/w Ball Valve



11.1 DESCRIPTION

An automatic sprinkler system is intended to detect, control and extinguish a fire, and warn the occupants of the occurrence of fire. The installation comprises fire pumps, water storage tanks, control valve sets, sprinkler heads, flow switches, pressure switches, pipework and valves. The system operates automatically without human intervention. The sprinkler head has a liquid filled glass bulb that breaks due to the heat of the fire and releases water that sprays over the fire. The various types of sprinkler systems are as follows:

(a) Wet pipe installation where the pipework is filled with water and ready to discharge once the sprinkler bulb breaks.

(b) Dry pipe installation where the pipe is always filled with air under pressure. Air is released when the sprinkler bulb breaks and water fills the pipe and is discharged at the sprinkler head.

(c) Pre-action installation where the pipework is normally charged with air under pressure and a valve is opened to fill the system with water when fire is detected by smoke or heat detectors. Water is discharged only when the sprinkler bulb breaks.

(d) Deluge installation where the sprinkler head has no bulb and water is discharged simultaneously from all heads when fire is detected and the deluge valve is opened.

The wet pipe installation is the most common type and a typical sprinkler system is shown in Figure 11.1.

Sprinklers installed at 17 metres and above the floor to be protected are no longer effective and alternative solutions such as early response sprinkler heads, large droplet sprinkler heads or deluge systems have to be considered.

11.2 DESIGN REQUIREMENTS

11.2.1 Design Standards

Under the Uniform Building By-laws 1984, By-laws 226 and 228 refer to the requirements for sprinkler systems. The accepted standards for automatic sprinkler installations are :

- BS EN 12845 : 2003 - Automatic Sprinkler systems - Design, installation and maintenance.
- NFPA 13.

Where a particular standard is adopted, the sprinkler system should follow the selected standard in total and should not rely on clauses in other standards unless the specific aspect is not covered in the selected standard.

11.2.2 Occupancy Hazard Groups

Sprinkler systems are designed based on the hazard classification described in the BS EN 12845 as follows:

(a) Light Hazard for non-industrial occupancies with low quantity and combustibility contents, eg. apartments, schools and hospitals.

(b) Ordinary Hazard for commercial and industrial occupancies handling and storing ordinary combustible materials and is further grouped under:

- OH Group I for offices, restaurants and hotels;
- OH Group II for laundries, bakeries and tobacco factory;
- OH Group III for car parks, departmental stores, large retail shops and cinemas, clothing and paint factories, and
- OH Group IIIS for match factories, film and television studios.

For high rise buildings with multiple type of occupancies, the hazard class recommended is Ordinary Hazard Group III.

(c) High Hazard for commercial and industrial occupancies having abnormal fire loads covering process hazards, high piled storage hazards and oil and flammable liquid hazards and is further grouped under:

- Process risk, e.g. clothing, rubber, wood wool and paint factories; and
- High piled storage risks which is further divided into four categories as follows:
- Category I for carpets and textile exceeding 4 metres in height;
- Category II for furniture factory piled above 3 metres high;
- Category III for rubber, wax coated paper piled higher than 2 metres;
- Category IV for foam, plastics piled above 1.2 metres in height.

11.2.3 Sprinkler Pumps

The sprinkler pumps draw water from sprinkler storage tank to feed the sprinkler network. Two sets of pumps, one on duty and the other on standby, are provided together with a jockey pump to maintain system pressure. Sprinkler pump capacity should be selected to meet the duties defined for the various classes of hazards. The nominal pressure and flow requirements depend on the height measured between the topmost and bottom most sprinkler head and are as listed below:

(a) Light Hazard
- 15 metres : 300 cu dm/min at 1.5 bars
- 30 metres : 340 cu dm/min at 1.8 bars
- 45 metres : 375 cu dm/min at 2.3 bars

(b) Ordinary Hazard Group I
- 15 metres : 900 cu dm/min at 1.2 bars
- 30 metres : 1150 cu dm/min at 1.9 bars
- 45 metres : 1360 cu dm/min at 2.7 bars

(c) Ordinary Hazard Group II
- 15 metres : 1750 cu dm/min at 1.4 bars
- 30 metres : 2050 cu dm/min at 2.0 bars
- 45 metres : 2350 cu dm/min at 2.6 bars

(d) Ordinary Hazard Group III
- 15 metres : 2250 cu dm/min at 1.4 bars
- 30 metres : 2700 cu dm/min at 2.0 bars
- 45 metres : 3100 cu dm/min at 2.5 bars

(e) Ordinary Hazard Group IIIS
- 15 metres : 2650 cu dm/min at 1.9 bars
- 30 metres : 3050 cu dm/min at 2.4 bars

In addition to the above flow requirements, the sprinkler pump should be capable of satisfying two other flows and pressures as described in BS EN 12845.

Where the building exceeds 45 metres, multiple stages of sprinkler installations have to be installed such that the multiple stages will be able to serve the full height of the building with each stage not exceeding 45 metres.

The standby sprinkler pumpset should be supplied with power from the emergency generator if this is available. Otherwise, the standby pumpset should be diesel engine driven. Fuel supply should be adequate for minimum 4 hours of continuous operation for Ordinary Hazard and 6 hours for High Hazard applications. Electrical cabling to supply power to the sprinkler pumps should be of MICC or fire rated type. Batteries for the diesel engine should be maintenance-free type.

For sprinkler pumps protecting high rise buildings, the static pressure between the pump and the lowest sprinkler head should be added to the above pump pressure requirement.

The sprinkler pumps should be under positive head as far as possible, protected from fire and away from locations likely to be flooded. Sump pumps shall be installed where the fire pump room is located in the basement below external drainage levels. It should also be ventilated by natural or mechanical means and provided with the necessary signage. A carbon dioxide type portable extinguisher should be provided as well.

Where fire pumps are provided for hydrant systems, the water supply for the sprinkler system can be taken off from the fire mains provided the fire pumps and tanks are sized for simultaneous operation of the hydrant and sprinkler systems. Pressure reducing valves should be provided in such cases as the hydrant pressure is usually very much higher than that required for the sprinkler system.

11.2.4 Pump Starter Panels and Controls

Pump starter panel should be compartmented for each of the duty, standby and jockey pumps and complete with indicator lights as shown in the Figure 11.2. Ventilation slots should be provided with insect screen to prevent entry of vermin. Power supply cables to the panel should be of mineral insulated copper core (MICC) or fire rated type routed within areas with low fire risk. The pump starter panel should be placed within the same room as the fire pumps it controls.

Three pressure switches should be provided at each installation for starting of the sprinkler pumps with the following suggested pressure settings:

- starting the duty pumpset set at 80% of the system pressure;
- starting the standby pumpset set at 60% of the system pressure; and
- starting and stopping the jockey pumpset set at 90% and 110% of the system pressure respectively.

Electrical interlocks should be provided so that the sprinkler pumps at each installation should not operate in parallel simultaneously. A buzzer should be sounded should the isolator be in the off or manual position.

Sprinker pumpsets should be capable of automatic starting but should only be stopped manually.

11.2.5 Sprinkler Tanks

The sprinkler storage tank not dependent on inflow should have a minimum effective capacity depending on the hazard classification and the height of the lowest to highest sprinkler not exceeding the following:

(a) Light Hazard
- 15 metres : 9 cu. metres
- 30 metres : 10 cu. metres
- 45 metres : 11 cu. metres

(b) Ordinary Hazard Group I
- 15 metres : 55 cu. metres
- 30 metres : 70 cu. metres
- 45 metres : 80 cu. metres

(c) Ordinary Hazard Group II
- 15 metres : 105 cu. metres
- 30 metres : 125 cu. metres
- 45 metres : 140 cu. metres

(d) Ordinary Hazard Group III
- 15 metres : 135 cu. metres
- 30 metres : 160 cu. metres
- 45 metres : 185 cu. metres

(e) Ordinary Hazard Group IIIS
- 15 metres : 160 cu. metres
- 30 metres : 185 cu. metres

(f) High Hazard
Storage capacity shall be dependent on the design density of discharge in mm/min.

Sprinkler tanks may be of pressed steel, fibre reinforced polyester (FRP) or concrete. Pressed steel tanks where used should be hot dipped galvanized and coated internally with bituminous paint for corrosion protection. The water tanks should be compartmented unless they are of reinforced concrete and ball float valves, overflow pipes, drain pipes and water level indicators should be provided for each compartment. The external surface of the tank should be painted red or where this is not desirable, a red band of minimum 200mm should be painted to indicate that this is a fire tank.

The sprinkler tanks not dependent on inflow may be located in any location. The sprinkler tank may be combined with hose reel tank in which cases, the tank capacity should be the sum total of the water storage for both the sprinkler as well as for the hose reel system. The hose reel tap off level should be above the sprinkler tap off level so that the water reserved for sprinkler system is always maintained.

11.2.6 Breeching Inlet

Breeching inlets are provided so that the firemen can pump water into the sprinkler tank to make up for water used. The breeching inlet should be a 4-way type complying with M.S.1210: Part 3. Where the breeching inlet is enclosed within a box, the enclosure should comply with M.S.1210: Part 5 and labelled 'Sprinkler Inlet'. A drain should be provided at the bottom of the riser to drain the system after use.

Breeching inlets should be located no more than 18 metres from the fire appliance access road and not more than 30 metres from the nearest external hydrant outlet.

11.2.7 Sprinkler Heads

Sprinkler heads are generally of the conventional pendant or upright type. The temperature rating of the bulb is selected based on minimum 30°C above the maximum ambient temperature of the space protected. Typically, this will result in a nominal temperature rating of 68°C. In kitchen areas, the sprinkler heads should have a temperature rating of 79°C.

The maximum spacing and coverage to be protected by one sprinkler head shall be as follows:

- 21 sq. m for light hazard installation at not more than 4.6m apart;
- 12 sq. m for ordinary hazard installations at not more than 4m apart; and
- 9 sq. m for high hazard installations at not more than 3.7m apart.

Generally all areas of the building should be protected with sprinklers except for the following:

- Staircases enclosures;
- Electrical rooms; and
- Toilets

Where the ceiling void exceeds 800mm, sprinklers should be provided within this space unless they are of non-combustible construction and do not contain combustible materials. Electrical wiring within such ceiling void should be contained in steel conduit unless they are of the fire rated type.

Sprinkler heads should not be subjected to pressure in excess of 12 bars, especially in the case of high rise buildings.

11.2.8 Installation Control Valve

Each sprinkler installation should have installation control valves comprising main stop valves, alarm valves, drain line with stop valves, water flow gauges and pressure gauges. The maximum no. of sprinklers to be feed from one set of installation control valve shall be:

(a)	Light hazard	: 500 sprinklers
(b)	Ordinary hazard	: 1000 sprinklers
(c)	High hazard	: 1000 sprinklers

For sprinkler systems designed for life safety, the arrangement shall be a duplicate alarm valve set each with downstream and upstream stop valves, flow and pressure gauges, and alarm test line. Alternatively, the arrangement can be a single alarm valve set with downstream and upstream stop valves, flow and pressure gauges, alarm test line and a bypass with stop valve. All stop valves except for the bypass valves should be locked in the open position and its status monitored by the fire alarm system. Flow switches should be provided above the installation valves to provide indication of flow of water. The maximum no. of sprinklers to be feed from one set of installation control valve for life safety systems shall be 200 sprinklers per zone, with no limit on the no. of zones.

For car parks, separate installation control valve shall be provided to serve not more than 1000 sprinkler heads each.

Where the sprinkler system is sub-divided into zones, each floor of the building protected should be designed as one or more zone. A flow switch should be provided in the distribution pipe to each zone to provide indication of flow of water to sprinklers within that zone. Electrical monitored subsidiary stop valve should be also be provided for each zone to give monitoring alarm signal on the main fire alarm panel when the valve is not in the fully open position.

11.2.9 Sprinkler Pipework

Sprinkler pipework shall be of black steel or galvanized iron to B.S.1387 (Medium grade) Class B minimum while underground pipework should be heavy gauge of Class C. Pipes of sizes 80mm and below should be installed with screw joints and only pipes 100mm and above may be welded. Welding procedures and materials shall be in accordance with B.S.2640 and B.S.2971 and should be carried out by qualified welders. Radiographic tests should be carried out where doubts exist. Alternatively, mechanical grooved coupling can be used for jointing for all pipe sizes up to 250mm.

Sprinkler piping should not be concealed in the floor or ceiling concrete slabs. All piping should be painted with primer and finished with red gloss paint or otherwise identified with red bands of 100mm width minimum at elbows and tees.

For high rise buildings, the pressure loss through the distribution piping including risers and droppers between the highest design point in the installation and the zone subsidiary stop valve at the same floor shall not exceed 0.5 bars at a flowrate of 1000 l/min. This allowable pressure loss may be increased for those sprinklers below the highest design point but should not exceed the static head gain between the sprinkler concerned and the highest sprinkler point.

11.3 TEST REQUIREMENTS

11.3.1 Static Pressure Test

The system should first be flushed to clear all debris from the inside of the riser. The riser is then hydraulically tested to a pressure of 14 bars or 150% the working pressure, whichever is the higher for 24 hours, measured above the installation control valve and a check is carried out for leakage at the joints and landing valve connections.

11.3.2 Flow Test

The test valve on the drain line of the installation control valve should be opened to permit full flow. The flowrate and pressure should be recorded and checked against the design flowrate required.

Each zone should be tested by opening the isolation valve on the test line. The flow switch for that zone should indicate an alarm on the fire alarm panel.

11.4 MAINTENANCE REQUIREMENTS

11.4.1 Inspection and Testing

A flow test should be carried out at the installation control valve to ensure that the pumps are in proper working condition. The pipework should be checked for leakage and the installation control valves, sprinklers, breeching inlets and drain valves should be inspected as recommended in the checklist attached.

The zone flow switches should be tested and the alarm should be indicated on the fire alarm panel.

11.5 DESIGN CHECKLIST

(a) Classification of fire hazard : -
- ❑ Light hazard
- ❑ Ordinary hazard : ______________
- ❑ High hazard
- ❑ Process hazard : Type ______________
- ❑ High piled storage hazard : Type ______________
- ❑ Portable spirit storage hazard : Type ______________
- ❑ Oil and flammable liquid hazard : Type ______________
- ❑ Other : ______________

(b) System Type :
- ❑ Wet
- ❑ Pre-action
- ❑ Deluge
- ❑ Other : ______________

(c) For high piled storage hazard :
- • Storage commodity : ______________
- • Storage height : ______________
- • Ceiling height : ______________

(d) Design density : ______________ (litres/min) / m^2

(e) Design area of operation : ______________ m^2

(f) Water source :
- ❑ Pump suction tank
- ❑ Fire water main
- ❑ Gravity tank
- ❑ Other : ______________

(g) Design water supply capacity : ______________ m^3

(h) Duration of water supply : ______________ minute.

(i) Water tank high / low level monitoring.

(j) Hydraulic calculation :
- ❑ Fully calculated
- ❑ Pre-calculated

(k) Sprinkler type :
- ❑ Conventional
- ❑ Spray
- ❑ Other : ______________

(l) Sprinkler temperature rating : __________ °C

(m) Design coverage area : __________ m² per sprinkler.

(n) Sprinkler spacing : ________ m X __________ m.

(o) Sprinkler K factor : ______________

(p) Sprinkler nominal size : ____________ mm.

(q) Minimum pressure at any discharging sprinkler : ___________ bar.

(r) Pipe material : ______________________________

(s) Total number of alarm control valve : __________ nos.

(t) Maximum number of sprinkler per installation : _______________ nos.

(u) Total number of sprinkler zone :_________________ nos.

(v) Maximum number of sprinkler per zone : _________________nos.

(w) Pressure and flow rate at alarm valve : _______ litres/min at ______ bars.

(x) Sprinkler Pump:
- Rated nominal flow rate : ________ litres/min at _____ metre head.
- Rated power : __________ kW.

(y) For diesel engine :
- Fuel capacity sufficient to run engine at full load for _______ hours.
- Reserve supply of fuel for ______ hours of engine full load running.

(z) Pipe nominal size :- Suction : _________ mm ; Delivery : _________ mm

11.6 VISUAL INSPECTION CHECKLIST

11.6.1 Visual Inspection of Water Supplies
Capacity of water available

Compartmentation of sprinkler tanks.

Priming tank (if any).

Monitoring of water tank level.

Vortex inhibitors for water tanks.

Flow metre.

Breeching inlet.

11.6.2 Visual Inspection of Sprinklers
Spacing of sprinkler heads.

- area of coverage
- maximum and minimum distance between sprinklers
- maximum and minimum distance between walls / partitions
- distance from beams, columns and other obstructions
- obstruction below sprinklers
- depth and combustibility of ceiling void
- clear space below sprinklers

Physical condition of sprinkler heads.

Temperature rating of sprinkler heads.

Sprinkler guards.

Spare sprinklers and sprinkler spanners.

11.6.3 Visual Inspection of Pipework
Type of pipes used.

Protection of underground pipework.

Painting of pipework.

Number of sprinklers installed on range and distribution pipes.

Pipe hangers and supports for pipework.

Pipe sleeves.

Fire seal.

Flow switches.

Total length of pipework between alarm valve and water alarm gong.

11.6.4 Visual Inspection of Sprinkler Pumps
Protection of rotating parts of pump sets.

Mounting of pump sets.

11.7 TESTING AND COMMISSIONING CHECKLIST

11.7.1 Testing and Commissioning of Water Supplies
Pump operating current and voltage.

Pump operating pressure and flow rate.

Pump operating RPM.

Pump not overheating.

Vibration and noise level.

Testing of electrical wiring system.

Alternative power supply for electric pumps.

Batteries for diesel pumps.

Fuel for diesel pumps.

Automatic operation of pumps.

11.7.2 Testing and Commissioning of Pipework

Hydrostatic testing of pipework.

Flushing of pipework.

Spray pattern of sprinkler.

Alarm gong operating.

Flow switches test.

Zone monitoring (tamper switch).

Table 11.1 Sample of Sprinkler Hydraulic Calculation

PROJECT												
Designed by			Checked by			Approved by				Job No.		
HAZARD CLASS :			Ordinary Group III			FLOWRATE : 1000 L/min				Date		
INSTALLATION VALVE NO. :			1			SIZE OF VALVE : 150mm				Sheet		
Design Point			Pipe Dia. (mm)	Pipe Length (m)	Bends		Total Equiv. Length (m)	Flow Rate (dm³/min)	Friction Loss (mb)	Static Head Gain (mb)	Total Loss less Static Head (mb)	
Symbol	Floor	Ref. Grid Lines			No. Off	Equiv. Length (m)						
A	3RD	C-D/3-1	65	3.5	EL 0 TE		3.5	1000	122			
			80	7	EL 0 TE		7	1000	111			
			100	49	EL 2 TE	6	55	1000	240			
									473	0	473	
B	3RD	C-D/3-2	65	7	EL 0 TE		7	1000	243			
			80	1.9	EL 0 TE		1.9	1000	30			
			100	20	EL 1 TE	3	23	1000	101			
									374	0	374	
C	2ND	C-D/2-1	65	10.5	EL 0 TE		10.5	1000	365			
			80	16.9	EL 0 TE		16.9	1000	268			
			100	28.3	EL 2 TE	6	34.3	1000	150			
									783	380	403	
D	2ND	C-D/2-2	65	8.8	EL 0 TE		8.8	1000	306			
			80	0	EL 0 TE		0	1000	0			
			100	16.3	EL 1 TE	3	19.3	1000	84			
									390	380	10	
E	GRD	C-D/1-1	65	10.5	EL 0 TE		10.5	1000	365			
			80	38.9	EL 2 TE	6	44.9	1000	712			
			100	2.5	EL 0 TE		2.5	1000	11			
									1088	760	328	
F	GRD	C-D/1-2	65	8.9	EL 0 TE		8.9	1000	309			
			80	9.9	EL 1 TE	3	12.9	1000	205			
			100	2.5	EL 0 TE		2.5	1000	11			
									525	760	-235	

Note : Pressure loss in all sections of distribution pipe should not exceed 500mbar.

Table 11.1 Sample of Sprinkler Hydraulic Calculation (Cont)

PROJECT			
Designed by	Checked by	Approved by	Job No.
HAZARD CLASS :	Ordinary Group III	FLOWRATE : 1000 L/min	Date
INSTALLATION VALVE NO. :	1	SIZE OF VALVE : 150mm	Sheet

Design Point			Pipe Dia. (mm)	Pipe Length (m)	Bends		Total Equiv. Length (m)	Flow Rate (dm³/min)	Friction Loss (mb)	Static Head Gain (mb)	Total Loss less Static Head (mb)
Symbol	Floor	Ref. Grid Lines			No. Off	Equiv. Length (m)					
G	3RD	C-D/3-1	65	3.5	EL 0 TE		3.5	1000	122		
			80	7	EL 0 TE		7	1000	111		
			100	49	EL 2 TE	6	55	1000	240		
									473	0	473
H	3RD	C-D/3-2	65	7	EL 0 TE		7	1000	243		
			80	1.9	EL 0 TE		1.9	1000	30		
			100	20	EL 1 TE	3	23	1000	101		
									374	0	374
I	2ND	C-D/2-1	65	10.5	EL 0 TE		10.5	1000	365		
			80	16.9	EL 0 TE		16.9	1000	268		
			100	28.3	EL 2 TE	6	34.3	1000	150		
									783	380	403
J	2ND	C-D/2-2	65	8.8	EL 0 TE		8.8	1000	306		
			80	0	EL 0 TE		0	1000	0		
			100	16.3	EL 1 TE	3	19.3	1000	84		
									390	380	10
K	GRD	C-D/1-1	65	10.5	EL 0 TE		10.5	1000	365		
			80	38.9	EL 2 TE	6	44.9	1000	712		
			100	2.5	EL 0 TE		2.5	1000	11		
									1088	760	328
L	GRD	C-D/1-2	65	8.9	EL 0 TE		8.9	1000	309		
			80	9.9	EL 1 TE	3	12.9	1000	205		
			100	2.5	EL 0 TE		2.5	1000	11		
									525	760	-235

Note : Pressure loss in all sections of distribution pipe should not exceed 500mbar.

Figure 11.1 Sprinkler System Typical Arrangement Drawing
SCALE: N.T.S

COMPONENT / EQUIPMENT

1 Water Tank	15 Concentric Reducer
2 4-Way Breeching Inlet	16 Check Valve
3 Vent Pipe c/w Mosquito Net	17 Jockey Pump
4 Access Opening	18 Pump Start Test Pipe
5 Level Indicator	19 Pump Starter Panel
6 External Cat Ladder	20 Sprinkler Alarm Valve
7 Overflow Pipe	21 Flow Metre
8 Warning Pipe	22 Sprinkler Alarm Valve
9 Standby Pump	23 Butterfly Valve
10 Eccentric Reducer	24 Flow Switch
11 Expansion Joint	25 Drain Valve
12 Y-Strainer	26 Sprinkler Head
13 Gate Valve	27 Air Release Valve c/w Ball Valve
14 Duty Pump	

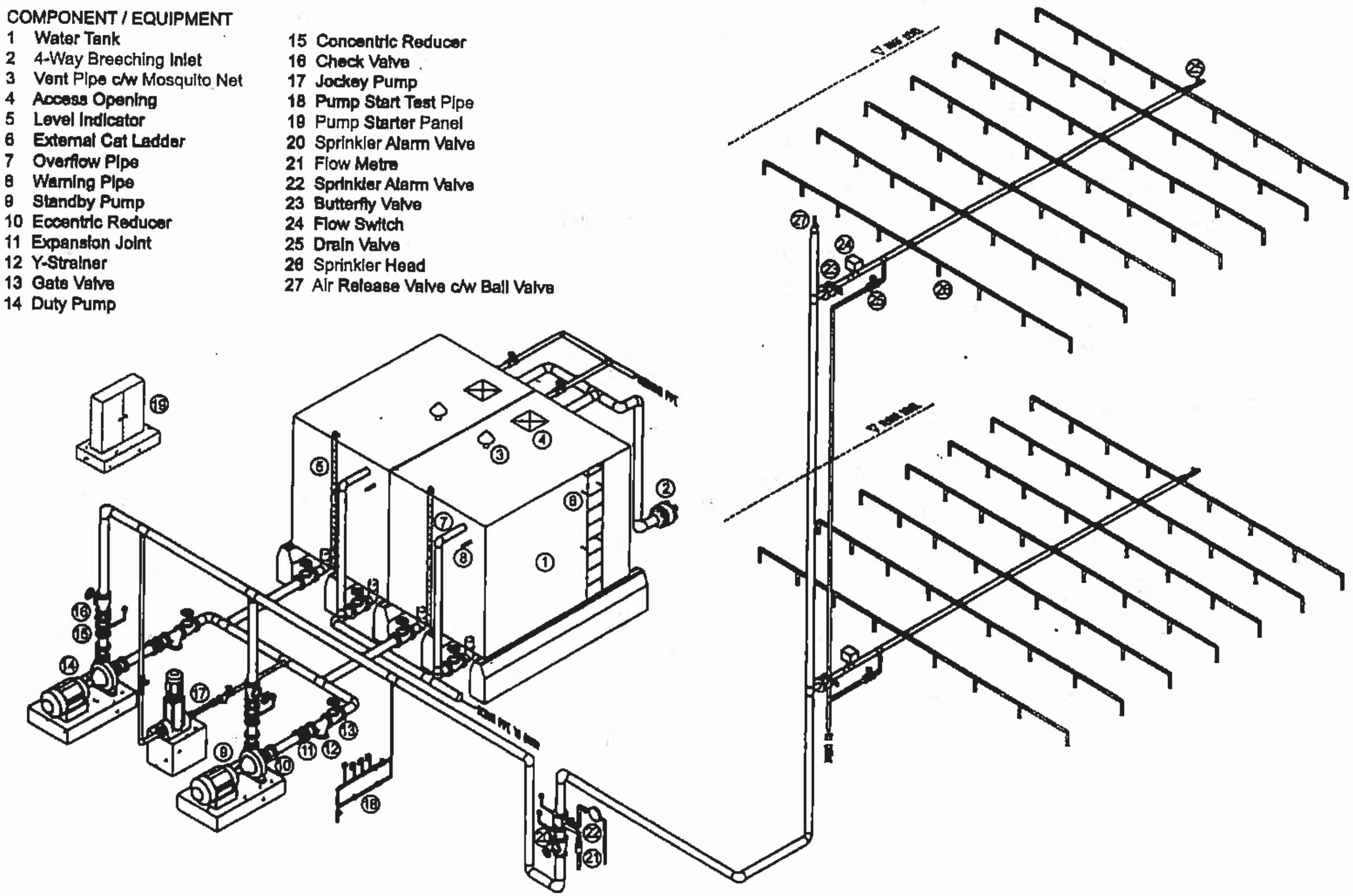
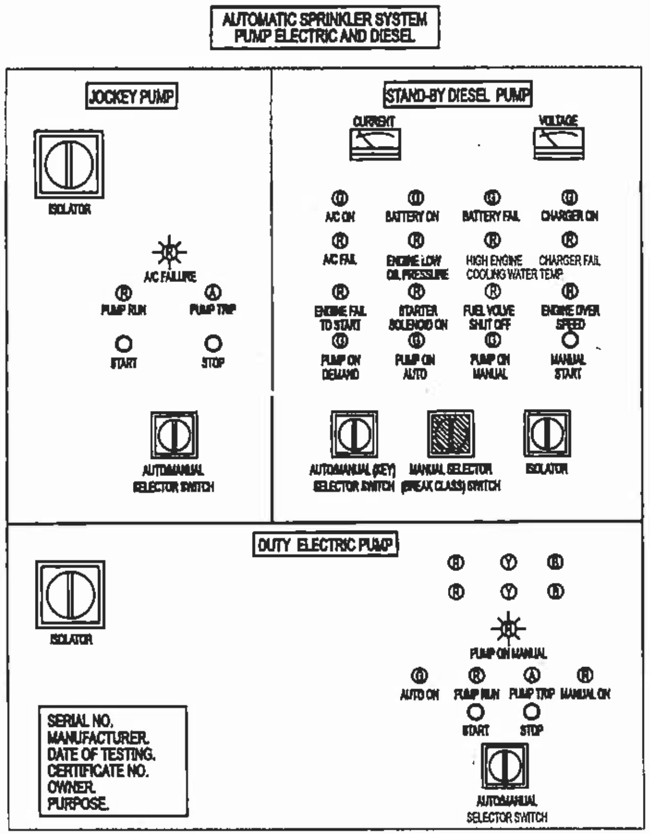


Figure 11.2 Automatic Sprinkler Pump Starter Panel



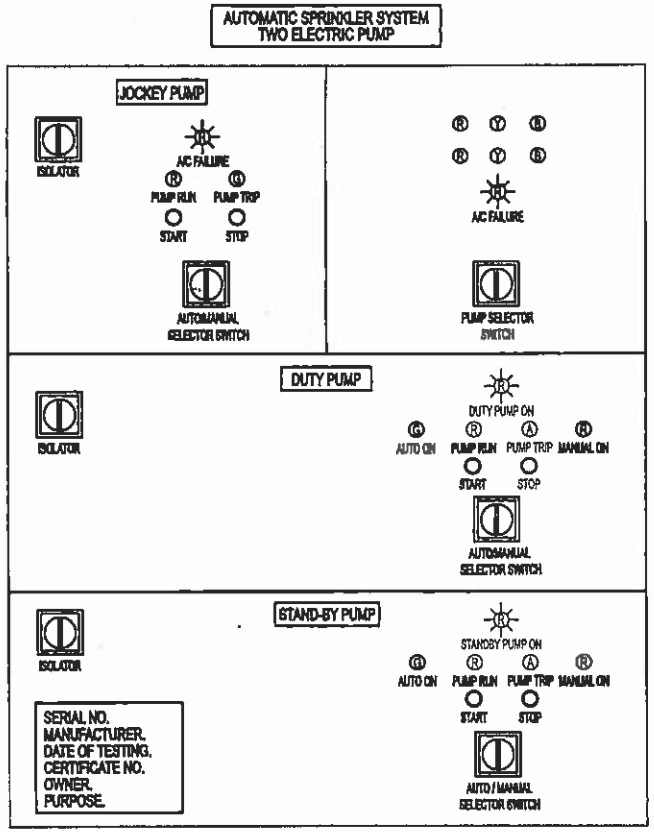
Note:

1. Phase indicator shall be shown in duplicate (double filament bulbs with a single alignment is acceptable as a alternate)

2. A/C failure indicator shall be monitored on to the fire alarm indicator panel.

Legend

- Ⓡ :- Red light
- Ⓨ :- Yellow light
- Ⓑ :- Blue light
- Ⓖ :- Green light
- Ⓐ :- Amber light
- Ⓡ (flashing symbol) :- Red flashing light



12.1 DESCRIPTION

Carbon Dioxide extinguishing system consists of carbon dioxide cylinders, steel piping, discharge nozzles, heat and/or smoke detectors and a control panel, which monitors the space, activates both visual and audio alarms before releasing the gas.

The carbon dioxide is discharged after a time delay upon detection of fire to warn any occupant to evacuate the room. Such system is usually provided for electrical transformer rooms, switchrooms and standby generator rooms and should not be installed for rooms, which are normally occupied.

A typical carbon dioxide extinguishing installation is shown in Figure 12.1.

12.2 DESIGN REQUIREMENTS

12.2.1 Design Standards
The relevant clause in the Uniform Building By-laws 1984, relating to carbon dioxide extinguishing systems is By-law 235 and the applicable standard is:

- MS 1590 : 2003.

12.2.2 System Operation
The quantity of extinguishing agent should be sufficient to ensure rapid extinction of any fire in the protected areas and with adequate spare capacity. The protected area should be flooded with Carbon Dioxide gas with flame extinguishing concentration of 50% at 21°C and shall be based on total flooding principle and/or local application with a time delay period of 30 seconds, adjustable up to 60 seconds maximum. The duration of total discharge shall not exceed 1 minute except for deep seated fires where the total discharge shall not exceed 7 minutes or 30% discharge within 2 minutes.

For local application using high pressure storage, the design quantity of carbon dioxide should be increased by 40% as only liquid portion of the discharge is effective.

All devices shall be designed for the service encountered and shall not be readily rendered inoperative or susceptible to accidental operation. They shall be located, installed or suitably protected against mechanical, chemical or other damage, which may render them inoperative. All devices for shutting down supplementary equipment shall be considered integral parts of the system and shall function with system operation.

The system shall operate from a supply voltage of 240 volts A.C., 50 Hz to the power charger module within the control panel. This voltage is transformed and rectified within the panel to 24 volt D.C. A 24 volt D.C standby battery of the maintenance free type shall be provided in case of mains voltage failure. This battery will automatically and Instantaneously be switched into use as soon as the mains supply fails. Such a failure shall be indicated both visually and audibly at the panel. The battery shall be trickle charged during normal operating conditions.

The space should be protected by two or more heat or smoke detectors. When one of these detectors goes into the alarm condition, the indicator light on the control panel should illuminate and an audible warning sounded via the alarm bell.

In order to discharge the extinguishing agent automatically, at least two detector zones must be activated. This mode of operation term as cross zoning will obviate the possibility of false discharge of the gas due to one detector operating to conditions which are regarded as normal.

Also to be provided is the independent facility for emergency operation by manually discharging the agent via a "break glass" handle type manual pull box which should be mounted outside the exit door to the protected space.

The detectors circuit wiring shall be supervised continuously for line fault. A disconnection to this circuit would be indicated as a fault at the control panel both visually and audibly by a fault lamp and buzzer.

12.2.3 Carbon Dioxide Cylinders
The Carbon Dioxide gas is stored in cylinders designed to hold the gas in liquefied form at ambient temperatures. The gas can be stored at low pressure of 2068 kPa with refrigeration or under high pressure at 5171 kPa at ambient temperatures. Most systems use high pressure storage due to cost considerations. Cylinders should be suitable for a working pressure of 59 bars at 21°C and pressure tested at 228 bars.

A reliable means of indication by weighing should be provided to determine the amount of gas in the cylinders. Each system should have a permanent name plate specifying the number, filling weight and the pressurisation level of the cylinders. All cylinders supplying the same manifold outlet for distribution of agent should be interchangeable and of one selected size. Where more than three cylinders are required, a pilot cylinder should be provided to activate the discharge valve from each cylinder.

Each container should be equipped with a discharge valve of the solenoid operated type to discharge liquid agent at the required rate. Containers with top-mounted valves should have an internal dip tube extending to the bottom of the cylinder to permit discharge of liquid phase agent.

Gas cylinders should be located outside of the hazard which it protects wherever possible. However, the risk of vandalism should also be taken into consideration.

12.2.4 Carbon Dioxide Control Panel
The system control panel should indicate the operation of the system, hazards to personnel, or failure of any supervised device and complying with M.S.1404 and B.S.7273. A positive alarm and indicator should be provided to show that the system has operated.

Alarm should be provided to give warning of a discharge or pending discharge where a hazard to personnel may exist. Alarms indicating failure of supervised devices or equipment should give prompt and positive indication of any failure and should be distinctive from alarms indicating operation or hazardous conditions.

A device should be incorporated into the system to shut down any exhaust fans and activate solenoid operated curtains across louvres before discharge.

Since a remote manual control should be a manual pull box type, a pressure switch in the discharge pipe may be required to provide the signal back to the control panel that the carbon dioxide gas has been discharged.

12.2.5 Discharge Nozzle
Discharge nozzles should be selected for use with carbon dioxide and for their discharge characteristics. For low pressure storage, nozzle pressure should be 1034 kPa minimum and for high pressure storage, the nozzle pressure should be 2068 kPa. The discharge nozzle should consist of the orifice and any associated horn, shield or baffle. Discharge orifices should be of corrosion resistant metal.

Discharge nozzle should be permanently marked to identify the nozzle and to show the equivalent single orifice diameter regardless of shape and number of orifice. This equivalent diameter shall refer to the orifice diameter of the 'Standard' single orifice type nozzle having the same flow rates as the nozzle in question. The marking should readily be discernable after connection. Discharge nozzle should be provided with frangible disc or blow out caps where clogging by foreign materials is likely.

12.2.6 Automatic Fire Detectors and Audio/Visual Alarm Units

The automatic fire detection is usually by means of either heat or smoke detectors. The detectors should be resistant to corrosion.

The audio unit should produce an audible warning at least 65dB noise level or 5dB above the ambient noise level. The audio alarm unit of alarm bell type should be of the trembling (not single stroke) and shall operate from the fire alarm panel battery supply. All audio/visual alarm circuitry shall be designed to be able to function continuously during the fire. The bells may be installed in any location for alarm purpose.

12.2.7 Pipework and Fittings

The material of piping and fittings, etc. for the installation of the system must be of non-combustible heat resisting and must have capacity to maintain its own shape in room temperature during the outbreak of fire. All piping should be of API Schedule 40 steel pipe for low pressure storage systems. For high pressure storage systems, piping should be of Schedule 40 for 20mm dia. pipes and Schedule 80 for 25mm dia. and above. Flexible piping, tubing or hoses (including connections) where used should be able to withstand the pressure ratings.

12.2.8 Warning Signs

Warning and instruction signs should be installed at entrances to and inside protected areas at prominent positions.

12.3 DESIGN CHECKLIST

(a) Hazard types :

- ☐ Flammable liquid materials.
- ☐ Electrical hazard.
- ☐ Ordinary combustibles (paper, wood and textiles).
- ☐ Hazards solids.
- ☐ Other : ______________

(b) Type of fire to be protected from :

- ☐ Deep seated fire (solids subject to smouldering)
- ☐ Surface fire (flammable liquids, gas and solids)
- ☐ Other : _____________

(c) Type of protection :

- Total flooding system
- Volume to be protected : _________ m^3.
- Design carbon dioxide concentration : ________ %.
- Volume factor : ___________
- Flooding factor : ___________
- System discharge rate : ___________ kg/minute.

☐ Local application system

☐ Rate by area method
- Area to be protected : ____________ m^2.
- Area per nozzle : ____________ m^2.
- Nozzle discharge rate : ____________ kg /minute per nozzle.

☐ Rate by volume method
- Assumed enclosure : ____________ m^3.
- System discharge rate : ____________ kg/minute.
- Nozzle spacing : ____________ m.

(d) Total number of nozzle : ____________ nos.

(e) Nozzle type : ________________ ; nominal size : ____________ mm.

(f) Duration of discharge : ________________

(g) Storage type :
☐ Low pressure (average storage pressure : 2,068 kPa)
- Design nozzle pressure (minimum 1,034 kPa) : _______ kPa.
- Pipe material shall be minimum of Schedule 40 or equivalent.

☐ High pressure (average storage pressure : 5,171 kPa)
- Design nozzle pressure (minimum 2,068 kPa) : _______ kPa.
- Pipe material shall be Schedule 40 or equivalent for nominal size up to 20mm and minimum Schedule 80 or equivalent for nominal size greater than 20mm.

(h) Total quantity of carbon dioxide cylinder : _______ nos (_____kg per cylinder)

(i) Additional quantity of carbon dioxide (to compensate for opening cannot be closed during extinguishment or special condition) : ____________

* For local application, high pressure storage, the design quantity of carbon dioxide shall be increased by 40% due to only liquid discharge portion is effective .

(j) Design calculations.

(k) Electrical clearance :
- System voltage : ________ kV.
- Clearance provided

(l) Detection type : ______________

(m) Actuation type : ______________

(n) Manual operating device : ________________

12.4 VISUAL INSPECTION CHECKLIST

12.4.1 Visual inspection of cylinders
Capacity of cylinders.

Location of cylinders.

Pilot cylinders.

Flexible hoses.

Safety valve.

Support brackets.

Weighing facility.

12.4.2 Visual Inspection of pipework
Type of pipes used.

Painting of pipework.

Pipe support.

Pipe sleeves.

Fire seal.

Nozzles.

12.4.3 Visual Inspection of detectors
Physical condition of detectors.

Conduit for all wiring.

12.4.4 Visual Inspection of panels
Protection of panel.

Mounting of panel.

12.4.5 Visual Inspection of accessories
Flashing lights.

Tripping devices.

Signage.

Visible and audible alarms.

Electrical and mechanical manual activation.

12.5 TESTING AND COMMISSIONING CHECKLIST

12.5.1 Testing and commissioning of pipework
Pneumatic testing of pipework.

12.5.2 Testing and commissioning of detectors
Detector test.

Electrical wiring test.

Interfacing of detectors and control panel.

12.5.3 Testing and commissioning of panel
LED test.

1 zone alarm test.

2 zone alarm test.

Discharge test.

Fault test.

Connection to main fire alarm.

12.5.4 Testing and commissioning of system
Simulated automatic discharge test.

Simulated manual discharge test.

Actual discharge test.

Bracket support during actual discharge test.

Table 12.1 Sample of Carbon Dioxide Extinguishing System

PROJECT			Date :
Job No. :	Calc. By :	Chkd. By :	Sheet No. : 1
CARBON DIOXIDE EXTINGUISHING SYSTEM			

1. ROOM DIMENSIONS

Room Name	:	Electrical Switch Board Room
Room Dimensions (in feet)	:	3.4m (L) x 3.0m (W) x 4.0m (H)

2. DESIGN CRITERIA

Design Code	:	NFPA 12:1985
Hazard Type	:	Total Flooding - Deep Seated
Design Concentration	:	50%
Rate of Application	:	Complete discharge in 7 minutes or 30% discharge in 2 minutes (Minimum)
Room Temperature	:	81°F (27.2°C)

3. AGENT DISCHARGE

Volume of Space (V)	:	40.8 m^3
Flooding Factor (F)	:	1.6 kg/m^3
Basic CO_2 Quantity (W)	:	40.8 (V) x 1.6 (F) = 65.28 kg

4. TOTAL AGENT QUANTITY

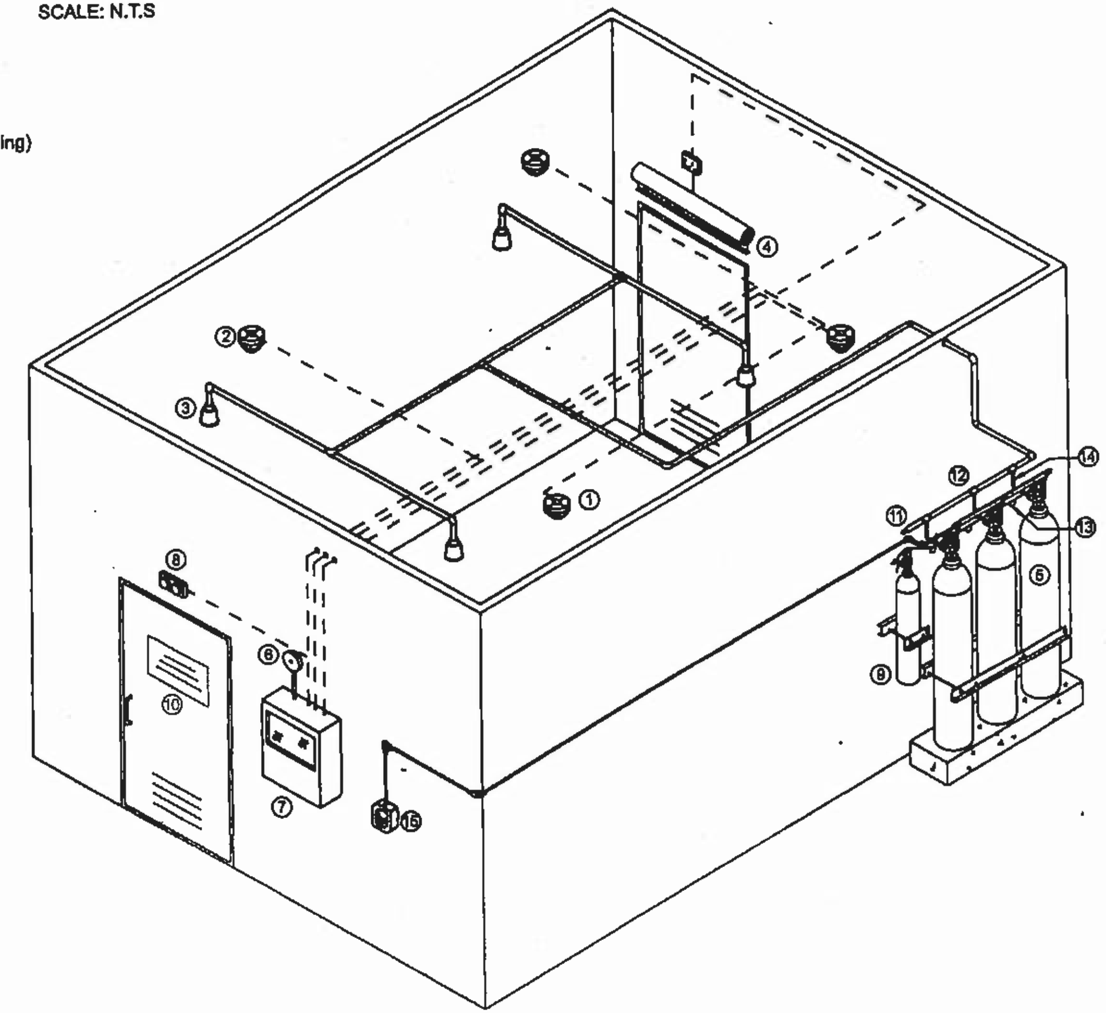
Basic CO_2 Quantity (W)	:	65.28 kg
Safety factor (5%)	:	3.264 kg
Total CO_2 Quantity (W_T)	:	68.544 kg
Agent Weight per Cylinder (W)	:	45 kg
No. of Cylinders	:	68.544 (W_T) / 45 (W_C) = 1.5232 Nos.
No. of Cylinders Provided	:	2 (Nos.) x 45 (kg) each

Figure 12.1 Carbon Dioxide Extinguishing System Typical Arrangement Drawing

SCALE: N.T.S

COMPONENT / EQUIPMENT

1 Heat Detector
2 Smoke Detector
3 Extinguishing Nozzles
4 Fire Curtain (for Louvre Door / Opening)
5 CO_2 Cylinder c/w Accessories
6 Alarm Bell
7 Double Inter-lock Control Panel c/w Back Up Battery
8 Normal / Discharge Light
9 Pilot Cylinder c/w Solenoid Valve
10 Warning Signage
11 Safety Plug
12 Piping Manifold
13 Copper Tubing
14 Discharge Hose c/w Check Valve
15 Manual Pull Station



AUTOMATIC FIRE DETECTION AND ALARM SYSTEM

13.1 GENERAL

13.1.1 System Concept

Fire detection and alarm systems are designed to provide warning of the outbreak of fire and allow appropriate fire fighting action to be taken before the situation gets out of control. As all systems are designed primarily to protect life, property, this places a great responsibility on the designer because each building will present a different set of problems in relation to the risk of fire and fire spread. Each fire detection and alarm system therefore must be specially designed to meet the requirements for each building.

13.1.2 Design Requirements

(i) **Codes and Standards**

(a) Automatic Fire Detection and Alarm System shall be designed based on:

B.S.5839 : Part 1
- Code of Practice for Design, Installation and Servicing.

B.S.5839 : Part 3
- Specification for Automatic Release Mechanism for certain Fire Protection Systems.

B.S.5839 : Part 5
- Specification for Optical Beam Smoke Detectors

M.S.1176 : Part 5
- Specification for Components of Automatic Fire Detection Systems
  Part 5 : Heat Sensitive Detectors - Point Detectors containing a Static Element System

M.S.1176 : Part 7
- Specification for Components of Automatic Fire Detection Systems
  Part 7 : Specification for Power-type Smoke Detector using Scattered Light, Transmitted Light or Ionization

M.S.1176 : Part 8
- Specification for Components of Automatic Fire Detection Systems
  Part 8 : Specification for High Temperature Heat Detectors

M.S.1176 : Part 9
- Specification for Components of Automatic Fire Detection Systems
  Part 9 : Methods of Test of Sensitivity to Fire

M.S.1471 : Part 3
- Vocabulary on Fire Protection
  Part 3 : Fire Detection and Alarm

M.S.1745 : Part 1
- Fire Detection and Fire Alarm Systems
  Part 1 : Introduction

M.S.1745 : Part 2
- Fire Detection and Fire Alarm Systems
  Part 2 : Control and Indicative Equipment

M.S.1745 : Part 3
- Fire Detection and Fire Alarm Systems
  Part 3 : Audible Fire Alarm Devices

M.S.1745 : Part 4
- Fire Detection and Fire Alarm Systems
  Part 4 : Power Supply Equipment

M.S.1745 : Part 11
- Fire Detection and Fire Alarm Systems
  Part 11 : Manual Call Point

B.S.7273 : Part 1
- Code of Practice for the Planning, Installation and Servicing of Electrical Equipment for Actuation of Gaseous Fire Suppression System

B.S.6266
- Code of Practice for Fire Protection for Electronic Data Processing Installations

(b) Automatic Fire detection and Alarm System requirements shall be based on:

- By- law 133 - UBBL 1984
- By- law 225 (1) - UBBL 1984
- By- law 237 - UBBL 1984
- By- law 238 - UBBL 1984
- By- law 239 - UBBL 1984
- By- law 240 - UBBL 1984
- By- law 241 - UBBL 1984
- By- law 244 (g) - UBBL 1984
- By- law 245 - UBBL 1984
- By- law 246 - UBBL 1984
- Tenth schedule - UBBL 1984

(c) Other relevant standards:

- B.S.5588 : Part 1
- B.S.5588 : Part 8
- B.S.5588 : Part 10

(ii) Type of Protection and Coverage

When designing a fire detection and alarm system, the objective has to be established whether it is for protecting the building and its contents or enhancing the safety of the occupants.

(a) Manual
A system which provides manual alarm only

(b) Automatic
A system that automatically detects a fire and initiates an effective alarm.

(c) Actuation of Ancillary Services

Fire detection and alarm system shall also be designed with the provision to close or open the circuit of ancillary services by means of relays or similar devices. The provision shall be for fire suppression system activation indicators or for activation of active fire suppression systems.

(d) Life protection

This classification provides for the protection of life, which is the safety of the occupants. It caters for the detection of a fire, initiates an alarm of fire, and provides sufficient time for the occupants to escape from the building.

(e) Property protection

This classification provides for the protection of property and its contents. It caters for the automatic detection of a fire, initiates an alarm of fire, indicates the location of the fire within the premises and summons the fire brigade.

(iii) Zone Configuration

One major function of a fire detection and alarm system is to indicate the location of a fire as precisely as possible. Hence detectors are grouped into zones. For conventional system, each zone is connected to the controller by a separate circuit. For addressable systems, one circuit may connect up to 99 detectors and protect several zones.

(a) Zones configuration guidelines

- The maximum floor area of a zone should not exceed $200m^2$.
- The search distance - the total travel distance by a searcher within a fire zone to determine visually the position of a fire should not exceed 30 metres.
- A single zone may extend to cover several fire compartments but shall lie along compartment boundaries.

(iv) Type of Fire Detection System

There are four types of fire detection systems:

(a) Conventional system

(b) Addressable system

(c) Analogue addressable system

(e) Air sampling system

13.1.3 Design Checklist

(i) System shall be designed in accordance to UBBL and relevant standards.

(ii) All requirements and limitations stated within UBBL shall be observed.

a. System type : Conventional / Addressable / Analogue Addressable / Air sampling

b. Total floor area : ______________________ m^2

c. Building height : ______________________ m

d. Total number of Zones : ______________________

e. Max area per zones : ______________________ m^2

f. Max number of detector / zone : ______________________

g. Number of loops : ______________________

h. Alarm mode : Manual / Automatic

13.2 CONTROL AND INDICATIVE EQUIPMENT

13.2.1 Concept

Control and Indicative Equipment will comprise equipment for the reception, indication, control and relaying of signals originating from detectors or manual call points connected to it, and for activation of alarm sounders and alarm signaling devices.

13.2.2 Design Requirements

(i) Codes and Standards

Control and Indicative Equipment for automatic fire detection and alarm system shall comply with:

B.S.5839 : Part 1
- Automatic Fire Detection and Alarm System for Buildings: Code of Practice for System Design, Installation and Servicing

B.S.1404 : Part 4
- Specification for control and indicative equipment

(ii) Operation Requirements

(a) The main Control and Indicative Equipment shall be located in the building fire command/ control centre in area on the ground floor. If command / control centre is not available, it shall be sited where it can be under constant observation in a position clearly visible from the main entrance.

(b) Noise or other sound levels in the vicinity of the Control and Indicative Equipment should not mask the audible alarm of sounders located near the control panel.

(c) The ambient light level in the vicinity of the Control and Indicative Equipment should be such that any visual indications can be clearly seen, and any instructions for use can be clearly read.

(d) Control and Indicative Equipment should be sited in areas of low risk, so that the equipment is unlikely to be involved in a fire before adequate warning has been given.

(e) If the system uses automatic detectors, then the area where the Control and Indicative Equipment is sited should be protected by the detection system.

(f) The fire alarm system should indicate the origin of the fire. The indications should be such that they can be easily, quickly and unambiguously related to the position in the building from which the alarm has originated.

(g) The primary indication of the origin of the alarm should be an indication of the zone of origin.

(h) The method of identification should be developed to match the extent of the premises. The method used should ensure rapid location of the fire, and should enable decisions to be made as to which parts (usually fire compartments) need to be evacuated.

(j) The location may be shown by one or more of the following:

- A display of letters and / or numbers, together with a suitable key (which may be the plan of a building).

- A permanent mimic diagram.

Note: Printers are not considered suitable as a primary indication, since in the event of ink, ribbon or paper being exhausted, the indication will be lost. They may, however, be acceptance as a backup to another display.

(k) On or adjacent to the Control and Indicative Equipment should be a complete set of the latest architecture building plans indicating the layouts of all fire protection systems and equipment, the circulation area and escape routes, and all fire alarm zones.

(l) All Control and Indicative Equipment should be connected to the nearest fire station through CMS system.

(m) The operation of all manual control and isolating devices should be limited to authorised personnel. Where controls need to be operated during a fire, access should not be controlled by a key - entered code.

(n) A logbook shall be kept in which details of all alarm (genuine, practice, test or false) fault, isolation, test and service shall be recorded in this logbook. When the fire alarm system is equipped with a printer, the print out information may be the event log record, but shall be tagged and recorded in the logbook. A recommended format for the logbook is described in Table 13.1.

TABLE 13.1 Log record for Automatic Fire Detection and Alarm system.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

13.2.3 Testing and Commissioning

(i) Check and ensure Control and Indicative Equipment is located in the control room on the ground floor near the main entrance of the building.

(ii) Ensure the ambient light and noise environment will not affect the proper operation of the Control and Indicative Equipment.

(iii) Check and ensure that the Control and Indicative Equipment is located in the area of low risk.

(iv). Check and ensure that the control room is protected by automatic fire detection and alarm system.

(v) Check and ensure that the Control and Indicative Equipment is tested to MS 1404 : Part 4 : 1996 and is type approved by the Fire and Rescue Department Malaysia.

(vi) Check and ensure that the facial features and the monitoring facilities provided for at the Control and Indicative Equipment comply with the requirements of the Fire Rescue Department Malaysia.

(vii) Check and ensure that a complete set of the latest architecture building plans indicating the layouts of all fire protection systems and equipment, the circulation area and escape routes, and all fire alarm zones is kept in the control room.

(viii) Check and ensure that a logbook is kept in the control room for logging all events to-date.

(ix) Before initiating test, ensure that the back-up battery is properly connected and ensure main power is being supplied to the Control and Indicative Equipment.

(x) With the Control and Indicative Equipment switched on, ensure the " Mains On " and " DC On" indications are illuminated. Ensure also " Mains Fail " and " Charger Fail " indications are not illuminated.

(xi) The voltage reading at the voltmetre at the Control and Indicative Equipment should read 24 ± 4 volts. The ampere metre should register minimum or no reading at all.

(xii) Initiate " Test Battery" by activating the toggle switch and ensure voltmetre reading is at 24 volts, with the ammetre reading certain charging current.

(xiii) Initiate tests of detectors and MCPs at different zone respectively and ensure the signal is relayed back to the corresponding zone though each respective indications on the Control & Indicative Equipment.

(xiv) Initiate auxiliary equipment and ensure the status is monitored as per indication on the Control Indicative Equipment.

(xv) For addressable system, initiate tests of detectors and MCPs at different detectors and MCPs and ensure that the signature of each of them is correctly programmed in accordance to the intended zonings.

(xvi) For all auxiliary shut down outputs, initiate test on activating device and record the response at the auxiliary equipment to ensure circuitry is working.

(xvii) Initiate test of detector / MCPs to ensure two stage alarm is in correct operating mode.

(xviii) Initiate fault on detector / MCPs and ensure signal is monitored back to the Control & Indicative Equipment at the respective zone.

(xix) Disable independent zone and initiate test on detector / MCPs and ensure that even though visual alarm indication is registered on the Control and Indicative Equipment, there is no audio alarm within any parts of the building.

(xx) Initiate lamp test on the Control and Indicative Equipment and ensure that all indicating lights are illuminated.

(xxi) Initiate " Evacuation" switch and ensure master alarm indication is illuminated and all system sounder units are activated for full evacuation.

(xxii) For all tests conducted which involved the initialisation of an alarm signal, ensure that the master sounder device on top of the Control and Indicative Equipment is activated as per requirement stated in the standard.

(xxiii) For all tests conducted which involved the initialisation of a fault signal, ensure that the buzzer within the Control and Indicative Equipment is activated.

(xxiv) Turn off mains power supply to the Control and Indicative Equipment and ensure that the back-up power supply is healthy and is able to sustain the load as per the requirement in accordance to the standards.

13.2.4 Design Checklist

a. Control and Indicative Equipment tested to : _______________

b. Control and Indicative Equipment Approved type : _______________

c. BOMBA Approval Certificate : _______________

d. Expiry Date of BOMBA Approval Certificate : _______________

e. Zone Alarm Indication / Rocker Switch

f. Zone Fault Indication / Rocker Switch

g. Zone Isolate Indication / Rocker Switch

h. Mains On Indication

j. DC On Indication

k. Mains Fail Indication

m. Battery Fail Indication

n. Charger Fail Indication

n. Bell Line Fault Indication

o. Lamp Test Toggle Switch / Full Indication

p. Battery Test Toggle Switch

q. Buzzer Silence Toggle Switch

r. Bell Silence Toggle Switch

s. System Rest Toggle Switch

t. Fire Brigade Toggle Switch

u. Duty Pump Run Indication

v. Standby Pump Run Indication

w. Jockey Pump Run Indication

x. Pump Manual Indication

y. A.H.U. Trip Indication

z. Fire Suppression System Discharge Indication

13.3 Audio & Visual Alarm

13.3.1 Concept

During a fire, if fire alarm system is installed, activation of an alarm sounder is to arouse the attention of the occupants so that evacuation can be carried out without causing harm to the occupants.

13.3.2 Design Requirements

(i) Code and Standard

Audio and Visual Fire Alarm System shall be designed to:
B.S.5839 : Part 1
- Fire Detection and Alarm System For Buildings
  Code of Practice for System Design, Installation and Servicing

(ii) Design Guidelines

(a) A minimum sound level of 65 dB (A), or 5 dB (A) above ambient noise level (whichever is greater) sustainable for a period of minimum 30 seconds should be produced by the Sounder Unit.

(b) For Sounder Unit that need to arouse sleeping person, the minimum sound level should be 75 dB (A) at bedhead with all doors closed.

(c) The type, number and location of fire Alarm Sounders should be that the alarm sound is distinctive from background noise.

(d) All Alarm Sounders within a building should have similar sound characteristics.

(e) In areas where a normal type of sounder may be ineffective, visual alarm signal need to be provided. In general, visual alarm signal should only be used to supplement audible alarm, and should not be used on its own.

13.3.3 Testing and Commissioning

(i) Check and ensure Alarm Sounder Unit is properly secured.

(ii) Check and ensure Alarm Sounder Unit wiring is properly secured to its terminals.

(iii) Check and ensure cable carrying conduit connected to the Alarm Sounder Unit is secured with cable lug.

(iv) Check and ensure all circuitry cables of Alarm Sounders Unit are of correct type and correct size in accordance to the requirements of the Code.

(v) Alarm sounder unit should be tested by activation using Manual Call Point of the same zone; note the sequence of the alarm.

(vi) Alarm Sounder Unit should be tested by simulation of activation of fire detectors of the same zone; note the sequence of alarm. The same Alarm Sounder Unit should also be tested by simulation of activation of fire detectors of different zone; note sequence of alarm.

(vii) Other than A/C power supply, Alarm Sounder Unit should also be tested using back-up battery power supply simulating a power failure.

(viii) Qualitative assessment of Alarm Sounder Unit should be carried out in general to assess the audibility of alarm signal. When in doubt, quantitative assessment should be carried out.

(ix) All visual alarm units should be tested for their flash rate and their frequencies. They should also be tested against background lighting condition and ensure there is no masking of the visual signal by any other light fittings.

13.3.4 Design Checklist

a. Alarm Sounder Unit tested to : ____________________

b. Alarm Sounder Unit Approved type : ____________________

c. BOMBA Approval Certificate number : ____________________

d. Expiry Date of BOMBA Approval Certificate : ____________________

e. Sound Level Output @ 1m : ____________________ dB(A)

f. Frequency / Frequency Range : __________ Hz - __________ kHz

g. Type : Mechanical / Electrical / Electronic

h. Height from floor level : ____________________ m

j. Type and size of cable used : ____________________

13.4 Manual Call Points (MCP)

13.4.1 Concept

Every fire detection system must include call points, so that in the event of a fire, help can be called immediately. All call points in the same installation shall have the same method of operation. All call points should be clearly identifiable and should not require instructions as to their mode of actuation.

13.4.2 Design Guideline

(i) **Codes and Standards**

Manual Call Point shall be based on:

(a) B.S.5839 : Part 1 : 1988
- Fire Detection and Alarm System For Buildings
  Code of Practice for System Design, Installation and Servicing

(b) B.S.5839 : Part 2 : 1983
- Specification for Manual Call Points

(ii) **Design Guideline**

(a) Manual Call Point shall be located on exit routes and in particular on the floor landings or stairways and at exits to open air.

(b) Manual Call Point shall be located so that to raise an alarm, no person in the premises need travel more than 30 metres.

(c) Manual Call Point shall be mounted at a height of 1.4 metres from the floor, easily accessible, well illuminated and conspicuous positions free from obstruction.

(d) Manual Call Point shall be sited against a contrasting background to assist in easy recognition.

(e) The delay between operation of a call point and the giving of the general alarm should not exceed 3 seconds.

(f) Manual Call Point may be flushed mounted where they may be seem readily. In locations where they may be viewed from the side (eg. in corridor) they should be surface mounted or semi-recessed in order to present a side profile area of not less than $750mm^2$.

(g) All colours of the Manual Call Point throughout the entire premises shall be of the same colour and shall be in bright red colour unless otherwise approved by Fire and Rescue Department Malaysia.

13.4.3 Testing and Commissioning

(i) Check and ensure Manual Call Point is properly secured.

(ii) Check and ensure Manual Call Point wiring is properly secured to its terminals.

(iii) Check and ensure cable carrying conduit connected to the Manual Call Point is secured with cable lug.

(iv) Check and ensure all circuitry cables of Manual Call Point are of correct type and correct size in accordance to the requirements of the Code.

(v) Test the Manual Call Point using testing key.

(vi) Test the Manual Call Point physically and time the response of the Alarm Sounder Unit to be within 3 seconds.

(vii) For two stage Fire Alarm System, test the Manual Call Point and ensure the sequence of the Fire Alarm is correct in accordance to zone configuration.

13.4.4 Checklist

a. Manual Call Point tested to : ________________

b. Manual Call Point Approved type : ________________

c. BOMBA Approval Certificate number : ________________

d. Expiry Date of BOMBA Approval Certificate : ________________

e. Distance between MCP (30 metres) : ________________

f. Height from floor level (1.4 metres) : ________________

g. Type and size of cable used : ________________

h. Surface / Flush Mounted : ________________

13.5 Fire Detectors

13.5.1 Concept

(i) Fire detectors are designed to detect one or more of the three characteristics of a fire - smoke, heat and flame. No one type of detector is suitable for all applications and the final choice will depend on individual circumstances.

(ii) Most, if not all, fire detectors are affected not only by the detected phenomena but also by the behaviour of the phenomena with time. However, all fire detectors will also respond to some extent to phenomena other than fire.

13.5.2 Design Guidelines

(i) Codes and Standards

(a) B.S.5839 : Part 5
- Specification for Optical Beam Smoke Detectors

(b) M.S.1176 : Part 5
- Specification for Components of Automatic Fire Detection Systems
Part 5 : Heat Sensitive Detectors - Point Detectors containing a Static Element System

(c) M.S.1176 : Part 7
- Specification for Components of Automatic Fire Detection Systems
Part 7 : Specification for Power-type Smoke Detector using Scattered Light, Transmitted Light or Ionization

(d) M.S.1176 : Part 8
   - Specification for Components of Automatic Fire Detection Systems
     Part 8 : Specification for High Temperature Heat Detectors

(e) M.S.1176 : Part 9
   - Specification for Components of Automatic Fire Detection Systems
     Part 9 : Methods of Test of Sensitivity to Fire

   B.S.5839 : Part 1
   - Fire Detection and Alarm System for Buildings
     Code of Practice for System Design, Installation and Servicing.

(f) AS 1603 : Part 8
   - Automatic Fire Detection and Alarm System, Multi point Aspirated Smoke Detectors.

(ii) **Types of Fire Detector**

(a) **Heat Detector**
- Fixed Temperature Heat Detector
- Rate-of-Rise Temperature Heat Detector
- Linear/ Line Detector

(b) **Smoke Detector**
- Ionization Smoke Detector
- Optical Smoke Detector
- Aspirating Smoke Detector
- Beam Detector

(c) **Flame Detector**
- Ultra Violet Flame Detector
- Infra-red Flame Detector

(iii) **Design Guidelines**

(a) **Heat Detector** (Point Detector)
- For open areas under flat horizontal ceilings, the horizontal distance from any point in the area to the detector nearest to that point should not exceed 5.3 metres.
- In a corridor less than 5 metres wide, the horizontal distance given in item a above may be increased by half the difference between 5 metres and the width of the corridor. For corridor wider than 5 metres, it should be treated as an open area.
- Under same condition stated in a, for estimation purposes, in any room or compartment, the number of point type heat detectors fitted should not normally be less than the room or compartment area divided by $50m^2$.
- Heat detector should be sited so that their sensitive elements are not less than 25mm or more than 150mm below the ceiling or roof.
- For pitched roof or north-light roof, heat detectors should be installed within each apex.
- Detectors should not normally be mounted on ceilings higher than the general limits stated in Table 13.2.

(b) Smoke Detector (Point Detector)

- For open areas under flat horizontal ceilings, the horizontal distance from any point in the area to the detector nearest to that point should not exceed 7.5 metres.

- In a corridor less than 5 metres wide, the horizontal distance given in an above may be increased by half the difference between 5 metres and the width of the corridor. For corridor wider than 5 metres, it should be treated as an open area.

- Under same condition stated in a, for estimation purposes, in any room or compartment, the number of point type smoke detectors fitted should not normally be less than the room or compartment area divided by $100m^2$.

- Smoke detector should be sited so that their sensitive elements are not less than 25mm or more than 600mm below the ceiling or roof.

- For pitched roof or north-light roof, heat detectors should be installed within each apex.

- Detectors should not normally be mounted on ceilings higher than the general limits in Table 13.2.

Table 13.2 Limits of Ceiling Height

Detector Type	Ceiling Heights	
	General Limits	Rapid Attendance
Heat detectors BS 5445 : Part 5 Grade 1 Grade 2 Grade 3	 9.0 7.5 6.0	 13.5 12.0 10.5
Point Smoke Detector	10.5	15.0
High Temperature Heat Detector BS 5445 : Part 8	 6.0	 10.5
Optical Beam Detector	25.0	40.0

(c) Aspirating Smoke Detector

- Depending on the sensitivity of the aspirated detectors and the response time required, the area coverage of each aspirated smoke detector should generally be limited to $1000m^2$.

- Each air sampling point or capillary headset should be sited so that is not less than 25mm or more than 600mm below the ceiling or roof.

- Aerodynamic designed fittings should be used to ensure smooth transportation of smoke particles from the fire source to the detection chamber.

- For open areas under flat horizontal ceilings:
  - Sampling holes of 2 mm diameter should be separated by intervals as specified in AS 1670 : 1995 and typically in the range of 2 to 8 metres intervals along the length of the pipework as well as between each adjacent air-sampling pipework.

- Each Sampling hole shall be identified in accordance with AS 1670 : 1995.

- For low ceiling height or raised floor void protection, the horizontal distance between air-sampling point should be as per itemed. The horizontal distance between each adjacent air-sampling pipework should be reduced to coincide with the angle of incident of the smoke particles.

- All air-sampling pipework should comply with BS 6099 or AS 2053 of 25mm nominal overall diameter and should be identified as a Fire Detection Sampling Pipe with imprint at intervals not exceeding 2 metres.

- All air-sampling pipework should be supported with proper bracketing at intervals not more than 1.2 metres and shall be installed in accordance with AS 3000.

(d) Optical beam detector
- Optical Beam Detector should be installed in accordance with the manufacture's instructions, with not more than 3 metres of the beam within 500mm of any wall or partition except those part of the beam within 500mm of the beam's transmitter, receiver or reflectors.

- The maximum length of the area protected by a single optical beam detector should not exceed 100 metres. Within this limitation, the manufacture's recommendation should be followed.

- If there is a possibility of people walking in the area of the beam, then the beam should be at least 2.7 metres above the floor.

- When optical smoke detectors are used in roof void areas having dropping smoke curtains, the beams should be so arranged so that they are not broken by the smoke curtains when they are dropped.

(e) Flame detector
- Flame detectors should be chosen for application where there is the likelihood of rapid flame development, so that an alarm is required before products of combustion or heat will reach a threshold level to raise an alarm.

- Flame detectors are essentially "line of sight" devices which can sense the presence of flames in a set field of view. This field is generally described by the cone of vision angle and the maximum perpendicular sensitivity in metres, although other considerations are important.

- Consideration should be to provide full coverage of the area to be protected with maximum multiple coverage to account for any detector malfunction.

13.5.3 Testing and Commissioning

(i) Check and ensure Detector is properly installed.

(ii) Check and ensure Detector wiring is properly secured to its terminals.

(iii) Check and ensure cable-carrying conduit connected to the Manual Call Point is secured with cable lug.

(iv) Check and ensure all circuitry cables of Detector are of correct type and correct size in accordance to the requirements of the code.

(v) Test the detector using standard testing procedure in accordance to the recommendation of the standards.

(vi) For Aspirated Smoke Detector, the criteria for testing the system is the response time. The response time is defined as the time registered from the moment test smoke particles are introduced at the least favorable point to the time they are detected at the smoke detector chamber. The maximum response time should not exceed 90 seconds. The response registered at the controller should be at least 30% of the sensitivity of the detector system.

13.5.4 Checklist

(i) Point Detector

a. Detector tested to : ____________________

b. Detector type : R.O.R / Ionization / Optical / Infrared / UV

c. Detector Mode : Conventional / Addressable

d. BOMBA Approval Certificate number : ____________________

e. Expiry Date of BOMBA Approval Certificate : ____________________

f. Manufacture : ____________________

g. Country of origin : ____________________

h. Distance between detector : ____________________

j. Height from floor level : ____________________

k. Distance from the slab : ____________________

l. Type and size of cable used : ____________________

m. Type of conduit used : ____________________

(ii) Aspirated Detector

a. Detector tested to : ____________________

b. Detector type : ____________________

c. BOMBA Approval Certificate number : ____________________

d. Expire Date of BOMBA Approval Certificate : ____________________

e. Manufacturer : ____________________

f. Country of origin : ____________________

g. Type of air-sampling pipe : ____________________

h. O.D. of air-sampling pipe : ______________________

j. Types of pipe fittings : ______________________

k. Distance between sampling points : ______________________

l. Distance between sampling pipes : ______________________

m. Height from floor level : ______________________

n. Distance from the slab : ______________________

o. Type and size of cable used : ______________________

p. Type of conduit used : ______________________

13.6. Power Supply

13.6.1 Concept

A vast majority of the fire alarm system relies on electrical power for their operation. No electrical power source is totally reliable; every power source will fail sometimes, even if it is for a limited period only.

The requirements for fire alarm system power supply is generally based on the principle that the unreliability of its main supplies source should not affect the reliability with which a fire alarm responds to a fire.

In general, high reliability of the power supply of fire alarm system can be realised by a normal supply from public mains, backed up by readily connected battery back-up supply in case of main supply failure.

13.6.2 Design Requirements

(i) Code & Standard

Power Supply shall be designed based on:

M.S.1745 : Part 4
- Fire Detection and Fire Alarm Systems
  Part 4 : Power Supply Equipment

(ii) General

(a) Any cables directly connected to a public or private distribution board should be in accordance with a current issue of IEE Wiring Regulations.

(b) Connection of main power supply to fire alarm panel should be via an isolating protection device (eg. isolating fuse) reserved solely for that purpose. The cover should be coloured red and labeled "Fire Alarm: Do Not Switch Off".

(c) Arrangement should be made so that the continuity of the electrical power supply to the fire alarm system is ensured. Particular care should be taken where there is a tendency to switched off power supply to a switch board eg. During maintenance of machinery, when unoccupied or for economy in the consumption of electricity.

(iii) Types of Power Supply

(a) Normal supply

- Normal supply shall be from the public mains, through a private switchboard. In the absence of public power supply, private generated power may be used.

(b) Secondary batteries

- The most commonly use type of standby supply is a secondary battery with an automatic charger.

- Where such a battery is used, it should be of a type having a life span of at least 4 years under the condition of use likely to be experienced inside the fire alarm panel.

- Since the life of the battery is frequently dependent on its charging conditions, care should be taken that the battery charger satisfies all requirements specified by the battery manufacturer.

- Where replacement batteries or battery capacities, refer to (iv) and (v)

- The charging rate of the battery should be such that, having been discharged to its final voltage, the battery can be charged sufficiently to comply with the recommendations of (v), after a charging period of 24 hours.

(c) Secondary Batteries with Standby Generator

- In most premises, other than supplies taken from the public mains, an emergency generator is provided which starts automatically on failure of the normal supply.

- Since there is a time delay between the mains power failure until the generator cranked into life to provide emergency backup power supply, the secondary batteries power supply is essential to provide continuous operation of the fire alarm system. They are also essential should the emergency generator fail to be activated.

(iv) Maximum Alarm Load

(a) The maximum alarm load is the maximum load imposed by the automatic fire alarm system on a power supply under fire conditions. It includes the power required to operate all the sounders simultaneously, together with any visible or audible indications at the Control and Indicative Equipment, any power drawn for the operation and/ or indication of ancillary services and the transmission of signals to remote manned centres. Because of the possibility of spread of fire throughout the building, the system should be able to support the maximum number of detectors that can simultaneously give signals indicating fire, and the operation of manual call point at all zones.

(b) Normal and standby power supply should each be capable of supplying the maximum alarm load irrespective of the conditions of other supply.

(c) The load imposed on the power supply by the simultaneous operation of detectors and / or manual call points should not cause an existing fire alarm to cease. In system using microprocessors or stored programs, the imposition of the maximum alarm load should not cause incorrect operation.

(v) **Duration of the Standby Supply**

(a) The standby power supply should be capable of automatically maintaining the system in normal operation for a period of not less than 24 hours after the detection of a fault in the normal supply and the initiation of remedial action.

(b) If the building is likely to be unoccupied and the fire alarm system unsupervised for periods longer than 24 hours, so that on reoccupation, the standby supply could be exhausted and the system inoperable, then facilities should be provided to give protection for a period of at least 24 hours after reoccupation, with sufficient capacity at the end of that time to sound an evacuation alarm in all zones for at least 30 minutes.

(c) For item 13.6.2 V.b., normally the assumption for the longest unoccupied and unsupervised period is taken over a long weekend, which is 72 hours.

(vi) **Battery Charger**

(a) To preserve the life of the Standby backup batteries, the proper selection of the battery charger is very important.

(b) Incorrect selection of battery charger and charging method will cause the battery to be overcharged thereby causing deterioration of the electrodes and hence the performance and the life span of the battery.

(c) For maintenance free sealed Lead-acid Battery, the Constant voltage constant current charge method is recommended. As charging proceeds, there is a rise in battery voltage, the constant voltage charger will detect the voltage increase and control of the charger amount.

(d) The constant voltage constant current charger has current limitation to prevent the initial current (at low battery voltage) from increasing.

(vii) **Battery Installation and Servicing**

(a) Standby batteries should be secured from excessive vibration or impact.

(b) All standby batteries when housed within the Control and Indicative Equipment should be compartment and positioned away from any heat generating body (eg. transformer). Batteries should be stored in upright position with battery compartment well ventilated.

(c) Batteries may produce a combustible gas. Avoid installation of closed equipment near sparks (i.e. near a switch or fuse).

(d) Using vinyl chloride sheathed cable or a vinyl chloride sheet may induce crack on battery container or cover.

(e) Avoid using batteries in the following areas:
- Area exposed to direct sunlight
- Area where there is excessive radioactivity, infra-red radiation, or ultra-violet radiation
- Area filled with organic solvent, vapor, dust, salt, or corrosive gases.
- Area of abnormal vibration

(f) When connecting the battery to a charger or a load, keep the circuit switch OFF and connect the battery's (+) pole to the (+) pole of the charger or the load and the (-) pole to the (-) pole of the charger or load.

(g) Never use batteries of different capacities, batteries of different performances, or new and old batteries together.

(h) Inspect and check for the following abnormalities, discover the cause and replace any defective batteries:
- Any voltage abnormalities
- Any physical defects (eg. cracked or deformed container)
- Any electrolyte leakage
- Any abnormal heat built up

(viii) **Battery Capacity Calculation**
(a) For battery capacity calculation, refer to Table 13.3

13.6.3 Testing and Commissioning

(i) Ensure batteries are properly connected to each respective terminal.

(ii) Check battery capacity with volt metre to ensure the battery is fully charged. Healthy battery should record 24 volts.

(iii) Record the date of commissioning on the batteries with marker pen.

(iv) Turn off the mains power supply of the fire alarm indicating and control panel, the volt metre on the panel surface should register 24 volts ± 4 volts. The ampere metre should register little or no readings.

(v) Using the facilities provided on the Control and Indicative Equipment, initiate a mains power failure.

(vi) Initiate all sounders, manual call points, selected detectors, ancillary outputs and any other power consumption devices for 30 minutes.

(vii) Monitor the performance of the batteries and compare with the power curve provided by the manufacturer to ensure compliance with the specification.

(viii) Recharged the batteries to fully charged status before conducting the standby power test.

(ix) For standby power test, repeat Clauses 13.6.3 (ii), 13.6.3 (iv) and 13.6.3 (v)

(x) Record time of conducting test and lock and seal the Control and Indicative Equipment and control panel including the battery compartment.

(xi) Record the battery 72 hours later with volt metre. Initiate all sounders for 30 minutes, the battery should be able to sustain such operation.

(xii) Turn the mains power supply back on and ensure the duration required to recharge the batteries the batteries to full charge capacity is within the duration specified by the manufacturer and as stipulated by the standards.

(xiii) Check each battery with voltmetre to ensure batteries registered 24 volts.

13.6.4 Checklist

a. Battery Manufacturer : ____________________

b. Make and Model : ____________________

c. Country of manufacture : ____________________

d. Test Standard : ____________________

e. Life expectancy of Battery : ____________________ Years

f. BOMBA approval certificate number : ____________________

g. Expiry Date of BOMBA approval certificate : ____________________

h. Battery Capacity : ____________________ AH

j. Battery Voltage : ____________________ Volts

k. Type of Charger : ____________________

l. Method of charging : ____________________

m. Charger Capacity : ____________________

n. Country of manufacture (charger) : ____________________

o. No of zones on Fire Alarm Panel : ____________________

p. No of Sounders : ____________________

q. No of Manual Call Points : ____________________

r. No of Detectors : ____________________

s. No of Indications on panel : ____________________

t. No of Ancillary output : ____________________

Table 13.3 Battery Standby Power Requirement Calculation

Fire Control and Indicative Panel __________ zones __________ type

A	Alarm Load	Ampere		Ampere
1.	Master Controller	1 x ____	=	
2.	C.M.S. to Fire Brigade	1 x ____	=	
3.	Zone Unit	____ x ____	=	
4.	Smoke Detectors	____ x ____	=	
5.	Heat Detectors	____ x ____	=	
6.	Smoke / Heat Detector	____ x ____	=	
7.	I.R./ U.V. Detector	____ x ____	=	
8.	Audio Fire Alarm Units	____ x ____	=	
9.	Visual Fire Alarm Units	____ x ____	=	
10.	Audio / Visual F.A. Units	____ x ____	=	
11.	Manual Call Points	____ x ____	=	
12.	Pump Indications	____ x ____	=	
13.	A.H.U. Tripping	____ x ____	=	
14.	Energized Fire Supp. Sys.	____ x ____	=	
15.	Gas Discharge Warning Lg.	____ x ____	=	
16.	Energized Drop Curtain	____ x ____	=	
17.	B.A.S.	____ x ____	=	
18.	Roller Shutter	____ x ____	=	
19.	Magnetic Door Holder	____ x ____	=	
20.	Smoke Extract System	____ x ____	=	
21.	Interface Units	____ x ____	=	
22.	Other Ancillary Outputs	____ x ____	=	
		Total Alarm Load		____________ Amp ============

B	Standby Load	Ampere		Ampere
1.	Master Controller	1 x ____	=	
2.	C.M.S to Fire Brigade	1 x ____	=	
3.	Zone Unit	___ x ____	=	
4.	Smoke Detectors	___ x ____	=	
5.	Heat Detectors	___ x ____	=	
6.	Smoke / Heat Detectors	___ x ____	=	
7.	I.R./ U.V Detectors	___ x ____	=	
8.	Audio Fire Alarm Units	___ x ____	=	
9.	Visual Fire Alarm Units	___ x ____	=	
10.	Audio / Visual F.A Units	___ x ____	=	
11.	Manual Call Points	___ x ____	=	
12.	Interfere Units	___ x ____	=	
13.	Other Ancillary Outputs	___ x ____	=	
		Total Standy Load		________ Amp ==============

Battery Capacity Sizing = (A x 1 H) + (B x 24 H) Ampere Hour

= _______ X 10% (Safety Factor)

= _______ A.H (Ampere Hour)

= _______ A.H (To Manufacturer's Requirement)

Note: Battery capacity sizing has to be selected based on the manufacturer's available size. The selection should only be based on selecting the next size up from the manufacturer's table if the exact size calculated is not available on the market.

13.7 Cables & Wirings

13.7.1 Concept

For fire Detection and Alarm system to function satisfactorily during a fire condition, all interconnections between components should be intact and should be operational.

13.7.2 Design Requirements

(i) Code and Standard

Cable wiring shall be designed based on:

B.S.5839 : Part 1
- Fire Detection and Alarm System For Buildings
- Code of Practice for System Design, Installation and Servicing.

(ii) General

A wide variety of cables can be used in various parts of a fire alarm system. However, because of their varying abilities to resists fire and electrical or mechanical damage, many of these cables may be restricted in their suitability for specific applications. The application is classified according to the need for fire protection as in Clauses 7.24 and 7.25.

(iii) Application

(a) Prolong operation during a fire is required:

- Cables used for the interconnection of components of a fire detection and alarm systems and required to continue to operate after a fire is discovered, eg. Control and Indicative Equipment, sounders, power supply.

- Cables used within the protected premises for the transmission of the alarm to a remote centre should be included in this class.

(b) Prolong operation during a fire is NOT required:

- Cables which are not required to continue to appreciated periods after the fire is discovered or they are attacked by fire.

- These cables will usually be only those to detectors or manual call points, but may also include those ancillary devices (such as door holders) in which failure of the cable due to a fire will not lead to a dangerous condition.

(iv) Recommended Cable Types

Types of cables recommended subjected to the restriction on their use and the recommendations for further protection in Clauses 7.24 and 7.25.

(a) Mineral-insulated copper sheathed cable complying with BS 6207, with or without an overall PVC sheath.

(b) Cables complying with BS 6387, meeting at least the requirements for categorisation as AWX or SWX.

(c) Cables complying with BS 6387, meeting at least the requirements for categorisation as A or S.

(d) PVC-insulated and sheathed cables complying with BS 6004.

(e) PVC-insulated non-sheathed cables complying with BS 6004.

(f) PVC-insulated cables of type BK, BR and BU complying with BS 6231.

(g) PVC-insulated and sheathed steel-wire-armoured cable complying with BS 6346.

(h) General – purpose elastomer-insulated textile-braided polyethylene or hard ethylene propylene rubber insulation complying with BS 5467.

(j) Polyethylene-insulated PVC-sheathed coaxial cable, with a central conductor of not less than 16 strands / 0.2mm in diameter, but otherwise complying with the dimensional requirements of BS 2316 : Part 3 for Uniradio Sheet M210.

(k) Cables designed for the detection of heat.

Cable Protection from Fire

(a) Prolong operation during a fire is required:

- Cables required to continue to operate during exposure to a fire should be type Clauses 13.7.2.(iv)(a) and 13.7.2.(iv)(b).

- Other cables may be used if they are buried in the structure of the building and protected by the equivalent of at least 12mm of plaster.

(b) Prolong operation during a fire is NOT required:

- Where prolonged operation during a fire is not required, any cables listed in Clauses 13.7.2.(iv) can be used without any additional fire protection.

Note: Cables listed in Clauses 13.7.2.(v)(a) (a.1) and 13.7.2.(v)(a) (a.2) should still comply with the requirements in Clause 13.7.2.(vi)

(vi) **Cable Protection from Electrical or Mechanical Damage**

(a) Electrical Protection

- M.I.C.C. cables should be electrically protected by ensuring that associated equipment complies with the cable manufacture's requirement for voltage surge protection.

- Polyethylene- insulated coaxial cable should not be used with nominal voltages exceeding 50 volts.

- Cables designed for the detection of heat should be used within their manufacturer's ratings.

(b) Mechanical Protection

- Some of the cables listed in Clause 13.7.2.(iv) are not sufficiently robust to withstand mechanical hazards, such as impact, abrasion, etc. In order to protect such cables from damage both during and after installation, it will be necessary to provide mechanical protections by installation in conduit, ducting or trunking or by laying the cables in a channel.

- Recommendations for mechanical protection are as follows:
  - Cables in Clauses 13.7.2.(iv)(a), 13.7.2.(iv)(h), and 13.7.2.(iv)(j), may be used without mechanical protection.

  - Cables other than Clause 13.7.2.(vi)(a) should always have mechanical protection.

(vii) Conduit, Ducting and Trucking

(a) Metal or high impact rigid PVC conduit may be used for cabling. High impact rigid PVC conduit should comply with classification 405/1 or 425/1 of BS 6099 : Section 2.2.

(b) If fire alarm cables are run in trunking or ducting, then either metal trunking or ducting; or non-metallic ducting or non-flame propagating trunking complying with BS 4678 : Part 4 should be used.

(c) All bracketing for conduits, trunkings, ducting should be properly constructed and secured at recommended specific intervals.

13.7.3 Testing and Commissioning

(i) Check and ensure that cable selection for each part of the Fire Detection and Alarm system is correct.

(ii) Ensure all cables met relevant fire, electrical and mechanical protections.

(iii) Ensure all conduits, trunkings, ducting comply with relevant standard.

(iv) Ensure proper elbows and tees with inspection openings, junction boxes are used with conduit for cabling.

(v) Ensure conduits are properly secured to junction box, elbow and tees to prevent cabling being severed by dislocation of the fittings.

(vi) Ensure all cables are colour coded for easy identification purposes and for ease of maintenance.

(vii) Check and ensure bracketing at recommended specific intervals.

13.7.4 Checklist

a. Type of Cables used : ____________________

b. Size of cable : ____________________

c. Country of Manufacture : ____________________

d. Make and Model : ____________________

e. Standard Tested to : ____________________

f. BOMBA Approval Certificate Number : ____________________

g. Expiry Date of BOMBA Approval : ____________________

h. Type of Conduit : ____________________

j. Size of Conduit : ____________________

k. Country of Manufacture : ____________________

l. Make and Model : ____________________

m. Standards Tested to : ____________________

n. BOMBA Approval Certificate Number : ____________________

o. Expiry Date of BOMBA Approval Certificate : ____________________

p. Type of Trunking : ____________________

q. Size of Trunking : ____________________

r. Country of Manufacture : ____________________

s. Make and Model : ____________________

t. Standard Tested to : ____________________

u. BOMBA Approval Certificate Number : ________________

v. Expiry Date of BOMBA Approval Certificate : ____________

13.8 VOICE ALARM SYSTEM (VAS)

13.8.1 Concept

(i) A voice alarm system is intended to be used in conjunction with a fire detection and alarm system to control the safe evacuation of building occupants be providing:

(a) A clear and unambiguous spoken instruction for evacuation of the area of immediate risk.

(b) Voice messages and signal which contribute to the management of an emergency.

(ii) Voice Alarm System (VAS) linked to Fire Detection and Alarm Systems (FDAS) may also be used to give warning of other incidents, eg. bomb alert, chemical spillage and extinguishing agent discharge.

(iii) The system may also be used for other functions, such as broadcast of music, paging or general announcement provided that such facilities are always overridden in the event of an emergency.

(iv) Once a fire is detected, it is essential that people be evacuated from the areas of immediate danger as quickly as possible to minimize risk to life. This may present few problems if occupants are familiar with the layout of the site and has undergone evacuation procedure drill. For public assembly areas where occupants are not familiar with the layout of the site or have no experience in evacuation procedure, precise verbal instruction will be necessary on the actions required of them.

13.8.2 Design Requirements

(i) Codes & Standards

(a) Voice Alarm System (VAS) should be designed based on:

B.S.5839 : Part 1
- Fire Detection and Alarm System For Buildings
Code of Practice for System Design, Installation and Servicing.

B.S.5839 : Part 8
- Fire Detection and Alarm System for Buildings
Code of Practice for the Design, Installation and Servicing of Voice Alarm System.

(ii) General

(a) Components of VAS should be compatible to ensure the effectiveness and intelligibility of broadcast messages.

(b) Compatibility should be ensured between microphones, amplifiers, loudspeakers and interconnecting cables for optimum performance of the system. Care should be taken to ensure compatibility with cable parameters, such as capacitance and signal characteristics.

(c) The VAS should "latch" on when receiving a signal from the FDAS until de-latched by a separate command from the FDAS.

(d) The interface between the FDAS and VAS should be such that any delay in the automatic transmission of the relevant pre-recorded message is minimised.

(e) The delay between operation of a manual call point and the start of VAS broadcast should not exceed 3 seconds.

(f) If the automatic transmission of the pre-recorded message is in response to a signal from an automatic fire detector, the broadcast should begin within 10 seconds after the detector responded.

(iii) Loudspeaker Circuit

(a) The integrity of VAS should be equivalent to that recommended by BS 5839 : Part 1 for sounder units.

(b) It is recommended that the wiring of the speaker circuits should be arranged that, in the event of a short-circuit developed during a fire, a minimum of one speaker should continue to operate.

(c) All loudspeaker circuits should be protected against fire and mechanical damage.

(d) An open-circuit or short-circuit fault on one loudspeaker circuit should not affect the operation of any other circuit or loudspeaker zone.

(e) A short-circuit fault on a loudspeaker circuit should not cause damage to the associated amplifier.

(f) Any failure of a loudspeaker circuit should result in a fault warning at the FDAS Control and Indicative Equipment.

(g) Additional loudspeaker circuits should be provided in the following huge assembly area (typically within a single space):

- Transportation

- Mall areas of covered shopping complexes.

- Public areas of
  - cinemas, theatres and other places of entertainment
  - large departmental stores
  - lecture theatres, centers

- Any uncompartmented public spaces within a building if the space is:
  - Greater than 4000m^2 in area or
  - Designed to accommodate more than 500 members of the public

(iv) **Visual Alarm Signal**

(a) In areas with high background noise or where occupant is wearing car protectors or impaired in hearing, the broadcast messages should be supplemented with visual alarm signals.

(b) Visual alarm signals should always be provided if background noise levels exceed 90dBA.

(v) **Interfaced with Other Sound Systems**

(a) If there are other independent system on site eg. public address, piped music system or sound reinforcement system, piped music system or sound reinforcement system, switching output should be provided for automatically muting systems.

(b) Cancellation of the mute should only be possible at the Control and Indicative Equipment of FDAS.

(vi) **Combined Use with Fire Alarm Sounder**

When the VAS is supplementary to the fire alarm system, it is recommended that:

(a) The operation of the fire alarm sounders should not cause the intelligibility of the voice broadcast to be below the recommended value.

(b) Attention-drawing signal for introducing voice message should be the same as those produced by the fire alarm sounders for a similar stage of alarm.

(c) The procedure for operating such systems should be such as to avoid confusion in an emergency.

(d) If it is necessary to silence the fire alarm sounders in order to broadcast the voice messages, restarting of the fire alarm sounders should be automatic within 10 seconds.

(vii) **Loudspeaker Zoning**

(a) The VAS should be capable of being subdivided into loudspeaker emergency broadcast zones determined by specific evacuation procedure.

(b) Loudspeaker zones need not necessarily follow or be the same as other fire detection zones.

(c) Loudspeaker emergency broadcast zones should be selected so that an effective evacuation of the building can be carried out without confusion or misinterpretation of the warning message.

(d) Loudspeaker zone boundaries should, where possible coincide with compartmentation walls, permanent partitions or doors within the building for distinctive zone separation.

(e) For loudspeaker zonings, care should be taken to ensure that a single loudspeaker zonings may contain one or more fire detection and alarm zonings but NO single fire detection and alarm system zone should contain more than one loudspeaker zone.

(viii) **Protection of Loudspeaker**

(a) To ensure that failure of the associated circuit is unlikely to occur if the loudspeaker is exposed to fire before evacuation is completed, the design measures should include:

- use of material blocks with a melting point of not less than 650°C eg. ceramic material, or

- use of terminal blocks of a lower melting point but protected with thermal insulation, or

- design of the terminal blocks such that, on melting, an open-circuit or a short-circuit does not occur.

(b) In order to prevent inadvertent contact and damage by falling objects or any other accidental damages, every flush-mounted ceiling loudspeakers should be fitted with a rear enclosure. This should be constructed from non-combustible material with a melting point at least 800°C, eg. steel.

(ix) Fire Microphone

(a) Fire microphone should be provided as a means of overriding pre-recorded emergency broadcast messages.

(b) As the microphone is common to all areas of broadcast, which may have varied ambient noise level, it should be of a suitable grade to achieve the required intelligibility of sound reproduction throughout the entire installation.

(c) The recommended types of microphone are as follows:

- unidirectional, mounted on a flexible or fixed with built-in windshield to prevent "popping" noise whilst speaking. The recommended minimum +- 5 dB frequency range for this type of microphone is 200Hz to 3kHz.

- hand-held close-talking noise-cancelling, with an integral press to talk switch. The recommended minimum +- 5 dB frequency range for this type of microphone is 250Hz to 5kHz.

(d) The siting of fire microphone(s) should be agreed with the Fire and Rescue Department

(e) Care should be taken in locating microphone to avoid:

- sound colouration
- feedback from system loudspeakers
- pick-up and amplification of background noise
- reverberant acoustic conditions at microphone, all of which can reduce the quality of the signal

(f) Fore accessibility, the fire microphone should either:

- be dedicated purely to the broadcast of emergency messages - care should be taken to prevent its use for non-emergency functions.

- be used for emergency and non-emergency functions - care should be exercised and means should be provided to prevent non-emergency broadcast from overriding a pre-recorded emergency broadcast.

(x) **Message Generator**

(a) For an effective VAS, the reliability and integrity of associated message generator is vital as the source for providing and delivering pre-recorded emergency messages.

(b) Message generator should be designed to use solid-state electronic exclusively for message storage and control. Apart from relays (associated with status or fault indication), there should be no moving parts; tape player or disk drives, for example should not be used.

(c) The recording should be stored in non-volatile memory and the recorded messages(s) should be protected from unauthorized changed.

(d) The broadcast voice should sound natural with high quality recording. No synthesised voice should be used unless the resultant broadcast sound is indistinguishable from that of a human voice.

(e) Each message generator should be monitored continuously to ensure the availability of audio output.

(xi) **Messages**

(a) Every message should be preceded by an attention-drawing signal. This is a non-speech signal in accordance with 9.4.1. and 9.4.5. of BS 5839 : Part 1 : 1988. The attention-drawing signal used for Alert and Evacuate alarms should be identical. Where this is not the case, the signal should not be in accordance with 9.9 of B.S. 5839 : Part 1 : 1988.

(b) The message should be clear, concise, intelligible and delivered in a calm and commanding manner.

(c) Live messages should be broadcast only by operators trained in the proper use of the microphone.

(d) Except where a Fire Officer or trained person in authority need to make special announcements in an emergency situation, the operator should broadcast agreed standard messages, reading from a script.

(e) For pre-recorded messages, the recording should be made by persons trained in the proper use of the microphone. The recordings should be made in a recording studio or a room with a controlled acoustic environment having an ambient noise level no greater than 30 dB and a reverberation time no greater than 0.5 seconds from 150 Hz to 10 kHz.

(f) For Evacuation Broadcast, the time sequence and format of the broadcast, from start to finish, should be : -

Attention-drawing signal - lasting 4 seconds to 10 seconds
followed by
Brief Silence - lasting 1 second to 2 seconds
followed by
Evacuate Message
followed by
Silence - lasting 2 seconds to 5 seconds

Note : The period of silence may vary according to the various environment, but should be capped such that the time between each repeated message does not exceed 30 seconds.

(g) Example of an Evacuation message:

"Attention Please. Attention Please,
Fire has been reported in the building,
Please leave the building immediately, by the nearest exit,
Do not use a lift."

(h) For Alert broadcast, the time sequence and format of the broadcast, from start to finish, should be : -

Attention-drawing signal - lasting 4 seconds to 10 seconds
followed by
Brief Silence - lasting 1 second to 2 seconds
followed by
Evacuate Message
followed by
Silence - lasting 10 seconds to 20 seconds

Note : The period of silence may vary according to the various environment, but should be capped such that the time between each repeated message does not exceed 45 seconds.

(i) Example of an Alert message:

"May I have your attention, please,
May I have your attention, please,
Fire has been reported in the building,
Do not panic,
Please listen for further instructions."

(xii) Control Equipments

(a) The control equipment of the VAS should normally comprise the following items:

- Reception, control and relaying of signals from the fire detection and alarm system or the fire microphone.
- Indication and warning associated with signals described in a. and system status.
- Generation, amplification and distribution of messages to loudspeakers.

(b) Provision for silencing of any messages initiated by the FDAS should only be at the Control and Indicative Equipment of the fire detection and alarm system.

(c) The colour visual indication emitting light should be as follows:

- Red for indication of emergency message broadcast
- Yellow for indication of fault

- Green for indication of energisation and selection of loudspeaker zone

- Any other indications within VAS should not be Red or Green

(d) The Control equipment should be designed to function reliably whenever serviced and maintained in accordance to the manufacturer's instructions. Equipment should be designed to have a service life of at least 15 years.

(xiii) Power Supply

(a) The operation of VAS is more complex than that of alarm sounders, where the power supply should be in accordance with BS 5839 : Part 4 and follow the recommendations for life safety systems of BS 5839 : Part 1 : 1988.

(b) The standby battery calculations should be as follows:

$$C_{min} = 1.25 \{(D_1 \times T_1 \times I_1) + (D_2 \times T_2 \times I_2)\}$$

C_{min} (AH)	is the minimum capacity of the battery at 20°C when new [in ampere hours (AH)]
T_1	is the battery standby period [in hours]
I_1 (Amp)	is the battery standby (quiescent) load current [in amperes] I_1 is measured or calculated as the sum of the quiescent current of all the components of the VAS, based upon operations at the nominal voltage (V), including contributions such as the current taken by the fault monitoring circuits
T_2 (hr)	is the alarm condition period [in hours]
I_2 (Amp)	is the total battery load current with all loudspeaker zones in full alarm condition [in amperes]
D_1	is a de-rating factor derived from the manufacturer's data, based upon the standby quiescent current I_1 and the discharge time T_1. This factor is the de-rating from the 20 hours rate
D_2	is a de-rating factor derived from the manufacturer's data, based upon full alarm load current I_2 and the discharged time T_2. This factor is the de-rating factor from the 20 hours rate and takes into account that the discharge time is not greater than 20 hours
1.25	the multiplying factor is included to allow for some ambient temperature variation and battery ageing

13.8.3 Testing and Commissioning

(i) Documentation should be provided within or adjacent to the control equipment:

(a) Operation Instruction (OI) for the correct action in the event of an emergency or fault indication.

(b) System logbook, similar to the fire detection and alarm system.

(ii) Drawings should be provided to the user, showing the positions of the various items of equipment, the size and routes of all cables and wiring for maintenance and record purpose.

(iii) The completed installation should be inspected to ensure that the work has been carried out in a satisfactory manner, that the methods, materials and components used are in accordance with BS 5839 : Part 8 : 1998.

(iv) The system should be tested to ensure that:

(a) The sound level produced by the loudspeakers is audible throughout the area of coverage.

(b) Each loudspeaker zone should be tested to ensure the correct alarm message is given in response to both automatic initiation and manual controls. Simulation of the automatic initiation should be conducted via the Fire Detection and Alarm system.

(c) Each loudspeaker zone should be tested for all other messages through each and every mode of initiation simulated through the normal operating procedure.

(d) Ensure the interface with the Fire Detection and Alarm system and any signal to ancillary equipment, such as visual beacons are operating satisfactory.

(v) The installer should supply to the submitting person and the Authority a certificate stating that the installation is in accordance with the recommendations given in relevant standards.

(vi) Should there be any deviation from the standards, and provided these standards have been agreed and approved by the Fire and Rescue Department Malaysia, statements of these deviations should be given by the installer together with the submissions of the complete certificate.

13.8.4 Checklist

(i) Voice Alarm System

a. VAS manufacturer : ______________________________

b. Make and Model : ______________________________

c. Country of Manufacture : ______________________________

d. VAS Test Standard : ______________________________

e. BOMBA Approved Certificate Number : ______________________________

f. Expiry Date of BOMBA Certificate : ______________________________

(ii) Back-up Battery

a. Backup battery manufacturer : ______________________________

b. Make and Model of Battery : ______________________________

c. Country of Manufacture : ______________________________

d. Battery Test Standard : ______________________________

e. BOMBA Approval Certificate Number : ______________________________

f. Expiry Date of BOMBA Approval : ______________________________

g. Life expectancy of back-up Battery : _________________________Years

h. Back-up Battery Capacity : ______________________________ AH

j. Voltage of Battery per cell : ______________________________ Volts

(iii) Battery Charger

a. Charger manufacturer : ______________________________

b. Type and Method of Charging : ______________________________

c. Charger capacity : ______________________________

d. Country of charger manufacturer : ______________________________

(iv) Loudspeaker

a. Loudspeaker Manufacturer : ______________________________

b. Type of Loudspeaker : ______________________________

c. Make and Model of Loudspeaker : ______________________________

d. Loudspeaker Test Standard : ______________________________

e. Dynamic range of Loudspeaker : ____________ Hz to ____________ kHz

f. No of Loudspeaker Zones : ______________________________

g. Country of Manufacture : ______________________________

h. BOMBA Approval Certificate Number : ______________________________

j. Expiry date of BOMBA Approval : ______________________________

(v) Fire Microphone

a. Fire Microphone manufacturer : ______________________________

b. Make and Model of Fire Microphone : ______________________________

c. Country of Manufacture : ______________________________

d. Type of Fire Microphone : ______________________________

e. Fire Microphone Test Standards : ______________________________

f. Dynamic Range of Fire Microphone : ____________ Hz to ____________ kHz

g. BOMBA Approval Certificate Number : ______________________________

h. Expiry date of BOMBA Approval : ______________________________

(vi) Cable

a. Cable Manufacturer : ______________________

b. Sizes of Cable/Cables : ______________________

c. Country of manufaclure : ______________________

d. Make & Model : ______________________

e. Cable Test Standard : ______________________

f. BOMBA Approval Certificate Number : ______________________

g. Expiry date of BOMBA Approval : ______________________

(vii) Conduit

a. Conduit Manufacturer : ______________________

b. Sizes of Conduits : ______________________

c. Country of manufacture : ______________________

d. Make & Model : ______________________

e. Conduit Test Standard : ______________________

f. BOMBA Approval Certificate Number : ______________________

g. Expiry date of BOMBA Approval : ______________________

(viii) Trunking/Ladder

a. Trunking/Ladder Manufacturer : ______________________

b. Sizes of Trunking/Ladder : ______________________

c. Country of manufaclure : ______________________

d. Make & Model : ______________________

e. Trunking/Ladder Test Standard : ______________________

f. BOMBA Approval Certificate Number : ______________________

g. Expiry date of BOMBA Approval : ______________________

PRESSURISATION SYSTEM IN BUILDINGS

14.1 DESCRIPTION

A pressurisation system is intended to keep protected escape routes of a building clear of smoke by means of introducing sufficient fresh air to maintain a positive pressure in protected escape routes against accommodation area. Protected routes may include staircases, lobbies and in some cases, the corridor.

Pressurisation system may be omitted if there is sufficient provision of natural ventilation in protected escape routes in accordance to the Uniform Building By-laws requirements and/or other acceptable standards.

14.2 DESIGN REQUIREMENTS

14.2.1 Design Standards

Pressurisation system shall be designed in accordance to:

(i) By-laws 196, 197, 200, 201 and 202 of the UBBL 1984
(ii) MS1472
(iii) AS1668

14.2.2 Methods of Pressurisation

(i) Method 1 - Pressurising Staircase only

The protection given by this method is entirely confined to the vertical part of the escape route. It should be used only when a staircase is approached directly from the accommodation space or through a simple lobby. Each stack of staircase shall be served by an independent pressurisation system.

(ii) Method 2 - Pressurising the Staircase and Lobby

If a lobby separating the staircase from the accommodation space is other than a simple lobby, this lobby shall be pressurised independently of the staircase. The pressure level at the lobby shall be about 5 Pa less than the pressure level at staircase.

(iii) Method 3 - Pressurising Staircase, Lobby and Corridor

If a corridor is of 30 minutes fire resistance or more and forms part of a protected escape route, this corridor shall be equipped with either a pressurisation system or smoke extraction system. The pressure level at the lobby/corridor shall be about 5 Pa less than the pressure level at staircase.

14.2.3 Detailed Design Requirements

The pressurisation systems shall be designed in accordance to the following parametres:-

(i) Method 1 - Pressurising Staircase only

(a) The pressure level at staircase should be 50 Pa higher than the pressure level at accommodation space.

(b) A minimum egress velocity of 1.0 m/s is required when 1 no. of staircase door is opened. The no. of opened doors shall be based on minimum 2 nos. of doors or no. of doors for 10% of the total floors (worst case condition), whichever is higher.

(ii) Method 2 and 3 - Pressurising Staircase, Lobby and Corridor (where applicable)

(a) The pressure level at staircase should be 50 Pa higher than the pressure level at accommodation space.

(b) The pressure level at lobby/corridor shall be higher (up to 45 Pa) than the pressure level at adjacent accommodation space, but less than the pressure level at staircase.

(c) A minimum egress velocity of 1.0 m/s is required when one lobby door and one staircase door on the same floor are opened. The no. of opened doors for both staircase and lobby shall be based on minimum 2 nos. of doors each or no. of doors for 10% of the total floors (based on worst case condition), whichever is higher.

Worst case condition refers to the 10% floor(s) that have the most number of egress doors.

14.3 SYSTEM COMPONENT

The installation and equipment associated to a pressurisation system shall account for:

14.3.1 Air Intake Arrangement

Air intake shall be arranged in a manner that it has minimum effect from wind velocity and direction and is at least 5m away from any contaminated exhaust outlet.

14.3.2 Fan Capacity and Operation

(i) 10% or 25% of additional volume flowrate shall be allowed for sheet-metal or builders' work ducting (masonry shaft) respectively.

(ii) Essential power shall be provided for the operation of pressurisation fan.

(iii) Pressurisation fan shall automatically start under fire mode. Manual control shall be provided at both fire command centre and on fan control panel.

14.3.3 Supply Air Outlets

(i) Air outlets shall be installed at not less than every 3 floors in a staircase, in order to provide efficient distribution and even pressure for the entire staircase.

(ii) There shall be at least 1 no. outlet per floor for lift lobby pressurisation system. These outlets shall not be located close to the main leakage path.

14.4 TYPES OF STAIRCASE PRESSURISATION SYSTEM DESIGN

14.4.1 Fixed Air Supply with Pressure Relief Dampers

Fresh air is continuously pumped into staircase regardless of the differential pressure between the staircase and accommodation area. The control of differential pressure between staircase and accommodation area relies on the operation of pressure relief dampers.

Pressure relief dampers shall open or close to maintain a 50 Pa differential pressure between staircase and accommodation area, when none of the doors are opened. Pressure relief dampers shall be provided at not more than 15 metres vertical interval to maintain an even pressure throughout the entire staircase.

14.4.2 Variable Air Supply with Motorised By-Pass Damper

For such application, the air quantity flow into staircase shall be controlled by a motorised by-pass damper located at ductwork connecting the fan and the staircase. A differential pressure sensor shall be installed near the bottom of the staircase and shall measure the pressure difference between accommodation area and the staircase.

In the event that the differential pressure is more than 50 Pa, the motorised by-pass damper will bleed the excess air into the atmosphere to maintain the pressure level.

14.4.3 Variable Speed Fan

The operation of this type of pressurisation system is similar to Clause 14.4.2 except that this system is equipped with variable speed fan instead of having motorised by-pass damper. The speed of the fan will vary in order to maintain a differential pressure of 50 Pa between staircase and accommodation area.

14.5 TYPES OF LIFT LOBBY PRESSURISATION SYSTEM DESIGN

14.5.1 Fixed Air Supply with Pressure Relief Dampers

This system is similar to Clause 14.4.1 except pressure relief dampers are located at every floor, in order to maintain a differential pressure between each lift lobby and adjacent accommodation area at every floor. Fusible link fire dampers shall be installed with the relief dampers to maintain fire integrity between lobby and accommodation areas.

14.5.2 Variable Air Supply with Motorised Fire Damper Control and Motorised By-Pass Damper

Each lobby is equipped with a motorised damper air outlet and differential pressure sensor. All motorised dampers shall be controlled in a manner that the differential pressure between each lobby and adjacent accommodation area is maintained at up to 45 Pa. Excess air will be relieved into the atmosphere by the motorised by-pass damper at the fan discharge.

14.5.3 Variable Air Flow with Motorised Damper Control and Variable Speed Fan

This system is similar to Clause 14.5.2 except the motorised by-pass damper is replaced with variable speed fan.

14.6 TEST REQUIREMENTS

14.6.1 Duct Pressure Test

The entire pressurisation ductwork shall be tested in accordance to SMACNA HVAC Duct Construction Standards - Metal and Flexible and manufacturer's recommendation. This is to ensure that air leakage is less than 10%.

14.6.2 Flow Test

Each outlet shall be balanced and tested to achieve the required design airflow.

14.6.3 Performance Test

(i) A simulation test shall be carried out with the no. of open doors as per design. The velocity across each opened door shall be not less than 1.0 m/s.

(ii) Differential pressure between staircase and accommodation space and between lobby and accommodation space when all doors are closed shall be measured by using a manometer or digital pressure meter or analogy type pressure meter.

14.7 DESIGN AND INSTALLATION CHECKLIST

14.7.1 Design Code and Standard Adopted

(i) MS1472
(ii) AS1668
(iii) By-laws 196,197, 200, 201, 202 of UBBL 1984
(iv) Other Standards, (to specify) ....

14.7.2 Design Checklist

(i) No. of floors
(ii) No. of doors per floor
(iii) Determine no. of closed and opened doors
(iv) Air leakage through closed door
(v) Air flow through opened door
(vi) Fan sizing

14.7.3 Visual Inspection Checklist

(a) Visual Inspection of Ductwork & Fittings
- (i) Sealant
- (ii) Fusible-link fire dampers
- (iii) Motorised dampers
- (iv) Fire Rated Ductwork
- (v) Fire Seal

(b) Visual Inspection of Fan and Wiring
- (i) Fan Installation
- (ii) Flexible Connection
- (iii) Wiring termination
- (iv) Cable size
- (v) Fan control panel
- (vi) Pressure sensor
- (vii) Control components

14.7.4 Testing and Commissioning Checklist

(a) Duct Pressure Test
- (i) Test pressure
- (ii) Test Duration
- (iii) Duct area
- (iv) Theoretical leakage
- (v) Pressure drop
- (vi) Actual leakage
- (vii) Test Apparatus

(b) Flow Test
- (i) Current and voltage
- (ii) Flow across each outlet
- (iii) Total flow
- (iv) Theoretical flow

(c) Performance Test
- (i) Air speed across opened doors
- (ii) Differential pressure between staircase and accommodation space

(iii) Differential pressure between lobby and accommodation space
(iv) Differential pressure between corridor and accommodation space
(v) Operation of motorised dampers
(vi) Operation of pressure relief dampers

14.8 CALCULATION

14.8.1 Example of Staircase and Lift Lobby Pressurisation System Calculation

14.8.1.1 General Description of Building

A 30 storey office building with 2 staircases constructed from ground floor up to roof level. Both staircases are connected to fire fighting lift lobbies, which in turn are connected to accommodation areas. There is only one single leaf door per floor for staircase. As for fire fighting lift lobby, there is only one single leaf door separating each lift lobby and the accommodation areas. There is one door connecting the lift lobby to a service shaft. However, this is not to be taken into account as it is opened into an enclosed area. Therefore, there are 30 doors in total for both staircase and fire fighting lift lobbies. Refer to Figure 14.1

14.8.1.2 Design Condition

(i) The staircase and lift lobbies will be independently pressurised.

(ii) All pressurisation shafts are not provided with sheet metal ductwork.

(iii) According to UBBL, the no. of opened doors shall be minimum 2 nos. or no. of doors at 10% of the total floors (worst condition), whichever is higher. Hence, for this case study, there will be 3 floors where all staircase and lift lobby doors are assumed to be opened.

(iv) The design of pressurisation system shall be based on constant speed fan with pressure relief system.

14.8.2 Sample Calculation for Staircase Pressurisation System

14.8.2.1 Estimation of Air Volume Flowing Past Doors When Doors Are Closed

(i) Design criteria based on MS1472

(ii) Leakage Area Calculation :
Based on 50 Pa pressure differential and interpolation of data from Table 3 and 4 (MS1472).

	Type Of Door	Size	Leakage Per Door (CMH)
Case A	Single leaf opening into a pressurised space	2.0m (H) 0.8m (W)	210 cmh
Case B	Single leaf opening outwards from an pressurised space	2.0m (H) 0.8m (W)	420 cmh
Case C	Double leaf opening into pressurised space	2.0m (H) 1.6m (W)	630 cmh

No. of single leaf doors opening into pressurised area = 27
No. of single leaf doors opening outwards from an pressurised area = 0
No. of opened single leaf doors = 3

14.8.2.2 Calculation of Air Leakage through Closed Doors

(i) (Case A)
Air leakage for 27 no. of door = 210 CMH x 27 = 5670 CMH

(ii) (Case B)
Air leakage for 0 no. of door = 420 CMH x 0 = 0 CMH

(iii) (Case C)
Air leakage for 0 no. of door = 630 CMH x 0 = 0 CMH

14.8.2.3 Calculation of Total Air Leakage

Total air leakage = 5670 + 0 + 0 =5670 CMH .... (A)

14.8.2.4 Estimation of Air Flow Past 3 Opened Doors

(i) The size of each door is 2.00m (H) x 0.8m (W)

(ii) Therefore, area of door is $1.60m^2$

(iii) Based on design criteria of 1 m/s air flow through door when the door is opened, air flowrate
= $1.60m^2$ x 1.0 m/s x 60 sec x 60 min = 5760 CMH

(iv) For 3 opened doors, the air quantity
= 5760 CMH x 3 = 17280 CMH .... (B)

14.8.2.5 Selection of Capacity for Pressurisation Fan

(i) The minimum air required
= (A) + (B)
= 5670 + 17280 CMH
= 22950 CMH

(ii) Add 25% leakage factor (masonry shaft)
= 28688 CMH

Note: If masonry shaft is of reinforced concrete, 10% leakage factor is adequate

(iii) The airflow of fan selected:
= 29000 CMH

14.8.3 Sample Calculation for Lift Lobby Pressurisation System

14.8.3.1 Estimation of Air Volume Flowing Past Doors when Doors are Closed

(i) Design criteria based on MS1472

(ii) Leakage Area Calculation:
Based 50 Pa pressure differential and interpolation of data from Table 3 and 4 (MS1472).

	Type Of Door	Size	Leakage Per Door (CMH)
Case A	Single leaf opening into a pressurised space	2.0m (H) 0.8m (W)	210
Case B	Single leaf opening outwards from a pressurised space	2.0m (H) 0.8m (W)	420
Case C	Double leaf opening into pressurised space	2.0m (H) 1.6m (W)	630
Case D	Lift landing door 2.0m (H)	2.0m (H) 2.0m (W)	Refer Section 5.3.2.3 (MS1472)

No. of single leaf doors opening into pressurised area = 27
No. of single leaf doors opening outwards from a pressurised area = 0
No. of opened single leaf door = 3
No. of lift landing doors = 30

14.8.3.2 Calculation of Air Leakage through Closed Lobby Doors

(i) (Case A)
Air leakage for 27 nos. of door = 210 CMH x 27 = 5670 CMH

(ii) (Case B)
Air leakage for 0 no. of door = 420 CMH x 0 = 0 CMH

(iii) (Case C)
Air leakage for 0 no. of door = 630 CMH x 0 = 0 CMH

14.8.3.3 Calculation of Air Leakage through Closed Lift Landing Doors

Refer to Equation (14) of sub-section 5.3.2.3 of MS1472

Equation : $Q_d = \frac{Q_c \times F}{n}$

where,

Q_d is the air leakage from one lobby past one lift door,

Q_c is the air leakage for an isolated lift door (value taken from Table 4 or derived from $Q_c = 0.0496 \times (P_E)^{1/2}$ where PE is the pressurisation level for the lobby,

F is the factor depending on vent size in lift shaft and taken from the appropriate column of Table 6 (MS 1472),

N is the number of pressurised lobby openings into the lift shaft

Hence, when applied to;

(iv) (Case D)

Q_d (for one lobby) $= \frac{Q_c \times F}{n}$ (assume lift shaft vent size = $0.16m^2$)

$$= \frac{0.0496 \times (50)^{1/2} \times 2.66 m^3/s}{30}$$

= 112 CMH

Number of lift(s) = 1

Total leakage = 112 CMH x 30 landings x 1 lift

= 3360 CMH

Table 6 (MS1472)

No. of pressurised lobbies opening into the lift shaft (=n)	Value of F for vent size	
	0.1m²	0.16m²
1	0.860	0.94
2	1.280	1.60
3	1.460	1.99
4	1.540	2.22
5	1.580	2.35
6	1.610	2.44
7	1.620	2.49
8	1.630	2.53
9	1.640	2.56
10	1.645	2.58
12	1.650	2.60
14	1.655	2.62
16	1.660	2.63
above 16	1.660	2.66

14.8.3.4 Calculation of Total Air Leakage

Total air leakage (before adjustment) = 5670 + 0 + 3360

= 9030 CMH .... (C)

14.8.3.5 Estimation of Air Leakage through 3 Opened Doors

(i) The total no. of doors is 30. Therefore, the design calculation shall consider 3 nos. of opened single leaf doors.

(ii) The size of the door is 2.00m (H) x 0.80m (W)

(iii) Therefore, area of door is 1.60m²

(iv) Based on design criteria of 1 m/s air flow through door when the door is opened:
= 1.60m² x 1.0 m/s x 60 sec x 60 min = 5760 CMH

(v) For 3 opened doors, the air quantity:
= 5760 CMH x 3 = 17280 CMH .... (D)

14.8.3.6 Selection of Pressurisation Fan Capacity

(i) The minimum air volume required
= (C) + (D)
= 9030 + 17280 CMH
= 26310 CMH

(ii) Allow leakage factor of 25% (masonry shaft)
= 32888 CMH

(iii) The airflow of fan selected
= 33000 CMH

14.9 TESTING AND COMMISSIONING PROCEDURES

14.9.1
Each individual pressurisation system should be tested thoroughly in terms of (but not limited to) static pressure achievable, velocity of air through designed doors, operation and fail safe operation of motorised dampers (if installed) and activated on receipt of the appropriate signaling device.

14.9.2
The Master Control Panel should provide the necessary pressurisation fan switches for testing and manual override of fan operation by authorised personnel.

14.9.3
All test data must be recorded and witnessed by the Client's representative and this information must also be logged in the O & M (Operation & Maintenance) Manual.

A full set of as-built drawings, system sequence control, schematic and servicing data must also be part of the O & M Manual.

14.9.4 Example of Testing and Commissioning Record Sheet

14.9.4.1 Function Test for Staircase/Lift Lobby/Corridor Pressurisation System

Project title: ....

Owner: ....

Consultant: ....

Contractor: ....

14.9.4.2 Function Test for Staircase Pressurisation System

Staircase No. ....

(i) Measure the differential pressure between accommodation area and staircase when all staircase doors are closed.

Item	Description	Requirement	Measured	Tick if Comply
1.	Differential Pressure	50 Pa	.... Pa	....

(ii) Measure the velocity across opened staircase door when the no. of doors equal to the designed no. of opened doors are opened randomly:

Item	Description	Requirement	Measured	Tick if Comply
1.	Velocity Across Opened Door	1 m/s	................m/s	....

Function Test for Lift Lobby/Corridor Pressurisation System

Lift Lobby No. ..../Corridor No. ....

(i) Measure the differential pressure between staircase/lift lobby/accommodation area when all lobby doors and staircase doors are closed.

Item	Description	Requirement	Measured	Tick if Comply
1.	Differential Pressure between staircase / accommodation	50 Pa	.... Pa	....
2.	Differential Pressure between lift lobby / accommodation	40-50 Pa	.... Pa	....

(ii) Measure the velocity across opened door when the no. designed lift lobby doors are opened.

Item	Description	Requirement	Measured	Tick if Comply
1.	Velocity Across Opened Door	1 m/s	................m/s	....

Test Carried out by: ....

Witnessed by: ....

Approved by: ....

Date: ....

Figure 14.1

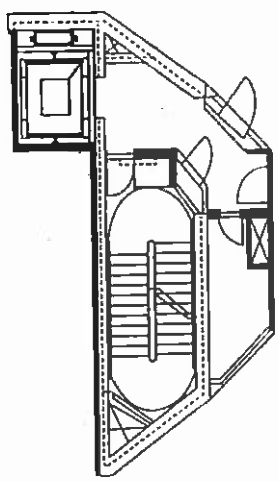
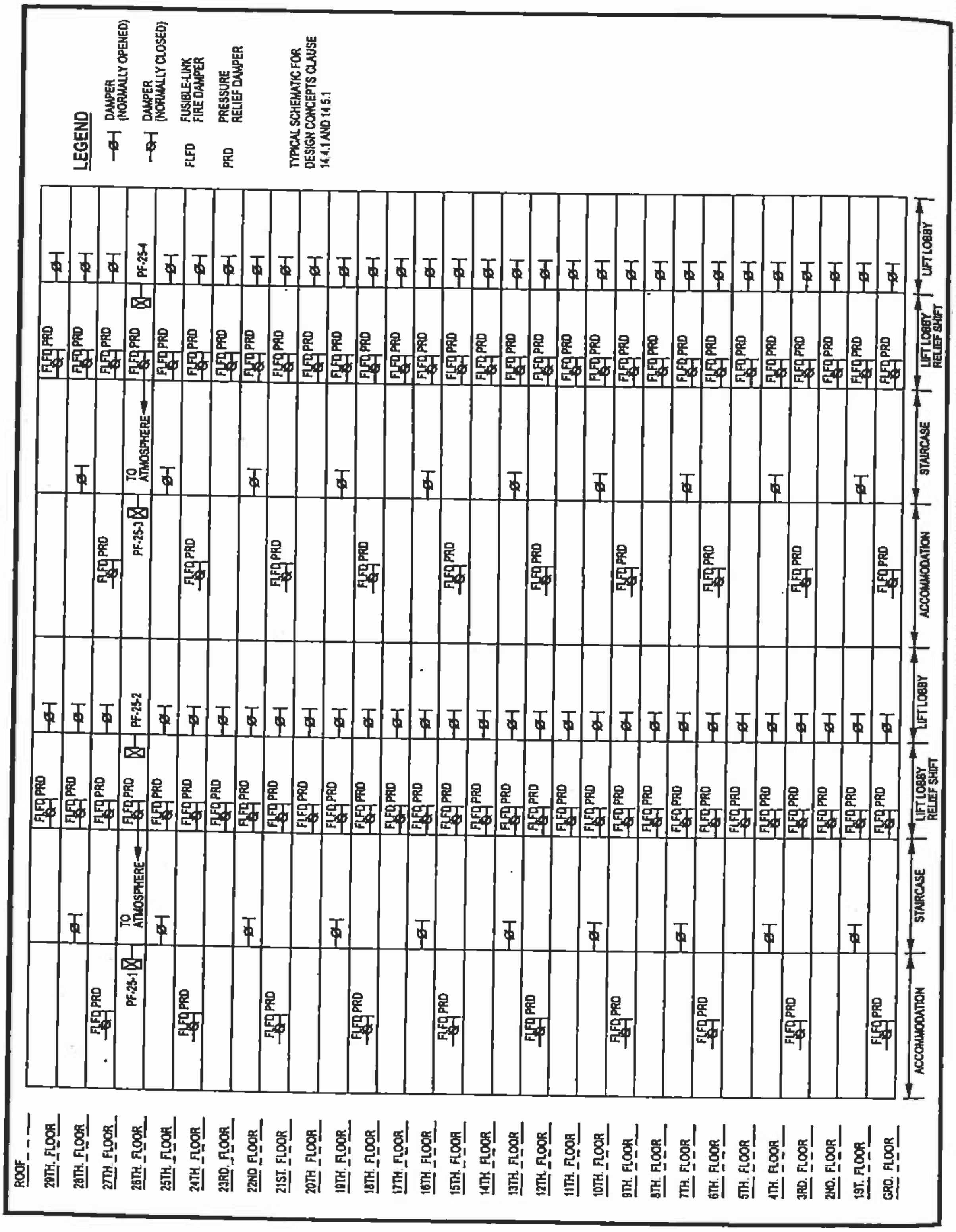


Figure 14.2 Typical Pressurisation Schematic Diagram



SMOKE CONTROL SYSTEM USING NATURAL (DISPLACEMENT) OR POWERED (EXTRACTED) VENTILATION

15 SMOKE CONTROL SYSTEM USING NATURAL (DISPLACEMENT) OR POWERED (EXTRACTED) VENTILATION

15.1 DESCRIPTION

This chapter describes smoke control by means of natural (displacement of exhaust) ventilation, powered (extract or exhaust and depressurisation) ventilation or a combination of both. Smoke control by means of pressurisation is described separately under the chapter on pressurisation.

15.2 DESIGN REQUIREMENTS

15.2.1 Design Standards

Design shall consider the following Standards:

(i) Uniform Building By-laws 1984
By-law 244 - The use of additional design standards as appropriate.
By-law 245 - Standards other than those listed in UBBL 1984 to be approved by DGFRDM.
By-law 249 - Smoke venting in windowless, underground structure and large area factories for safe use of exit.
By-law 250 - Natural draught smoke vents to be opened automatically by an approved means in the event of a fire.
By-law 251 - Smoke vents provided under By-law 249, shall be adequately designed with an element of safety to ensure protection of life.
By-law 252 - All ventilators and openings shall allow FRDM full control of the system. -
By-law 257 - Malaysian Standards to supersede all other standards.

(ii) MS 1780
(iii) BS 5588 Parts 4, 7, 10, 11
(iv) BS 7346 Parts 1, 2, 3
(v) BS 4422 Part 5
(vi) BR 186 and 258
(vii) Other acceptable Standards
(viii) Fire Safety Engineering - Performance Based Approach

15.2.2 Design Concepts

(i) Smoke obscures visibility and can contribute towards fatalities in a fire incident. In fact smoke kills more people in fires than heat, flames or structural collapse. It is therefore increasingly realised that occupant safety in a fire can be greatly improved by providing efficient smoke control systems. Moreover, such systems can limit property damage, both directly by reducing the spread of smoke, and indirectly by providing better visibility and thus easier access to the seat of the fire for fire fighters.

(ii) Smoke control is one of the tools which the fire safety engineer may use to ensure adequate fire safety within a building. As such it should not be considered in isolation, but as an integral part of the total package of fire safety measures designed for the building. Thus the need for smoke control in any building must be designed in conjunction with the means of escape, compartmentation and active suppression systems. Smoke control should be considered under the following circumstances.

(a) Smoke Control for Life Safety
Smoke control for life safety purposes is of benefit in buildings where means of escape to the open air cannot be achieved within a short period of time and in which the means of escape could be severely contaminated with smoke and become impassable. Examples include shopping malls, atrium buildings and high rise buildings with phased evacuation i.e. when a proportion of the occupants are expected to stay in the building for the duration or part duration of the fire.

(b) Smoke Extraction for Fire Fighter Access
Smoke extraction for fire fighter access is desirable for buildings where either:

- fire brigade access is difficult, eg. basements and high rise buildings; or

- rapid attack on fire is necessary to reduce fire spread and property damage.

Buildings where smoke clearance by natural means may be difficult (eg. basements, windowless buildings and buildings without openable windows) will require a powered smoke purging/dilution system.

15.2.3 Methods of Smoke Control
The efficiency of the smoke control system may be adversely affected by wind or outside temperatures. Pressures generated by wind may affect operation of the extraction of smoke by providing a positive pressure at the point of extraction. Internal climatic conditions may also affect the movement of smoke particularly in spaces with large volumes, such as atriums. This is because forced air circulation may prevent the smoke of low-buoyancy from reaching initially the point of detection. The stack effect in tall buildings and temperature inversion may also need to be considered.

The various techniques commonly used for smoke control are as described below:

(a) Smoke Containment (passive method)
Smoke Containment relies on physical barriers to limit the spread of hot smoky gases from one compartment in a building to another. Passive compartmentation such as doors, walls and floors can be used to provide some protection against smoke ingress. The extent to which smoke will leak through these barriers will depend on the size and shape of leakage paths and the pressure differentials across the paths.

(b) Smoke Dilution
Smoke Dilution describes any method of mixing the smoky gases with enough clear air to increase the available visibility and to reduce the threat from toxic products of combustion. Application includes car parking area where the low ceiling height and exhaust ductwork configuration may make smoke reservoir principle impractical.

(c) Smoke Reservoir Exhaust Ventilation (See also Clauses 15.2.4 & 15.2.5)
This is a method that provides a separation between an upper layer of smoke and a lower layer of relatively clear air. This is achieved by continuously extracting smoke from the buoyant smoke reservoir (or layer), using either natural extract ventilators or powered smoke exhaust fans. This air is then replaced by outdoor air, which re-enters the space below the base of the smoke layer.

(d) Depressurisation
Depressurisation involves the control of smoke using pressure differentials in which the air pressure in the space containing the fire is reduced below that in the adjacent spaces requiring protection. This method can be combined with a variation of other system designs. Examples of application are internal rooms of an office floor with a total floor area exceeding 1,000m^2 where the introduction of low level replacement air is impractical.

15.2.4 Engineered Smoke Control System
Engineered Smoke Control System provides the following intent:

(i) The system will safely control the movement and spread of smoke within the building.

(ii) The system is designed to remove smoke produced by a fire type and risk associated with a specific building use.

(iii) The control and removal of smoke will enhance the conditions inside the building for purposes of safe evacuation from the building and ingress for search and rescue operation.

(iv) The contained and designed movement of the smoke will enhance the operational effectiveness of the sprinklers.

(v) The containment of the smoke within the smoke reservoir will minimise the spread of smoke throughout the building and thus reduce the costs associated with smoke damage to the building fabric, stock and capital items.

(vi) The control and removal of smoke will maintain clearer and safer conditions for people to evacuate the premises. This is done by keeping the movement level of people clear from smoke and hot toxic gases and increasing the visibility levels to aid safe escape.

15.2.5 Smoke Reservoirs/Zones

(i) A smoke reservoir will prevent the spread of hot smoke and gases throughout the whole area of the building. It will also assist in keeping the smoke as hot as possible and therefore maintain maximum buoyancy and movement towards the extraction point.

(ii) The reservoir serves as a collection point for the smoke and the design needs to ensure the smoke reservoir is maintained above head height, thereby ensuring maximum conditions for breathing and visibility (and minimising conditions for panic). Minimum smoke layer base (head height clearance) shall be:

For the Lowest Floor or Single Storey
= 2.75m (natural displacement ventilation)
or
2.00m (powered extraction ventilation)

Upper Storey
= 3.00m (natural displacement ventilation)
or
2.00m (powered extraction ventilation)

(iii) Smoke reservoir creates a single position from which smoke can be extracted.

(iv) For natural smoke ventilation, the limit of each smoke reservoir/zone would be 2,000 m^2. Also refer to Clause 15.3.8.

(v) For powered smoke ventilation, the limit of each smoke reservoir/zone would be 2,600 m^2. Also refer to Clause 15.3.8.

(vi) The maximum length of a smoke reservoir/zone would be in the region of 60 metres unless proven otherwise by engineered calculation.

(vii) The amount of smoke extraction from the reservoir should be sufficient to prevent the smoke layer from building down to below the design head height clearance.

(viii) The rate of extraction (natural or powered) must be sufficient to meet the design requirements, in that it must be capable of extracting the amount of smoke which is entering the base of the smoke layer.

(ix) For any ventilation system to work effectively there must be an adequate supply of make up fresh air (replacement air) to 'balance' the system.

(x) The replacement air must be introduced at the lowest possible level (at least 0.5 metres below the base of the smoke layer). This is to ensure that the smoke layer is not disturbed by the flow of air into the building. The air velocity should be minimised to a value not exceeding 5 metres/second.

(xi) The preference is for the replacement air to be introduced naturally, for example via:

Louvres, doors, roller shutters, windows, or ventilators, all of which must open automatically so that the supply of fresh air is guaranteed.

(xii) Powered replacement air should not exceed 75% or be less than 50% of the extracted air volume.

15.3 APPLICATIONS

15.3.1 Basement Smoke Control System

(i) Where the total aggregate floor area of all basement storeys does not exceed 1,000m^2, smoke vents in accordance with Clause 15.3.1 (iii) may be provided in lieu of engineered smoke control system.

(ii) Where the total aggregate floor area of all basement storeys exceeds 1,000m^2, engineered smoke control system that complies with the requirements stipulated in Clause 15.3.8 shall be provided for all parts of basement with the following exceptions:

(a) Where the basement or a portion of the basement is used as carpark, Clause 15.3.1 (iv) can be adopted for the carpark, provided it is compartmented from rest of the basement.

(b) Plant/equipment room with floor area not exceeding 250m^2 and compartmented from the rest of the basement and provided with two doors for better reach in fire fighting operation.

(c) Plant/equipment room with floor area exceeding 250m^2 but not exceeding 1,000m^2, smoke vents in accordance with Clause 15.3.1 (iii) or smoke purging system of at least 10 air-changes per hour shall be provided.

(d) Service areas such as laundries, office storeroom and workshops (restricted to staff only) which are compartmented, smoke venting provision in accordance with Clause 15.3.1 (iii) or smoke purging system of at least 10 air-changes per hour may be accepted for those areas in lieu of the engineered smoke control system. Automatic fire alarm/extinguishing system shall also be provided where required under the UBBL.

(iii) Smoke vents shall be uniformly distributed to induce and enhance cross ventilation adequately along perimeter of basement and their outlets (which shall effectively discharge directly to the outside) shall be easily accessible during fire fighting and rescue operations. Installation shall comply with the following requirements:

(a) The number and their sizes shall be such that the aggregate effective vent openings shall not be less than 2.5% of the basement floor area served.

(b) The vent outlets if covered under normal conditions shall be breakable/openable in case of fire. Breakable covers should be capable of being opened by the fire service from outside the building and permanent notice identifying the area they serve should be provided on or adjacent to the covers.

(c) The vent outlets are sited not less than 5 metres away from exits.

(d) Where ducts are required to connect the vent to outlets, the ducts shall be constructed to give at least 1 hour fire resistance rating.

(e) Separate ducts and vent outlets or equivalent arrangements such as sub-ducts shall be provided for each basement storey.

(iv) Where powered ventilation system is required for car parking areas in basements with total floor area exceeding 1,000m^2, a smoke purging system which is independent of any system serving other parts of the building shall be provided to give a purging rate of not less than 10 air changes per hour. Installation shall comply with the following requirements:

(a) The smoke purging system shall be activated automatically by the building fire alarm system. In addition, a remote manual start-stop switch shall be located at the fire command centre, or at the main fire alarm panel. Visual indication of the operation status of the smoke purging system shall also be provided with this remote control switch.

(b) Supply air shall be drawn directly from the external and its intake shall not be less than 5 metres from any exhaust discharge opening.

(c) Where there is natural ventilation for such basement carpark based upon openings equal to not less than 2.5% of the floor area of such storey, such natural ventilation may be considered as a satisfactory substitute for the replacement air of the smoke purging system for that storey.

(d) Exhaust air shall be discharged directly to the external and shall not be less than 5m from any air intake opening.

(e) Separate ducts or equivalent arrangements such as sub-ducts shall be provided for each compartmented basement storey.

(f) Where ducts are used for the basement carpark smoke purging system, they shall comply with the requirements of the DGFRDM.

(v) Where engineered smoke control system is preferred, it shall be provided as specified under Clause 15.3.8.

15.3.2 Smoke Control System for Above Ground Premises

(i) Where the total non fire compartmented aggregate floor area exceeds 1,000m² or the volume exceeds 7,000m³, a smoke control system shall be provided.

(ii) Where natural smoke ventilation is provided, the smoke vents shall be in accordance with Clause 15.3.2.(v)

(iii) Where powered smoke control system is provided, this shall comply with Clause 15.3.2.(vi)

(iv) Where engineered smoke control system is provided, this shall comply with the requirements as stipulated in Clause 15.3.8.

(v) Smoke vents shall be positioned at high level above the smoke layer base and conform to the requirements specified below:

(a) The number and their sizes shall be such that the aggregate effective vent openings shall not be less than 2.5% of the floor area served.

(b) The vent outlets (which shall effectively discharge directly to the outside) shall be of the permanently opened type or will open automatically under a fire mode condition without human intervention.

(c) Replacement air shall be by means of natural ventilation.

(d) Conformance to Clause 15.2.5.

(vi) Engineered Smoke Control System design shall be applicable only for ceiling heights exceeding 2 or 3 metres (See Clause 15.2.5) for the smoke reservoir principle to be effective.

Below 2 or 3 metres (See Clause 15.2.5) ceiling heights, powered smoke purging/dilution system of at least 10 air changes per hour shall be provided to suit the concepts adopted.

Make up or replacement air shall be provided in the following manner:

(a) For smoke depressurisation concept, no purpose provided replacement air is necessary. However, pressure differential between depressurised zone and the adjacent zone shall be maintained at between 10 to 50 Pa.

(b) For smoke dilution concept, replacement air may be introduced at any level but, if powered, shall be limited to not less than 50% and not greater than 75% of the exhaust air volume.

15.3.3 Smoke Control System for Fire Fighting Access Lobby

(i) Fire fighting access lobby where not mechanically pressurised, shall be smoke vented in compliance with the requirements specified below:

(a) The openable area of windows or area of permanent ventilation shall not be less than 25% of the floor area of the lobby, and if ventilation is by means of openable windows, additional permanent ventilation having a free area of 464 cm² shall be provided.

(ii) A smoke lobby shall be treated as a protected stairway as described under Clause 15.3.4.

15.3.4 Smoke Control System for Protected Stairway

(i) Protected stairway where not mechanically pressurised should be provided with either:

(a) Openable windows at each upper storey or landing level having a clear openable area not less than 5% of the cross sectional area of the stairway; or

(b) An openable vent outlet at the top having a clear area of not less than $1m^2$.

15.3.5 Smoke Control of Hotel Internal Corridors

(i) Where internal corridors in hotels are not mechanically pressurised, such corridors shall be smoke purged at a purging rate of not less than 10 air changes per hour.

(ii) Engineered smoke control system may be applied only for corridors exceeding 2 or 3 metres height (Clause 15.2.5).

(iii) Natural ventilation is permissible only if induced cross ventilation is available and the aggregate effective vent openings of not less than 2.5% of the floor area served can be provided.

15.3.6 Smoke Control for Auditorium (Cinemas, Theaters etc)

(i) Smoke vents with effective openings of not less than 2.5% of the floor area served shall be provided for auditoria which are not sprinkler protected and to auditoria having floor area more than $500m^2$ if sprinkler protected.

(ii) Where engineered smoke control system is preferred, it shall conform to Clause 15.3.8.

15.3.7 Atrium Smoke Control System

(i) Where the requirement for compartmentation specified in UBBL 1984 are relaxed for atrium spaces in a building, smoke control system shall be provided for a sterile tube atrium type as specified below:

(a) Where the height of the atrium is 17 metres or less and the volume of the atrium is $17,000m^3$ or less, the smoke exhaust rate shall be 19 m^3/s or 6 air changes per hour, whichever is greater.

(b) Where the height of the atrium is 17 metres or less and the volume of the atrium is more than $17,000m^3$, the smoke exhaust rate shall be 19 m^3/s or 4 air changes per hour, whichever is greater.

(c) Where the height of the atrium is more than 17 metres, the smoke exhaust rate shall be at a minimum of 4 air changes per hour.

(d) Where engineered smoke control system is preferred, it shall be provided as specified in Clause 15.3.8.

(ii) For a non sterile tube atrium type, engineered smoke control system complying with the requirements as stipulated in Clause 15.3.8 shall be adopted.

(iii) The smoke control system shall be activated by:

(a) smoke detectors located at the top of the atrium and adjacent to each return air-intake from the atrium or beam detectors at the appropriate levels;

(b) the automatic sprinkler system serving the atrium zone/s;

(c) automatic detector system (but not manual call point);

(d) manual controls readily accessible to the Fire Brigade.

15.3.8 Engineered Smoke Control System

(i) Engineered smoke control system shall be in the form of a smoke ventilation system by natural or powered extraction designed in accordance with:

(a) BR 186 - Design principles for smoke ventilation in enclosed shopping centres; or

(b) BR 258 - Design approaches for smoke control in atrium buildings; or

(c) Other acceptable standards, such as:

- Warrington Fire Research Consultants (WFRC)
- Society of Fire Protection Engineers Publication (SFPE)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

(Note BR 186 and BR 258 are reports published by the Fire Research Station, Building Research Establishments, UK).

(ii) The building to be provided with engineered smoke control system shall have a smoke layer temperature not exceeding 250°C.

(iii) Capacity of the smoke ventilation system shall be calculated based on the incidence of a likely maximum fire size for a sprinkler controlled fire as recommended in the following table:

Occupancy (Sprinklered)	Fire Size	
	Heat Output (MW)	Perimeter of Fire (m)
Shops	[illegible]	12
Offices	6	12
Hotel Guest Room	0.5	6
Hotel Public Areas	2.5	12
Assembly Occupancy with fixing seating	[illegible]	12
Warehouse	10	18
Basement Service Area (Lorry Parks)	7	15
Car parks	[illegible]	[illegible]

(iv) The capacity of a smoke ventilation system shall be capable of handling the largest demand for smoke exhaust under the worst case scenario.

(v) The design smoke layer base shall be above the heads of people escaping beneath it. The minimum height shall be as described under Clause 15.2.5.

(vi) Smoke reservoirs to prevent the lateral spread of smoke and to collect smoke for removal shall be of non-combustible construction capable of withstanding smoke temperatures.

(vii) For cases where smoke is removed from the room of origin the smoke reservoir size for a smoke ventilation system should not exceed:

(a) 2,000m^2 for natural smoke ventilation system

(b) 2,600m^2 for mechanical smoke ventilation system

(viii) For cases where smoke is removed from the circulation space or atrium space the smoke reservoir size for a smoke ventilation system should not exceed:

(a) 1,000m^2 for natural smoke ventilation system

(b) 1,300m^2 for powered smoke ventilation system

(ix) For cases where smoke is removed from the circulation space or atrium space, the rooms discharging smoke into the circulation space/atrium spaces should either:

(a) have a floor area not exceeding 1,000m^2 (for natural ventilation system) or 1,300m^2 (for powered ventilation system) or

(b) be subdivided such that smoke is vented to the circulation space or atrium only from part of the room with floor area not exceeding 1,000m^2 for natural ventilation system or 1,300m^2 for powered ventilation system, that are adjacent to the circulation space or atrium. However, the remainder of the room needs to be provided with independent smoke ventilation system/s.

(x) The maximum length of the smoke reservoir should not exceed 60 metres, unless proven otherwise.

(xi) Adequate arrangement(s) shall be made in each smoke reservoir for the removal of smoke in a way that will prevent the formation of stagnant regions.

(xii) Replacement air shall be drawn directly from the external or adjacent spaces, and;

(a) The design replacement air discharge velocity shall not exceed 5m/s to prevent the escapees being affected by the air flow.

(b) Replacement air intake shall be sited at least 5 metres away from any exhaust air discharge.

(c) Replacement air shall be discharged at low level, at least 0.5 metres beneath the designed smoke layer, to prevent "fogging" of the lowest clear zone.

(d) Where the inlet cannot be sited at least 0.5m below the smoke layer, a smoke curtain or a baffle shall be used to prevent replacement air distorting the smoke layer.

(e) Where replacement air is taken through inlet air ventilators or doorways, devices shall be incorporated to automatically open such inlet ventilators and doors to admit replacement air upon activation of the smoke ventilation system.

(xiii) For cases where the smoke reservoir is above the false ceiling, the ceiling shall be of perforated type or evenly distributed air inlets with at least 10% openings.

(xiv) The smoke ventilation system shall be provided with secondary source of power supply.

(xv) In conjunction with Clause 15.3.7 (iii), the smoke ventilation system shall be activated by smoke detectors located in the smoke control zone. Use of smoke detectors for activation must be carefully designed so that accidental or premature activation of smoke detectors at a non-fire zone due to smoke spill or spread from other areas is avoided.

(xvi) A remote manual activation and control switch as well as visual indication of the operation status of the smoke ventilation system shall also be provided at the fire command centre and where there is no fire command centre, at the main fire indicator board.

(xvii) Except for ventilation systems for escape routes and smoke lobbies, all other air conditioning and ventilation systems within the areas served shall be shut down automatically upon activation of the smoke ventilation system.

(xviii) Fans shall be capable of operating at 250°C for 2 hours.

(xix) The fans and associated smoke control equipment shall be wired in protected circuits designed to ensure continued operation in the event of the fire.

(xx) The electrical supply to the fans shall be by means of cables of at least 2-hours fire resistance.

(xxi) Smoke ventilation ducts (both exhaust and replacement air ducts) passing through another fire compartment shall be constructed to have fire resistance rating not less than that of the compartment.

(xxii) Non-motorised fire dampers shall not be fitted in the smoke ventilation system.

(xxiii) The time taken from the smoke ventilation system within a smoke zone to be fully operational shall not exceed 60 seconds from system activation.

(xxiv) For natural smoke ventilation system the natural ventilators shall be:

(a) defaulted in the "open" position in the event of power/system failure; and

(b) positioned such that they will not be adversely affected by positive wind pressure.

(xxv) Natural exhaust ventilation shall not be used together with powered replacement air or powered smoke exhaust ventilation.

(xxvi) All smoke curtains where required, unless permanently fixed in position, shall be brought into position automatically to provide adequate smoke-tightness and effective depth.

(xxvii) Smoke curtain or other smoke barrier at any access route forming part of or leading to a means of escape shall not in their operational position obstruct the escape of people through such route.

(xxviii) Where glass walls or panels are used as smoke screens to form a smoke reservoir or as channeling screens, they shall be able to withstand the highest design smoke temperature.

(xxix) All smoke control equipment (including smoke curtains) shall be supplied and installed in accordance with the accepted standards such as BS 7346.

(xxx) To minimise the phenomena of plugholing, multiple inlets should be (calculated or modelled) used for powered smoke extraction system. Also, the maximum mass flowrate through each exhaust inlet must be limited to suit the depth of smoke layer below the exhaust inlet.

(xxxi) The ceiling jet produced when smoke plume hits the ceiling can impact the effectiveness of a powered smoke venting system. To contain this impact, smoke extraction should be designed for a minimum smoke layer depth of 10% of the floor to ceiling height.

15.4 CALCULATION

15.4.1 Examples of Basement Carpark Smoke Control System

15.4.1.1 Description of Building

A 12-storey office building consisting of 3 basement carpark levels.

15.4.1.2 Design Consideration

The 3 levels of below grade carpark shall be independently smoke controlled by means of powered exhaust system with natural replacement supply air.

The carpark ventilation system is designed with low and high level exhaust inlets to ensure the removal of heavier than air toxic carbon monoxide and dioxide gases as well as rising hot air. Under smoke spill mode, the principle of smoke reservoir may not be practical due to the low <3 metres headroom as well as the need to remove the heavier CO and CO_2 gases at low level. Hence the dilution method of smoke extraction will be more practical.

Each level of carpark shall be compartmentalised by means of fire rated roller shutters installed at the ingress ramps to limit its volume to 42,000m³ per compartmented zone to comply with UBBL 1984.

The ventilation rate shall be 6 air-changes per hour (ACH) for normal operation and 10 ACH for fire mode operation.

15.4.1.3 Design Calculation

Each Carpark level

Nett Floor Area = 13,000 m²
Floor to Floor Height = 3 m
Volume = 39,000 m³
10 ACH = 108.3 m³/s
4 Fan rooms located at 4 corners of each carpark floor.
2 Replacement Air Shafts located at opposite ends.

Refer to Figure 15.4.1

15.4.1.4 Design Specification

For each carpark level
Under normal mode, fans in operation (to provide minimum 6 ACH)
- 8-off @ 9.1 m³/s = 72.8 m³/s

Under Fire mode, fans in operation (to provide minimum 10 ACH)
- 12-off @ 9.1 m³/s = 109 m³/s

15.4.2 Example of Smoke Control System for Office Floors

15.4.2.1 Description of Building

A 12-storey office building consisting of 3 basement carpark levels, 3 public area podium levels, 5 office levels, a Mechanical & Electrical Plantroom level and incorporating a 7 storey atrium.

15.4.2.2 Design Consideration

The smoke control design for the office floors adopts the guidelines issued by Warrington Fire Research Consultants (WFRC) as well as the "Design of Smoke Management Systems" published by American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and Society of Fire Protection Engineers (SFPE).

Fig. 15.4.2 illustrates the concept of the Office Floor Smoke Control system. A sandwiched pressurisation - smoke extract system is adopted, whereby the floor on fire will be under a negatively pressured smoke spill mode whilst the floor immediately above and below the fire floor are positively pressurised.

15.4.2.3 Description of Engineering Design

Each office floor contains 6 Air Handling Unit (AHU) rooms. Replacement air is delivered into the AHU rooms by primary AHU's (6 nos.) located at Level 6 (L6) plantroom. 6 nos. smoke spill fans located at L6 plantroom are ducted into each AHU room and connected to the return air ducts. By means of a series of motorised smoke dampers, smoke is extracted from the fire floor and discharged above the roof line. The positively pressurised floors are achieved by actuating the respective floor AHUs to operate under pressurization mode - Refer Fig. 15.4.2 for clarity. The smoke spill mode for each office floor is activated by any of the following devices:

(i) Smoke detectors mounted within the raised floor plenum, ceiling and return air intake

(ii) Sprinkler flow switches serving each office floor

(iii) Remote manual controls from the Main Fire Control Panel

15.4.2.4 Calculation

Typical Office Floor area = 3,610 m^2
Raised floor height = 0.4 m
Slab to raised floor ht = 3.475 m
Ceiling to raised floor ht = 2.7 m

Design Fire Size Heat Output, Q = 1.5 MW (Clause 15.3.8)

Fire Perimeter, P = 12m (Clause 15.3.8)

Using WFRC Guidelines, $M = 0.19\ Py^{3/2}$

Where M = mass of smoke (kg/s)

y = height from floor to smoke layer base (m)

Therefore $M = 0.19 \times 12 \times 3.1^{3/2}$
$= 12.44$ kg/s

Temperature of smoke layer above ambient,

$$\theta = \frac{Q}{M} = \frac{1500}{12.44} = 120.6°C$$

Ambient temperature,

$T_o = 273 + 33 = 306K$

Smoke Temperature,

$T_c = 306 + 120.6 = 426.6K$

Smoke Volume,

$$V = \frac{M \times T_c}{354.5} = \frac{12.44 \times 426.6}{354.5} = 15\ m^3/s$$

Based on volumetric space, this translates to 4.3 ACH

15.4.2.5 Design Specification
6 nos. smoke spill fans are specified to divide the smoke reservoir into 6 zones, each less than 2,600m^2.

6 fans each of 2.5 m^3/s are selected, to give a total capacity of 15 m^3/s

These fans can also be utilised for the following functions:
(i) Smoke purging after fire
(ii) Normal mode air flushing for avoidance of Sick Building Syndrome

15.4.3 Examples of Smoke Control System for Atrium

15.4.3.1 Description of Building
A 12-storey office building consisting of 3 basement carpark levels, 3 public area podium levels, 5 office levels, a Mechanical & Electrical Plantroom level and incorporating a 7-storey atrium.

15.4.3.2 Description of Atrium
The atrium consists of 7 levels (LG1 to L5). Level LG1 which is the base of the atrium extends beyond the foot print of the atrium void to enclose common area lobbies and foyers. The occupied rooms adjacent to these circulation areas are separated by barriers (walls etc).

The ground floor level can be classified generally as being opened directly to the atrium from the exterior. The office levels (L1 to L5) are separated from the atrium void by glass enclosures. However, each office level incorporates a perimeter circulation balcony overlooking the atrium. Escape routes for office tenants into the 4 protected lobbies/staircases need not transverse these exposed balconies.

The building is fully sprinklered. The glass walls separating the balconies and the office space are protected with close ranged sprinklers spaced 1.8m apart. However, the atrium void which exceeds 17m height, is not sprinklered.

The arrangement of this atrium can be classified as a fully open atrium due to the open access balcony on each level. Refer Fig. 15.4.3.

15.4.3.3 Description of Engineering Design

The atrium void smoke spill fans are installed at the L6 Plantroom with the air extraction points located above the highest occupied office (L5) level. The extracted air is directed to discharge at the roof openings by means of fire-rated ducts.

The smoke spill fans are activated by any of the following devices:

(i) Smoke detectors (beam types) located at L6 and L1 heights for detection of the void area

(ii) Smoke detectors located at each office level balcony ceiling

(iii) Smoke detectors serving unenclosed public/common areas of the Ground and LG1 floors

(iv) Smoke detectors located at the return air intake of the atrium air handling units.

(v) Sprinkler flow switch serving the atrium balcony floors

(vi) Remote manual controls at the Main Fire Control Panel

15.4.3.4 Calculation and Assumptions

(a) Based on Clause 15.3.7.1 (i) (c) for sterile tube Atrium type (for comparison purposes only).

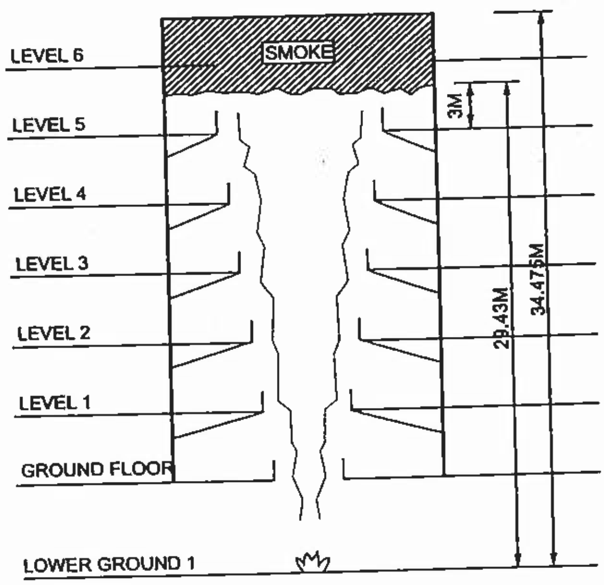
(i) Height of atrium = 34.475m

(ii) Volume of atrium = LG1: 1125 m^2 x 4.025 m = 4528 m^3
= GF: 1300 m^2 x 6.3 m = 8190 m^3
= L1 to L5: 919 m^2 x 4.025 m x 5 = 18495 m^3
= L6 void: 919 m^2 x 4.025 m = 3699 m^3
34,914 m^3

Smoke extraction rate at 4 ACH = 39 m^3/s

(b) Based on Design of "Smoke Management Systems" published by ASHRAE and SFPE.

The worst case scenario is for a fire located in the centre of the atrium floor with an axisymmetric plume.



Using Equation 10.9 of the SFPE Guide

Z_l = $0.166\ Ec^{0.4}$

Where Z_l = limiting height above fuel

E = convective heat release rate of fire = 1.5 MW

E_c = effective heat release rate of fire = 0.7 x 1.5 MW

Therefore Z_l = $0.166\ (0.7 \times 1500)^{0.4}$
= 2.68 m

Since the limiting height is less than the clear smoke height of 29.43 m, the latter is used for subsequent calculation.

Using Equation 10.8 of the SFPE guide

m = $0.071\ Ec^{1/3}\ Z^{5/3} + 0.0018\ Ec$

where m = mass rate of smoke production

Z = height from top of fuel surface to bottom of smoke layer

Therefore m = $0.071\ (0.7 \times 1500)^{1/3}\ 29.43^{5/3} + 0.0018 \times 0.7 \times 1500$
= 204.25 kg/s

Applying Equation 10.12 of the Guide

V = $C \dfrac{m}{e}$

where V = Volumetric smoke production rate

C = entrainment constant = 1

e = density of plume gas = 1.2 kg/m^3

Therefore V = $1 \times \dfrac{204.25}{1.2}$ = 170.2 m^3/s

15.4.3.5 Design Specification

From the above calculations, Clause 15.3.7 (i) (c) is clearly inadequate in this instance, as the said 4 ACH method applies to sterile tube Atrium type only.

Hence, using the ASHRAE/SFPE method

(i) Calculated smoke extraction rate = 170.2 m^3/s

Specified smoke spill fans

24 nos. each 7.1 m^3/s = 170.4 m^3/s

(ii) Fresh air intake from
   (a) LG1 low level supplied by AHU/L6/1A and 1B
   (b) Ground floor Main entrance doors (automatically opened)

(iii) Plugholing check:

$$V_{crit} = \frac{2\,(g \times d^5 \times \theta \times To)^{0.5}}{Tc}$$

$$\text{Min No. of extract points} = \frac{V}{V_{crit}}$$

Where
d = Centre line of extract to smoke layer base
θ = Temperature of smoke layer above ambient (°C)
To = Ambient temperature (K)
Tc = Smoke temperature = To + θ
g = 9.81 m^2/s

15.4.4 Example of Smoke Control System for a Warehouse

15.4.4.1 Description of Building
A single storey air conditioned warehouse without jack roof or permanently opened roof ventilators. Warehouse is fully sprinklered.

15.4.4.2 Design Consideration
The smoke control design adopts the guidelines issued by Warrington Fire Research Consultants (WFRC). Figure 15.4.4 shows the various critical dimensions.

15.4.4.3 Design Calculation
Warehouse dimension = 200 m L x 20 m W x 15 m H.

Floor area = 4000 m^2

For natural ventilated smoke reservoir, the maximum size = 2,000m^2 (Clause 15.2.4).

Hence, the warehouse needs to incorporate a smoke curtain (either permanent or drop down type) to divide the smoke reservoir into 2 zones of 2,000m^2 each.

Fire size shall be, Q = 10 MW heat output and P = 18m perimeter of fire (Clause 15.3.8)

Minimum smoke clearance height to life safety design

y = 3m (Clause 15.2.4)

Mass flowrate of smoke,

$m = 0.19\,Py^{3/2}$ (kg/s)

Hence m = 0.19 x 18 x 3 3/2 kg/s = 17.8 kg/s

Temperature of smoke layer above ambient,

$$\theta°C = \frac{Q}{m} = \frac{10{,}000}{17.8} = 561.8°C$$

This calculated smoke layer temperature exceeds 250°C, which is deemed as the highest temperature suitable for safe escape below the smoke layer. However, for a fully sprinklered building, the maximum smoke layer temperature is assumed as 250°C due to the cooling provided by the activated sprinkler/s. Hence, this calculated smoke layer temperature is meant for unsprinklered building consideration.

This worked example will demonstrate the calculation for both sprinklered and unsprinklered application for comparison purposes.

For unsprinklered building, to limit the smoke layer temperature to 250°C maximum, then if the ambient temperature is 33°C, the temperature rise should not exceed 250°C - 33°C = 217°C.

Next, allow for the building structure to absorb up to one third of the energy of the fire, then

$$\theta = \frac{217°C}{0.67} = 323.9°C$$

Then y

$$= \left[\frac{(\quad Q \quad)^{2/3}}{(\ 0.19 \times P \times q\ )^{2/3}}\right]$$

$$= \left[\frac{(\quad 10{,}000 \quad)^{2/3}}{(0.19 \times 18 \times 323.9)^{2/3}}\right]$$

= 4.33 m

and m = $0.19 \times P \times y^{3/2}$

= 30.8 kg/s

Smoke temperature,

Tc = To (Ambient temperature) + θ

= (273 + 33 + 250) K = 556K for sprinklered warehouse

or

= (273 + 33 + 323.9) K = 629.9K for unsprinklered warehouse

Smoke volume, V m^3/s

$$= \frac{m \times Tc}{354.5}$$

$$= \frac{17.8 \times 556}{354.5} = 27.9\ m^3/s \text{ for sprinklered warehouse}$$

or

$$= \frac{30.8 \times 629.9}{354.5} = 54.7\ m^3/s \text{ for unsprinklered warehouse}$$

Vent Area (where vent area (Av) = inlet area (Ai) is derived from:

$$Av = \frac{mT^{0.5}\,(288 + T)^{0.5}}{54\,(d\theta)^{0.5}}\ m^2$$

Where T = 288 + θ

d = distance between centre line of vent and base of smoke layer

$$\text{Therefore } Av = \frac{17.8 \times 538^{0.5}\,(826)^{0.5}\ m^2}{54\,([15-3]\,250)^{0.5}} = 4.01\ m^2 \text{ of ventilation per smoke zone for sprinklered warehouse}$$

or

$$Av = \frac{30.8 \times 611.9^{0.5}\ 899.9^{0.5}\ m^2}{54\,([15-4.33]\,323.9)^{0.5}} = 7.2\ m^2 \text{ of ventilation per smoke zone for unsprinklered warehouse}$$

Note that for powered smoke extraction system in this example, if the maximum size of the smoke reservoir zone is not preferred, then smoke spill fans for both zones shall be activated simultaneously and all fans shall be under emergency power supply.

15.5 TESTING AND COMMISSIONING PROCEDURES

15.5.1

Smoke Control systems are designed for use during a fire condition with temperatures produced by the fire that are significantly higher than ambient temperature conditions. Therefore, the use of cold smoke tests does not reflect the efficient operation of the smoke control system as designed. What it will do, is to show the airflow patterns that will be potentially induced by the smoke extract equipment. BR 186-Design principles for smoke control in enclosed shopping Centres states "Cold smoke tests are sometimes used for the acceptance testing of smoke ventilation systems. Whilst this cold smoke can be used to operate the smoke detection system and therefore activate all the components of the smoke ventilation system, it should be noted that since the smoke itself is cold it would not have the buoyancy that smoke in a true fire condition would have, and cannot therefore adequately test the ventilation efficiency of the system".

This is particularly relevant in high buildings where smoke produced by a 'fogging machine' at floor level, has very little temperature in itself to rise quickly to the point of extraction.

Design utilising the technique of smoke dilution and incorporating low level exhaust (eg. carparks) can be adequately tested with cold smoke (fogging machine). During such test, the smoke spill fan/s should be allowed to activate under its automatic mode and visibility should be maintained for evacuation purposes at all times.

There have been real fire tests using full size fires to assess the effect and efficiency of the equipment and parametres for design. However, such tests, if necessary, should be limited to projects of high complexity. Verification using established Computational Fluid Dynamics/Modulation analysis is also applicable for such projects.

The designer and installer (who may be different people), must therefore be able to show that the design follows accepted and published design principles, whilst the equipment also conforms to the test and certification procedures required for smoke control equipment. In this way there can be confidence in the ability of the design to meet the requirements and in the equipment to meet the design.

15.5.2

The system should be tested thoroughly and the activation on receipt of the appropriate signaling device (from whichever detection method chosen and approved) is required. The ability of the system to fail safe to the design position should also be checked.

15.5.3

The Main Fire Alarm Panel should provide the correct information and operational sequence and the interfaces with other allied systems should be checked.

15.5.4
All test data must be recorded and witnessed by the client's representative and this information also logged in the O & M Manual. A full set of as-built drawings, system sequence control, schematic and servicing data must also be part of the O & M manual.

15.5.5 Example of Testing & Commissioning Record Sheet
Function Test for Smoke Control System

Project Title: ....

Owner: ....

Consultant: ....

Contractor: ....

A. Floor: .... (Fire mode simulated on this Floor)

Item	Description	Requirement	Tick if Comply
1.	Air Handling Units	Run	....
2.	Return Air Damper	Close	....
3.	Smoke Spill Damper	Open	....
4.	Fresh Air Damper	Open	....

B. Floor above and below Fire Floor i.e. .... to ....

Item	Description	Requirement	Tick if Comply
1.	Air Handling Units	Run	....
2.	Return Air Damper	Close	....
3.	Smoke Spill Damper	Close	....
4.	Fresh Air Damper	Open	....

C. General Fire Alarm activated after 5 minutes

1.	AHU's on all Floors except ___ and ___.	Trip	....
2.	Smoke Spill Dampers on all Floors except ___	Close	....

NOTE: Test with both normal and emergency power supply

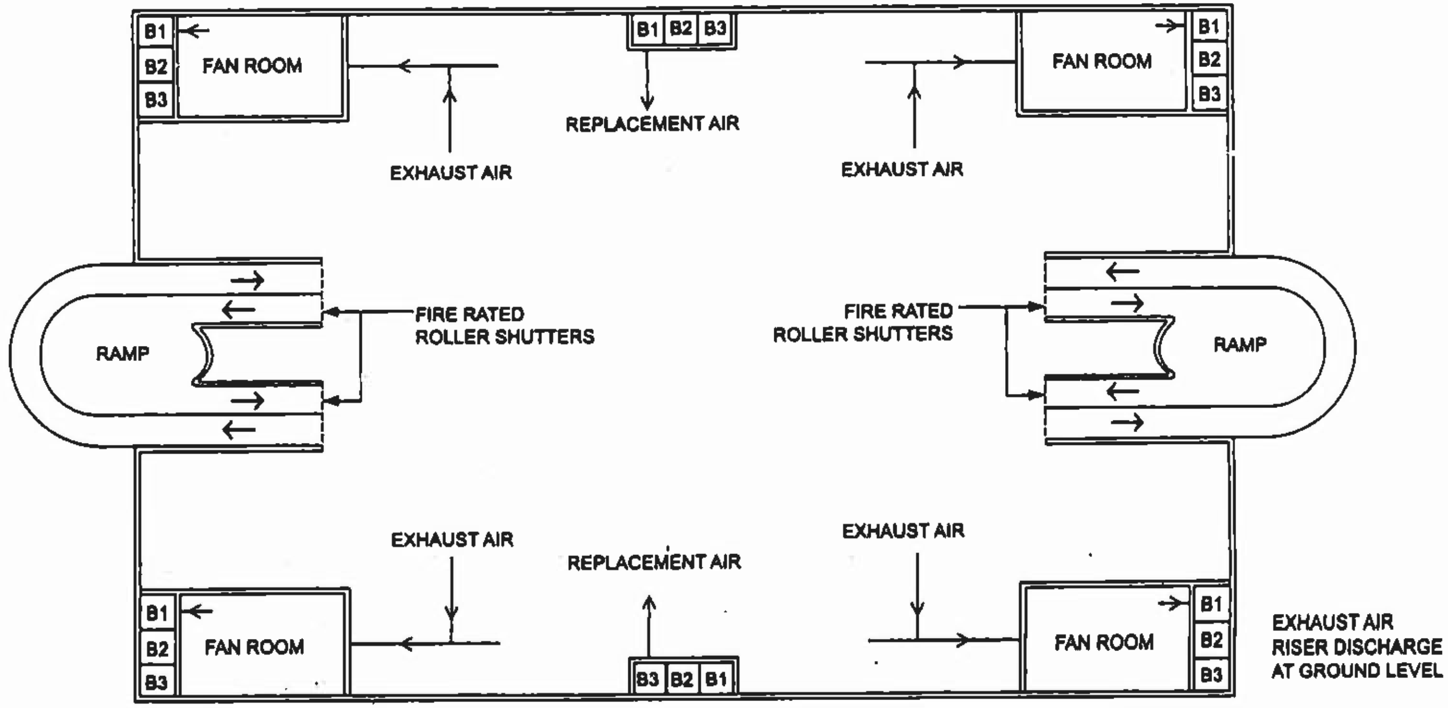
Test carried out by: ....

Witnessed by: ....

Approved by: ....

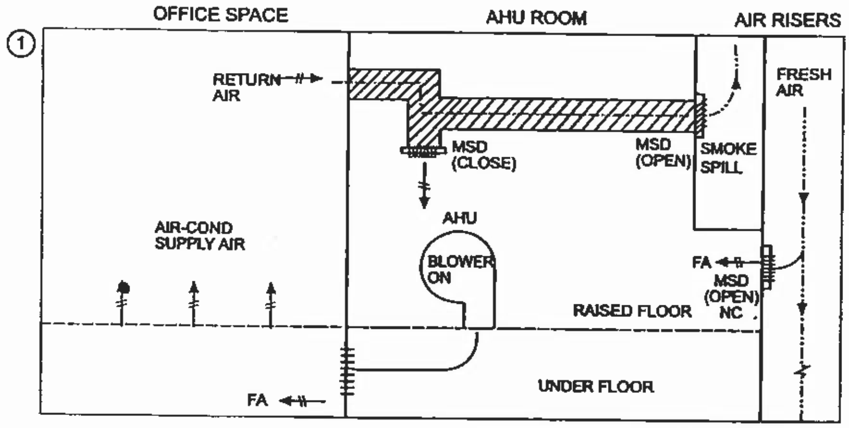
Date: ....

Figure 15.4.1 Basement Car Park Smoke Control System



Typical Floor Layout

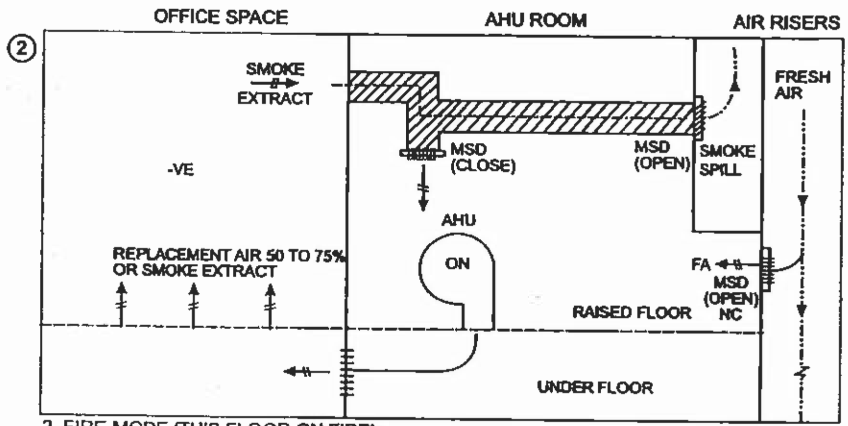
Figure 15.4.2 Office Floor Smoke Control



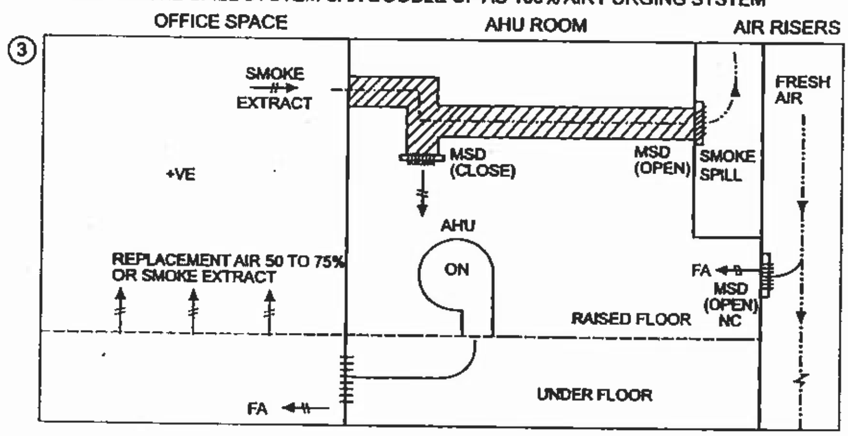
NOTE:
1) UNDER FIRE MODE, OTHER AHU'S SHALL TRIP AND MSD'S AND MFD CLOSED

LEGEND:
MSD - MOTORSED SMOKE DAMPER
MFD - MOTORSED FIRE DAMPER
FA - FRESH AIR
- FIRE RATED DUCT

1. NORMAL AIR-CONDITIONING MODE

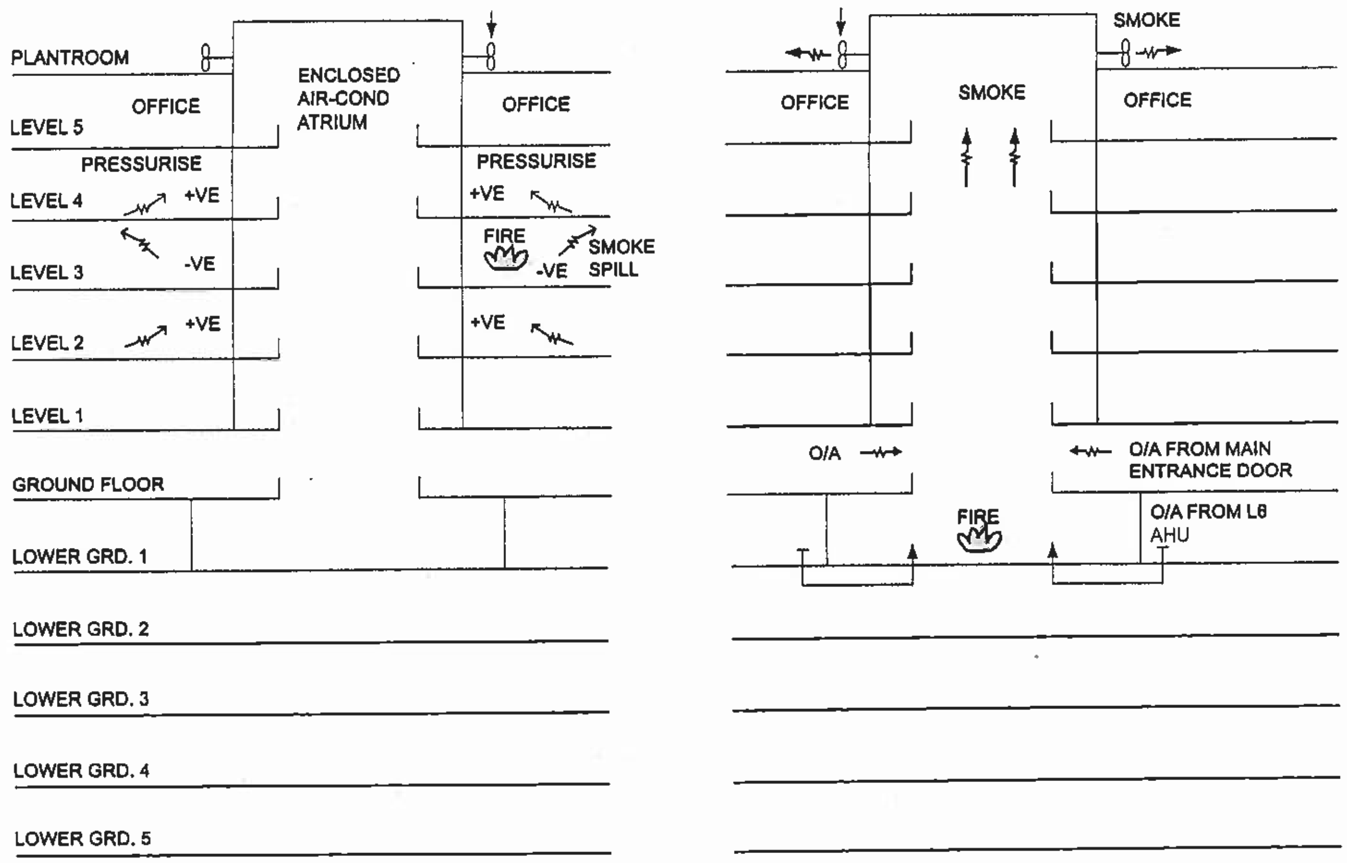


2. FIRE MODE (THIS FLOOR ON FIRE)
THIS SMOKE SPILL SYSTEM CAN DOOBLE UP AS 100% AIR PURGING SYSTEM



3. FIRE MODE (FLOOR NOT FIRE BUT IS ONE FLOOR ABOVE OR BELOW FIRE FLOOR)

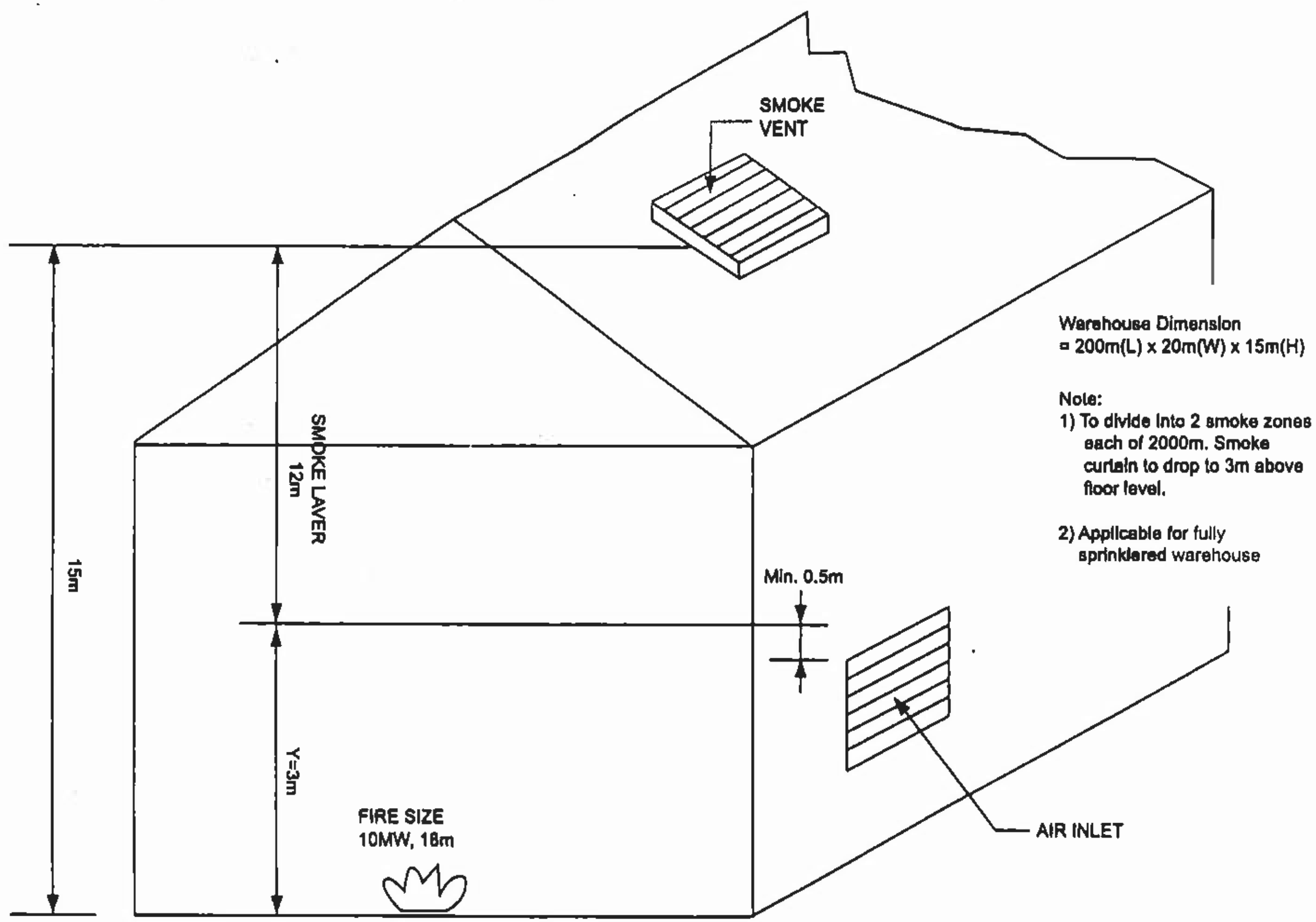
Figure 15.4.3 Smoke Control System for Atrium



1. FIRE ON L3
   a) SMOKE SPILL SYSTEM AT L3 OFFICE ACTIVATED
   b) L4 AND L2 OFFICE FA OPERATE IN PRESSURISED MODE
   c) AHU'S ON ALL OTHER FLOORS TRIPPED

2. FIRE IN ATRIUM VOID
   a) ATRIUM SMOKE SPILL FANS OPERATE
   b) ALL AHU'S TRIPPED

Figure 15.4.4 Smoke Control for Warehouse
(Natural Ventilation)



FIRE LIFT

16.1 DESCRIPTION

In a building where the topmost occupied floor is over 18.5 metres above fire appliance access level, fire lift/s shall be provided. A penthouse occupying not more than 50% of the area of the floor immediately below shall be exempted from this measurement.

Fire lifts mean lifts capable of being commandeered for exclusive use by firemen during an emergency.

16.2 DESIGN REQUIREMENTS

16.2.1 Design Standards
The installation shall be designed and installed for vertical transportation of firemen in accordance with the latest edition of

(i) Uniform Building By-laws 1984
(ii) Factories and Machinery Regulation 1967
(iii) Occupational Safety and Health Act 1994
(iv) BS 2655
(v) Other acceptable Standards

Building layout plan indicating the location of fire lifts shall be submitted to FRDM and DOSH, Malaysia for approval and/or record.

16.2.2 Location of Fire Lifts
Fire lifts shall be located at not more than 61 metres travel distance from the furthermost point of the floor. The fire lifts shall also be located not more than 61 metres travel distance from the main entrance of the building on the designated floor or the fire control room whichever is nearer.

A fire lift shall be located within a separately protected shaft if it opens into a separate lobby.

16.2.3 Number of Fire Lifts
Fire lifts shall be provided at the rate of one lift in every group of lifts that discharge into the same protected enclosure or smoke lobby containing the rising mains.

16.2.4 Number of Floors to be Served
Fire lifts shall serve all floors including the topmost occupied floor.

16.2.5 Lift Well/Shaft
Fire lifts shall be located in protected lift shafts of at least 2 hours fire resistance protection (FRP).

No piping, conduit or equipment other than that forming part of the lift or necessary for its maintenance shall be installed in any lift shaft or lift shaft enclosure.

16.2.6 Landing Doors
Landing doors shall have a FRP of not less than half of the FRP of the lift shaft structure with a minimum FRP of half an hour.

No glass shall be used for landing doors except for vision in which case any vision panel shall be glazed with wired safety glass, and shall not be more than $0.0161m^2$ and the total area of one or more vision panels in any landing door shall be not more than $0.0156m^2$. Each clear panel opening shall reject a sphere 150mm in diameter.

Provision shall be made for the opening of all landing doors by means of an emergency key irrespective of the position of the lift car.

16.2.7 Wiring and Cabling

All wiring and cabling for fire lifts shall be of fire resisting cables, routed along areas of least fire risk. The cables shall be sized to continuously carry current required by the equipment it is supplying to without failure.

16.2.8 Other Requirements for Fire Lifts

Lift Speed shall be such that it will run its full travel distance in not more than 1 minute.

Lift Lobby width shall be as a minimum twice the car depth.

Lift lobby shall have a floor area of not less than $5.57m^2$. (60 sqft)

Fire lifts shall have an effective platform area not less than $1.45m^2$ and be capable of carrying a load not less than 550kg. The lifts shall have power operated doors giving a minimum clear opening width of 800mm.

16.2.9 Fire Lift Switch

A fire lift switch shall be installed adjacent to the lift opening at fire control level. The switch shall be of the type that does not require a key for operation.

16.2.10 Illumination

Approved self contained emergency light shall be provided in fire lifts. Such emergency light shall be activated when there is a power failure. The emergency light shall be of the following specifications:

(i) 8 watt fluorescent tube,
(ii) provide a minimum of 3 hours of emergency lighting after 12 hours of recharging,
(iii) approved by FRDM and EC (Energy Commission)

16.2.11 Fire Mode Operation

The fire mode operation shall be initiated by a signal from the fire alarm panel which may be activated automatically by one of the alarm devices in the building or activated manually.

If mains power is available, all lifts shall return in sequence directly to the main access floor, commencing with the fire lifts, without answering any car or landing calls and at the same time overriding the emergency stop button inside the car, but not any other emergency or safety devices, and park with doors fully open.

All landing call points and control switches shall be rendered inoperative and sole control vested in the car control station ensuring that any collective control becomes inoperative.

All fire lifts shall be available for use by the fire brigade on operation of the fire lift switch. Under this mode of operation, the fire lifts shall only operate in response to car calls but not to landing calls.

A sign indicating 'Fire Mode' operation shall be illuminated at the lift console.

16.2.12 Emergency Power Supply Mode with and without Fire Mode Operation
On failure of mains power, all lifts shall return in sequence directly to the designated floor, commencing with the fire lifts, without answering any car or landing calls and park with doors open.

After all lifts are parked, the lifts connected to emergency power shall resume normal operation.

Provided that where sufficient emergency power is available for operation of all lifts, this mode of operation need not apply.

In the event of fire mode operation under mains power supply failure, there shall be emergency power supply provided to all the lifts, to operate the fire lifts continuously and to bring all the other lifts to park at the designated floors.

When lifts are operated under the 'Mains Power Failure Mode' a sign indicating this mode shall be illuminated at the lift console.

16.3 TESTING REQUIREMENTS

The system shall be tested for but not limited to the following:

(i) Full system performance test under power failure and fire mode.
(ii) The test shall be recorded in the test form attached.

16.4 MAINTENANCE REQUIREMENTS

16.4.1 Inspection And Testing
The system performance under power failure and fire mode should be tested half yearly. A log book of the testing activities shall be maintained in the motor room for inspection by FRDM.

16.5 DESIGN CHECKLIST

Uniform Building By-laws 1984
Requirements of DOSH
BS 2655

Fire Lift requirement shall fulfill the following conditions;

a. In a building where the topmost occupied floor is over 18.5 metres above fire appliance access level fire lifts shall be provided. A penthouse occupying not more than 50% of the area of the floor immediately below shall be exempted from this measurement. ❑

b. Fire lift is located not more than 61 metres from the building main entrance or the fire control room whichever is nearer. ❑

c. Fire lift is located not more than 61 metres travel distance from the furthermost point of the floor. ❑

d. There is a fire lift allocated in every group of lifts that discharge into the same protected enclosure or smoke lobby containing the rising mains. ☐

e. Fire lifts serve all floors ☐

f. Fire lift is located within a separately protected shaft if it opens into a separate lobby. ☐

g. Cable & wiring material: ____________________________

h. Fire lift car platform area is __________ sq. metres

j. Width of fire lift lobby is ______ times the depth of car depth.

k. Fire lift door is of an opening width of ____________ mm

l. Fire lift switch is located at ____________________________

m. Emergency Illumination is provided

16.6 TESTING AND COMMISSIONING CHECKLIST

Performance Test for Power Failure and Fire Mode - Sample Record Sheet

Project Title:

Project Location:

Owner:

Consultant:

Contractor:

Lift Manufacturer:

Lift Identification No:

Item	Description	Requirement	Tick if Comply
1.	Fire Mode Operation Under Mains Power Supply Situation	All lifts return in sequence directly to the designated floor, commencing with the fire lifts, without answering any car or landing calls, overriding the emergency stop button inside the car and park with doors open.	☐
		Fire lifts operate in response to fire lift switch operation.	☐

2.	Fire Mode Operation Under Standby Power Supply Situation	All lifts return in sequence directly to the designated floor, commencing with the fire lifts, without answering any car or landing calls, overriding the emergency stop button inside the car and park with doors open.	☐
		Fire lifts operate in response to fire lift switch operation.	☐
3.	Fire Lift Switch	On operation of the fire lift switch, the fire lift is operational under fire mode operation	☐

Test carried out by: **Date:**

Witnessed by: **Date:**

Approved by: **Date:**

EMERGENCY POWER SYSTEM

17.1 DESCRIPTION

An emergency power system shall be provided to supply electrical power automatically in the event of failure of the normal supply to equipment essential for safety to life.

The supply system for emergency purposes shall comprise a generator set driven by prime mover and of sufficient capacity to supply circuits carrying emergency loads with suitable means for automatic starting of the prime mover on failure of the normal service.

A typical emergency power system installation is as shown in Fig. 17.1

17.2 DESIGN REQUIREMENTS

17.2.1 Design Standards

The installation shall be designed and installed for supplying of electrical power in case of mains power failure in accordance with the latest edition of:

Uniform Building By-laws 1984
Electricity Regulation
Requirement of the Energy Commission

Emergency power system shall provide power for the following emergency loads that are associated with fire protection system:

(i) pressurisation system
(ii) smoke control and management system
(iii) fire alarm and monitoring system
(iv) pumpsets for fire fighting
(v) emergency public address system
(vi) fire lifts
(vii) emergency lighting
(viii) other emergency fire systems

The main schematic drawing shall be submitted for FRDM approval and/or record.

17.2.2 Standby Generator Set

The generator shall provide adequate capacity and rating for the emergency operation of all equipment connected to the system including simultaneous operation of all fire lifts.

The engine of the generator shall be capable of meeting all the specified requirements while operating on 'Class A' fuel to BS 2869.

In the event of failure of normal power supply to or within the building or group of buildings concerned, 100% of the emergency power shall be available within 30 seconds of interruption of the normal supply. When normal supply is restored, the generator shall continue to run for not less than 3 minutes.

17.2.3 Automatic Mains Failure Board (AMF Board)

An automatic mains failure board (AMF board) shall be provided to control and monitor the generator. This AMF board shall be located within the same compartment as the generator set. The AMF board shall include the following features:

(i) fault alarm bell
(ii) battery charging status
(iii) emergency stop button
(iv) generator start/stop indication
(v) temperature trip indication/alarm
(vi) oil pressure trip indication/alarm
(vii) over speed trip indication/alarm
(viii) low fuel level indication/alarm
(ix) extra low fuel level alarm/alarm
(x) fail to start indication/alarm

Under any circumstance should the generator fail to start, a signal shall be sent to the main fire console indicating such an event.

17.2.4 Fuel Tank

A fuel tank with cover-plate having a minimum capacity sufficient for 4 hours continuous duty for emergency use shall be provided. This fuel tank shall be located within the same compartment as the generator set.

A kerb of not less than 100mm height and 100mm width shall be constructed continuously around the fuel tank to contain the full volume of fuel should there be a tank leakage.

17.2.5 Wiring & Cabling

All wiring and cabling for emergency systems shall be in metal conduit or of fire resisting cables, routed along areas of least fire risk. The cables shall be sized to continuously carry power required by the equipment it is supplying without failure in the case of normal service interruption. The cables shall be sized in accordance with BS 7671- Requirements for Electrical Installation: IEE Wiring Regulations.

17.2.6 Battery and Charger

A storage battery with a charger shall be provided with sufficient capacity to provide six successive abortive starts of the engine without recharging, comprising 15 seconds cranking and 15 seconds rest between each cycle. The battery and charger shall be located within the same compartment as the generator set.

The battery charger shall be of constant charging type and shall be suitable for continuous operation at full rated load output without the temperature rise of the transformer choke or any other component exceeding 55°C. The battery charger shall be sized such that the batteries can be fully charged within 18 hours of charging.

17.2.7 Total Gas Flooding System

Total Gas Flooding System (such as Carbon Dioxide) where provided for the generator room shall be configured such that in the case when the generator room is on fire or the gas (such as carbon dioxide) is discharged, a signal shall be fed to the generator from the Total Gas Flooding System control panel to stop the generator.

17.3 TESTING REQUIREMENTS

The system shall be tested for (but not limited to) the following:
- Battery performance test for six successive abortive generator starting
- Full system performance test under power failure and fire mode

The test shall be recorded in the format as per Form 1 herein.

17.4 MAINTENANCE REQUIREMENTS

17.4.1 Inspection and Testing

The coolant, battery, battery charger, fuel supply, automatic change-over device and generator set should be inspected at least monthly.

The generator set should be tested regularly on test mode with and without load, to ensure it can be run up and provide emergency power when the need arises.

A log book of the inspection and testing activities shall be maintained in the generator room for inspection by FRDM.

17.5 DESIGN CHECKLIST

a. Emergency power system is required based upon the following:

- Fire lift/s, if installed
- Pressurisation and/or Smoke Control System, if installed
- Electric fire pumpsets, if installed for fire fighting systems (i.e. hydrant, hose reel, sprinkler and wet riser)
- Other life support systems, if installed, and as required by FRDM

b. The capacity of generator is ________ kVA

- load shedding scheme is designed ☐
- load shedding schematic submitted ☐
- main schematic submitted ☐
- generator capacity calculation submitted (Form 2) ☐
- load shedding scheme is acceptable ☐
- generator capacity is acceptable based on the calculation ☐

c. The following features are provided:

- automatic change over device ☐
- fault alarm bell ☐
- alarm indication lights ☐
- battery charging status ☐
- emergency stop button ☐
- generator start/stop indication ☐
- temperature trip indication ☐
- oil pressure trip indication ☐
- over speed trip indication ☐
- low fuel level indication ☐
- extra low fuel level alarm/alarm ☐
- fail to start indication/alarm ☐
- indication at main fire alarm panel

d. Fuel tank capacity sufficient to run engine at full load for __________ hours.

e. Cable & wiring material: _________________

17.6 VISUAL INSPECTION CHECKLIST

17.6.1 Visual Inspection of Standby Generator Set

Generator set is located within a fire rated compartment ❑

17.6.2 Visual Inspection of Automatic Mains Failure Board

The following features are provided: ❑

- automatic change over device ❑
- fault alarm bell ❑
- alarm indication lights ❑
- battery charging status ❑
- emergency stop button ❑
- generator start/stop indication ❑
- temperature trip indication ❑
- oil pressure trip indication ❑
- over speed trip indication ❑
- low fuel level indication ❑
- extra low fuel level alarm/alarm ❑
- fail to start indication/alarm
- indication at main fire alarm panel

17.6.3 Visual Inspection of Fuel Tank

- Fuel tank is located within the same compartment as the generator set ❑
- The volume of the tank is ______ mm x _______ mm x _______mm ❑
- Fuel tank is topped up to the required level ❑
- Min. 100mm x 100mm continuous kerb around the fuel tank is provided ❑

17.6.4 Visual Inspection of Wiring & Cabling

- Cable material is either fire resisting type or in metal conduits ❑
- Cable is installed in accordance to relevant code of practice ❑
- Cables is terminated in accordance with code of practice ❑

17.6.5 Visual Inspection of Battery Charger

- Battery capacity is ____________ AH ❑
- Battery voltage is ____________ volts (DC or AC) ❑
- Charger setting is acceptable ❑

17.7 TESTING AND COMMISSIONING CHECKLIST

Form 1: Performance Test for Power Failure and Fire Mode - Sample Record Sheet

Project Title:

Project Location:

Owner:

Consultant:

Contractor:

Generator Manufacturer:

Alternator Engine
Model & Serial No:

Test Simulation Condition: Power failure simulated by shutting down power supply at the intake point. At the same time a fire mode shall be simulated (in order of preference) by either sprinkler activated alarm or heat or smoke detector activated alarm or manual break glass activated alarm or others.

Item	**Description**	**Requirement**	**Tick if Comply**
1.	Generator Starting and Change-Over Time	100% load in less than 30 seconds	☐
2.	The generator started without any interruption?	Yes	☐
3.	Lift Homing under genset mode (where applicable)	- All lifts homed to main access floor and doors remain fully open.	☐
		- Fire lifts homed to main access floor and doors remain open.	☐
		- Fire lifts become operational when fire lift switch is activated.	☐
4.	Pressurisation and Smoke Control System (where applicable)	- All affected Pressurisation and Smoke Control System activated.	☐
5.	Fire pumpsets (where applicable)	- All affected fire pumpsets activated and performing to requirements.	☐
6.	Public Address System (where applicable)	- Able to perform public paging clearly.	☐
7.	Emergency lights	- Illuminated	☐
8.	Fire Control Console	- Remain operational without disruption	☐
9.	Air-conditioning System	- Shut down (where designated) on fire mode operation	☐
10.	Load Shedding (where applicable)	- Able to load shed certain essential (but non emergency) loads supplied by generator set under fire mode operation (if the scheme is designed)	☐

11.	Total Flooding (Carbon Dioxide) System	- The generator set stops upon alarm from the Total Gas Flooding system control panel for the generator room	❑
12.	Battery performance test	- Able to provide six successive abortive generator starting and generator started on the seventh start	❑

Test carried out by: **Date:**

Witnessed by: **Date:**

Approved by: **Date:**

Form 2: Generator Sizing Form

Table 1 Total Connected Load Of Emergency System

Item No.	System Description	Total Connected Load At 0.85 Lagging p.f.
1	Pressurisation System	kVA
2	Smoke Control System	kVA
3	Fire Alarm And Monitoring System	kVA
4	Sprinkler System	kVA
5	Hose Reel System	kVA
6	Wet Riser System	kVA
7	Hydrant System	kVA
8	Public Address System	kVA
9	Fire Lift kVA	kVA
10	Other Lifts* (refer to note 1)	kVA
11	Other Life Support Systems (to list)	
	a)	kVA
	b)	kVA
	c)	kVA
	Total Connected Load of Emergency System (Total sum of items 1 to 11)	**kVA**

*Note 1: Connected load of non-fire lifts (number of lifts as per lift homing requirement), if the non-fire lifts depend on the generator for homing during normal power outage. Otherwise these need not to be included.

Table 2 Load of Essential (but Non Emergency) System

Item No.	System Description	Total Connected Load At 0.85 Lagging p.f.
1	Illumination	kVA
2	Escalators	kVA
3	Travellators	kVA
4	Other Essential Systems (to list) a) b) c)	kVA
	Total Connected Load of Essential System (Total sum of items 1 to 4)	**kVA**
	Maximum Demand of Essential System at a diversity factor of ____	**kVA**

Table 3 Load of Essential System Shed off During Fire Mode Operation

Item No.	System Description	Total Connected Load At 0.85 Lagging p.f.
1	Essential Systems (to list)	kVA
	a)	kVA
	b)	kVA
	c)	kVA
	Total Connected Load of Essential System (sum of items 1)	**kVA**
	Maximum Demand of Essential System at a diversity factor of ____	**kVA**

Generator Capacity Sizing

The following shall be the minimum total generator capacity at a power factor of 0.85 lagging:

(i) for installation where no load shedding is designed

The Generator Capacity = Total Connected Load of Emergency System (Table 1) + Maximum Demand of Essential System (Table 2)

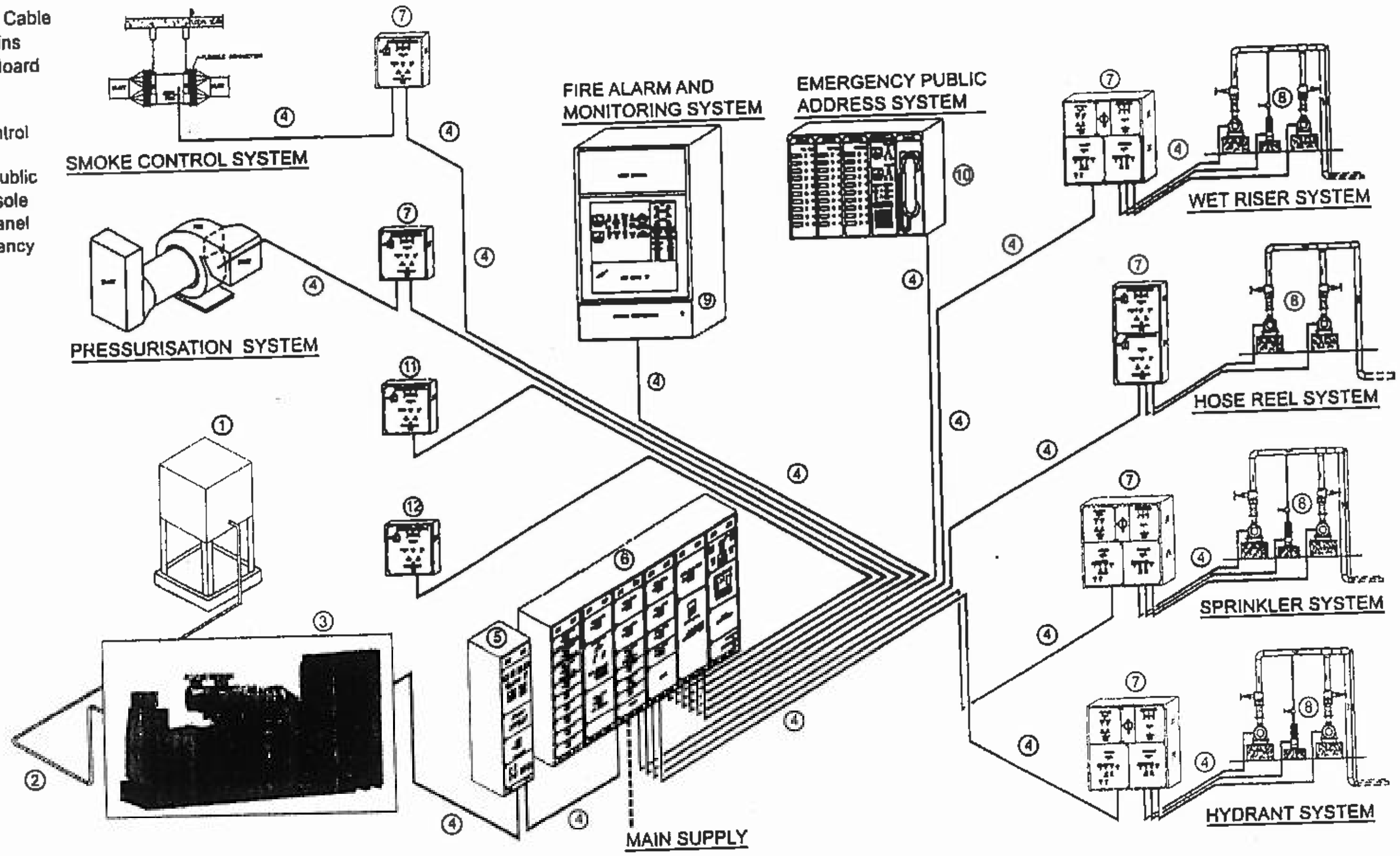
(ii) for installation where load shedding during fire mode operation is designed ^

The Generator Capacity = Total Connected Load of Emergency System (Table 1) + Maximum Demand of Essential System (Table 2) - Maximum Demand of Load Shedding (Table 3)

^ The schematic of load shedding scheme shall be submitted.

Figure 17.1 Emergency Power System

COMPONENT / EQUIPMENT
1 Fuel Tank
2 Fuel Line
3 Generator
4 Fire Resisting Cable
5 Automatic Mains
6 Main Switch Board
7 Control Panel
8 Pump Set
9 Main Fire Control Console
10 Emergency Public Address Console
11 Lift Control Panel
12 Other Emergency System



FIRE ENGINEERING - PERFORMANCE BASED APPROACH

18.1 CONCEPT

The Fire Engineering - Performance Based Approach (FE-PBA) is a methodology for design, evaluation and assessment office safety in buildings. It identifies an engineering approach to building fire safety, and gives guidance on the application of scientific and engineering principles, to the protection of people and property from unwanted fire. Additionally, it outlines a structured approach, to assessment of total building fire safety system effectiveness, and to the achievement of pre-identified design objectives

The methodology facilitates performance-based design that meets the fire safety objectives of Building Codes. Many factors, including a building's form of construction, means of escape, occupancy factors, smoke management, detection, alarm and fire suppression facilities, contribute to the achievement of fire-safety objectives. The guidelines of Fire Engineering - Performance Based Approach, are based on the premise that all these measures, form part of an integrated fire safety system for the building, which must respond to any fire developing within that building. Consequently, it is required that designers recognise the interactions between elements of a fire safety system and that they develop complete and integrated design solutions.

The basic principles of Fire Engineering - Performance Based Approach may be applied to specific types of buildings and their uses. However, the principle and the guidelines developed do NOT cover buildings which are used for bulk storage or processing of flammable liquids, industrial chemicals or explosive materials. The intrinsic risks associated with such buildings will necessitate special consideration and is beyond the scope of this chapter.

The Fire Engineering - Performance Based Approach concept is intended for application during the conceptual phase of building fire safety system design, prior to the detail design, specification and documentation phase of selected fire-safety sub-systems (or elements). Fire Engineering procedures require early consultation and co-operation between the project manager, Architect and other members of the design team, together with the Fire and Rescue Department Malaysia. The detailed design and specification of fire-safety sub-systems (which will follow agreement of the conceptual design) may not be specific during this stage. But it is imperative that when executed, these strictly adhere to the decisions and agreements reached during the conceptual phase.

18.2 DESIGN REQUIREMENTS

18.2.1 Codes and Standards

(i) Fire Safety Engineering Guideline published by the Australian Building Codes Board (ABCB)

(ii) BS 7974 : Application of Fire Safety Engineering Principle to the Design of Building - Code of Practice

18.3 FIRE SAFETY ENGINEER REQUIREMENTS

The Fire Engineering - Performance Based Approach study should only be carried out by a qualified, and experience and accredited Fire Safety Engineer (FSE) when acting as part of a design team. This will permit achievement of the requisite level of fire safety for a building without imposing unnecessary constraints on other aspects of its design.

The qualification and capability of a FSE should be accredited by an appropriate professional institution or by FRDM. The criteria of an appropriate Fire Safety Engineer shall be a person, who by education training and experience is:

(i) familiar with the nature and characteristics of fire and associated products of combustion.

(ii) one who has understanding of how fires originate, spread within and outside buildings / structures, and/or extinguished.

(iii) able to anticipate the behaviour of materials, structures equipment and processes related to the protection of life and property from fire.

(iv) able to use appropriate quantitative fire engineering methodology as well as understanding all the techniques utilised in respect to assumptions, limitations and uncertainties.

(v) aware of matters of fire safety management, including the role of fire prevention and the risks to building fire-safety associated with construction, installation, operation and maintenance.

(vi) familiar with relevant Building Codes, Standards, Codes of Practice, legislation, etc.

(vii) is registered with the Board of Engineers, Malaysia as a Professional Engineer or Board of Architects, Malaysia as a Professional Architect.

18.4 SCOPE OF FIRE ENGINEERING - PERFORMANCE BASED APPROACH

The application of FE-PBA shall be restricted as follows :

(i) Normal Building Category (refer to UBBLI 1984 Tenth Schedule).
- Shall follow UBBL 1984 requirements
eg. schools, shop houses, factories

(ii) High Rise Building Category
- Shall follow UBBL 1984 requirement
- FE-PBA shall be applied only to specific area/spaces not covered by UBBL 1984
eg. Kuala Lumpur City Centre, Menara Kuala Lumpur

(iii) Mega Project and Special Use
- FE-PBA may be applied
eg. Kuala Lumpur International Airport

18.5 EXCLUSION OF FIRE ENGINEERING - PERFORMANCE BASED APPROACH APPLICATION

The following type of buildings shall be excluded from the application of Fire Engineering - Performance Based Approach:

(i) Buildings used for bulk storage

(ii) Buildings used for processing of :
(a) flammable liquids
(b) industrial chemicals ,
(c) explosive materials.

The intrinsic risks associated with such buildings will necessitate special consideration and is beyond the scope of this study.

18.6 FIRE ENGINEERING - PERFORMANCE BASED (FEPB) REPORT

The format of the FEPB Report may depend on the nature and scope of the Fire Engineering - Performance Based study and shall contain the following information:

(i) Objective of the Study

(ii) Description of the building and type of occupancy

(iii) Members of the Design Team

(iv) Results of the design overview
- (a) Fire safety objectives
- (b) Results of hazard identification
- (c) Basis for selecting fire scenarios for analysis
- (d) Acceptance criteria
- (e) Trial concept design
- (f) Redundancies between and within sub-systems
- (g) Influence of Fire Safety Management

(v) Analysis of Results
- (a) Assumptions
- (b) Engineering judgement
- (c) Calculation procedures
- (d) Validation of methodologies
- (e) Sensitivity analysis
- (f) Evaluation of the results of the analysis against the acceptance criteria

(vi) Final Conceptual Design & Conclusion
- (a) Fire Protection measures required
- (b) Applied Management issue which is integral to the design

(vii) Reference
- (a) Drawings
- (b) Design documentation
- (c) Technical literature

Based on the contents of FEPB Report, it is desirable that the main body of text provides an overview of the study The calculations, computer outputs, detailed analysis and other documents should be included in the appendices.

It is also important that the FEPB Report draws a clear distinction between life safety, property protection and environmental protection, so that the building owner, manager and Fire and Rescue Department Malaysia clearly understand the purpose of the proposed measures.

18.7 APPROVAL

Fire Engineering is a developing discipline and some of the judgement needed may be subjective. Therefore, the Fire and Rescue Department Malaysia must be consulted for prior approval of the overall concept before final parameters and assumptions are laid down for the Fire Engineering design using Performance Based Approach.

Fire Engineering design begins with Qualitative Design Review During the Qualitative Design Review, the scope and objectives of the fire safety design shall be defined, performance criteria established and one or more potential design solutions proposed.

Quantitative Analysis shall apply the fundamental fire science and engineering methodology to evaluate the potential solution proposed in the Qualitative Design Review The Quantitative Analysis shall include the following criteria:

(i) Fire initiation and development within the enclosure
(ii) Smoke Development and Management within and beyond the enclose
(iii) Fire spread and management beyond the enclosure of origin
(iv) Fire detection suppression
(v) Occupant avoidance
(vi) Communication and response by Fire and Rescue Department Malaysia

All the results from the quantitative analysis shall be compared with the, acceptance criteria identified during the Qualitative Design Review

Three types of approaches may be considered:

(i) Deterministic
(ii) Probabilistic
(iii) Comparative

The FEPB Reports shall be certified by a FSE for presentation to the Director General of the Fire and Rescue Department Malaysia

18.8 PEER REVIEWER

A FEPB Report shall be supported by a Peer Review Report confirming its findings.

The Fire Safety Engineer preparing the Peer Review Report shall be independent and shall NOT be engaged by the same Fire Safety Engineer who is conducting the FE-PBA or by the project management team or by the owner of the said project or anyone who is related to the same project.

The Fire Safety Engineer preparing the Peer Review Report shall be appointed by the Fire and Rescue Department Malaysia, and the cost incurred shall be borne by the owner

The Peer Review Report shall be submitted independently to the Director General of Fire and Rescue Department Malaysia as a basis of comparison of the assumptions and criteria set forth by the FEPB Report.

The requirements of a Peer Reviewer shall be as follows:

(i) in accordance with the requirements as stipulated in section 18.3
(ii) shall have at least 15 years of relevant working experience
(iii) shall be currently involved in or has access to research and development activities in the fire engineering field
(iv) shall be an approved Professional Engineer or Professional Architect

18.9 DECISION

The Decision of the Director General of Fire and Rescue Department Malaysia shall be final in accordance to UBBL 1984, By-law 245.

18.10 LEGAL IMPLICATION

The application of Fire Engineering - Performance Based Approach is a complex exercise that involves public safety. Hence, the qualified, competent and experienced professional adopting Fire Engineering - Performance Based Approach shall be responsible and accountable should the design deviate from the UBBL 1984 and subsequently fail during a fire. For the professional who practices Fire Engineering - Performance Based Approach, notice shall be taken whereby:

(i) "Judicial notice" under the Evidence Act 1950 is not accorded to the responsible submitting Architect and/or Engineer.

(ii) Under the Law of Negligence, generally if there is professional negligence, pursuant to the Evidence Act 1950, the burden of proving negligence is on the party who wants judgement from the court and the standard of proof is generally of balance of probabilities.

(iii) Should the professional adopting the Fire Engineering-Performance Based Approach, whereby the engineering design is within the knowledge of the designer, then the doctrine of *res ipsa lquidor* will apply whereby the burden of proving negligence asserted by the plaintiff will be shifted to the professional to prove that he is not negligent.

(iv) In normal negligence suit, the legal burden is on the plaintiff to prove the existence of negligence on the part of the professional.

MALAYSIA INCIDENT COMMAND STRUCTURE (MICS)

19 MALAYSIA INCIDENT COMMAND STRUCTURE (MICS)

Two thousand five hundred year ago, a Master military strategist said:

"in peace prepare for war, in war prepare for peace"

- Master Sun Tzu, Art of War, 506 B.C.

Similarly in time of normalcy prepare for disaster, in time of disaster prepare for quick return to normalcy.

19.1 INTRODUCTION

The submitting person is required to submit the Fire Operation Manual (FOM) before Certificate of Fitness is issued to a building. The Fire Operation Manual essentially consists of the overall as-built Fire Protection Systems and the Emergency Response Plan (ERP). In the past the FOM only consists little information on the ERP for the building. However professionals must now update their knowledge on ERP. The Fire and Rescue Department have established a Malaysian incident Command Structure (MICS) for the protection of plants. This standard is based on the National Fire Protection Association 12 - Incident Command Structure (ICS) which is widely practised by all hazardous industries in many developed countries.

The ERP is a detail Emergency Planning system which involves life safety, evacuation, mitigation, fire fighting and rescue, etc. and will require a qualified and experienced person to draft the plan, taking into consideration various aspects such as anticipated strategies based on some logical or variable scenario in a particular building, the type of risks (fire risk assessment), and many other factors depending on nature, size, occupancy, etc of the building.

19.2 UNIFIED COMMAND AND CONTROL

The Big Picture

- The incident Command Structure was developed by a multi-agency task force after a major wildland fire which destroyed a large portion of Southern California, USA in 1970.

- The ICS is designed as a system which can be used from the initial stages of any incident until the situation returns to normalcy. It is also applicable to both daily situations (non-emergency) as well as very large and complex incidents. It is designed to be used in response to emergencies caused by fires, earthquakes, floods, riots, explosion or hazardous chemical spills and other natural or man-made incidents.

- The structure of the ICS is not restrictive and operates like a number of boxes, where it can expand or contract depending on the demand and changing condition of an incident. However, it should be staffed and operated by trained and qualified personnel from any emergency services eg. Fire and Rescue Department Malaysia, Police, army, hospital, etc.

- As such, this strategic system can be used for any type or size or emergency involving single agency to multiple agencies and from 5 hamburger to 500,000 hamburger requirements.

- The ICS establishes procedures for control of personnel, facilities, equipment, communications, common terminology and operating procedures. It will also ensure the timely combination of resources during an emergency.

- This system will ensure different agencies could work together towards a common objective in an effective and systematic manner.

19.3 THE MAIN "ICS" OPERATION REQUIREMENTS

Is an organisational structure of responding agencies adaptable to any emergencies or incident to which the Fire and Rescue Department Malaysia would be expected to respond. It must provide for the following kinds of operations:

- Single jurisdiction/single agency involvement
- Single jurisdiction with multi-agency involvement
- Multi jurisdiction/multi-agency involvement

It must be applicable and acceptable to users both nationally and cross boarder operation, if necessary - eg. Indonesia Forest Fires, Turkey and Taiwan earthquakes, etc.

It should be easily and readily adaptable to new technology and local conditions - Directive NSC No. 20. (Arahan MKN No. 20)

Is flexible and able to expand in a logical manner from an initial attach situation into a major incident.

Has a common basic element in organisation, terminology and procedures which will ensure continuation of a total mobility concept.

It's implementation should have the least possible disruption to existing systems.

Is effective in fulfilling all the above requirements and yet be simple enough to ensure low operational and maintenance costs when in use.

The ICS has considerable flexibility, where it can grow or shrink to meet differing needs. It is a cost effective and efficient management system, and can be applied to a wide variety of emergency and non-emergency situations such as:

- Fire and explosions, hazards in multi-casualty incident
- Multi jurisdiction and multi agency disasters (Unified Command)
- Flood and earthquake
- Major forest fires
- Pest eradication and disease control
- Oil spill response and recovery incident
- Air, rail, water or ground transportation accident
- Planned events e.g. celebrations, parades, concerts
- Private sector emergency management programmes
- State or local major natural hazard management

19.4 ORGANISATION AND OPERATION

The ICS organisation focuses on five major functional areas - but it is easily remembered as "Commander cannot FLOP" which is:

- Command
- Finance
- Logistics
- Operation
- Planning

Command is responsible for overall management and control of the incident supported by trained and qualified staff. The command function in the ICS can be managed by a single command or Unified Command.

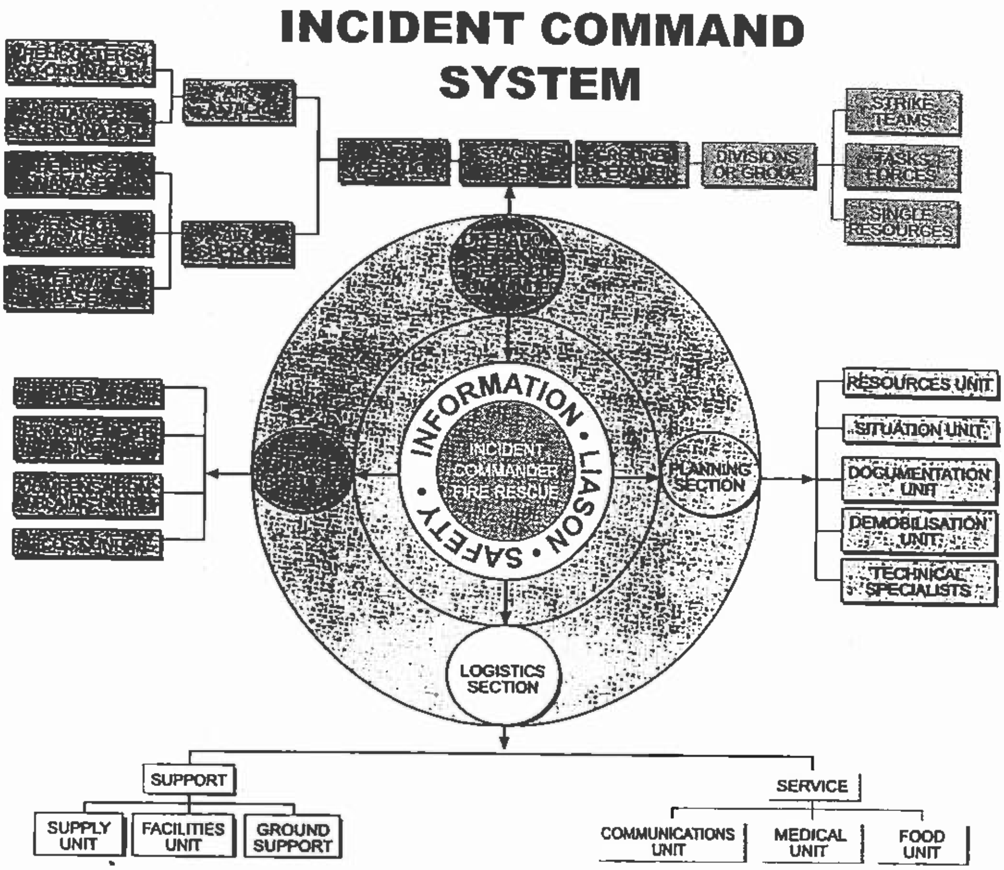
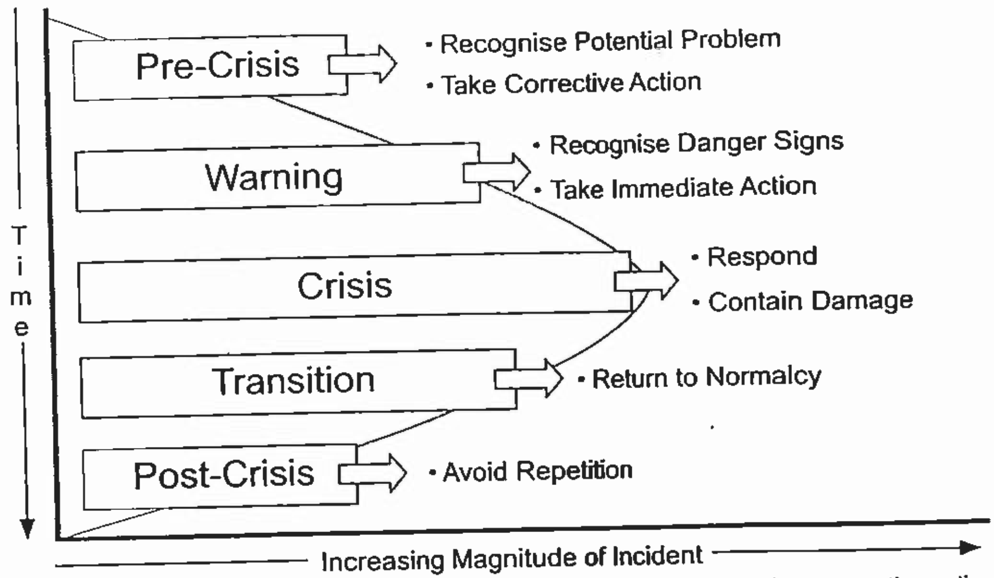


Diagram of Incident Command System

19.5 EMERGENCY RESPONSE PLAN

An Emergency Response Plan (ERP) is a plan for survival in an emergency and mitigation and is perhaps the most important element of emergency management. Mitigation is the daily effort to reduce the hazards and quick recovery from disaster depends on pre-planning. The ERP can help us to prevent and prepare the effects of a disaster. Development of an ERP is truly proactive as well as reactive and also one that is effective and practical. It is useful to re-emphasise as well as expand upon the five basic principles:

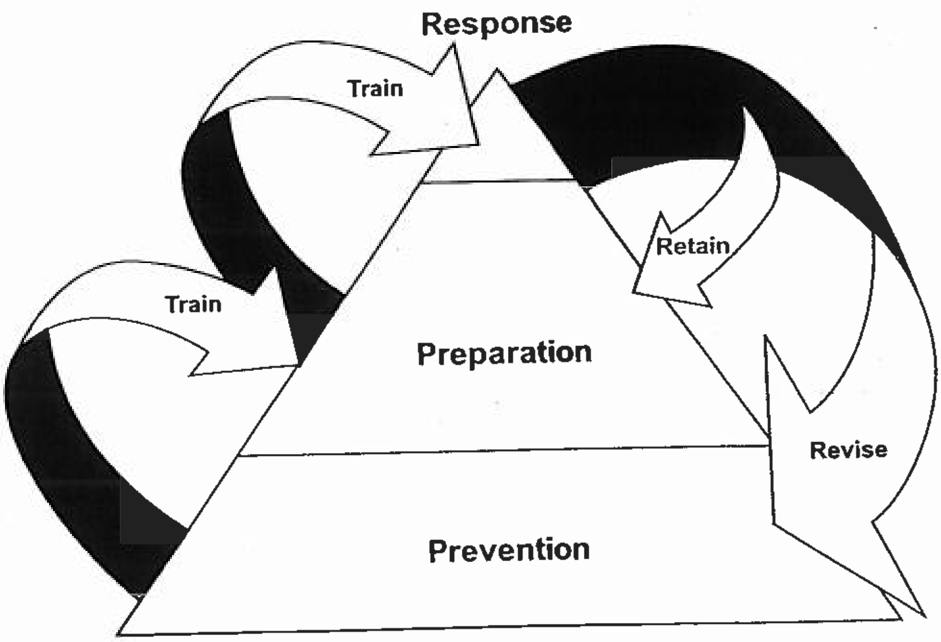
- Proper Emergency Planning begins with Owners, Operations, and Managers of the Facility involved in or contributing to a potential or actual emergency.



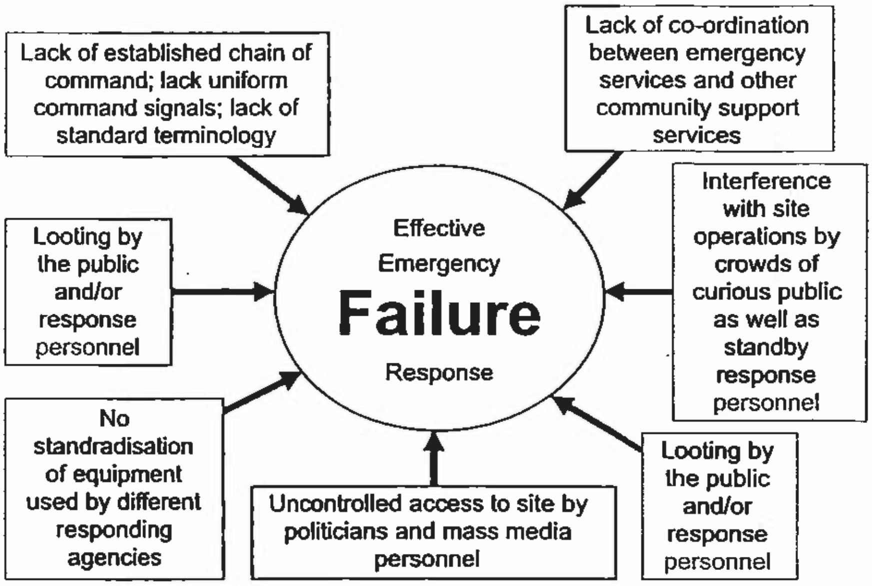
Typical phases in development of crisis. Note that appropriate corrective actions taken at early signs of impending crisis can prevent or mitigate the actual crisis

Paul A. Erikson,
Emergency Response Planning for Corporate and Municipal Manager

- An ERP is only as good as the training given to the personnel who must implement the plan.



- Communication plays an especially vital role in both the prevention of and the response to any emergency



Common causes of failure in emergency response operations

Paul A. Erikson,
Emergency Response Planning for Corporate and Municipal Manager

- On-going facility audits and practice drills are essential for updating and refining an ERP.

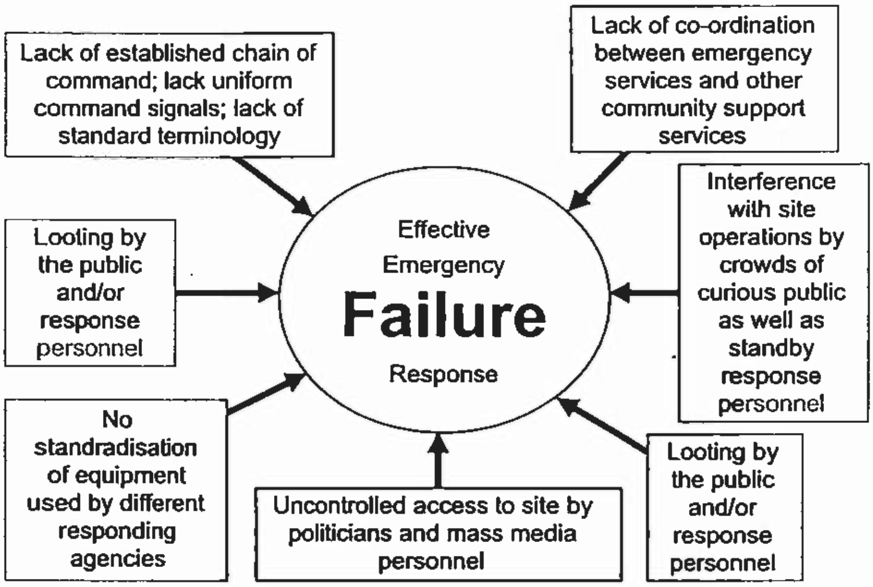
- There can be no proper emergency response without the existence of a practised, on site chain of command.

19.6 INDUSTRIAL FACILITY

Regardless of the type of facility, an ERP for an industrial facility should contain (at a minimum) the following basic categories of information:

- Objectives
- Responsibility and Authority
- Distribution of plan
- Emergency Equipment and Supplies
- Location of Data / information
- Assessment of Hazard
- General procedures
- Notification procedures
- Evacuation Procedures
- Containment procedures
- Special Procedures (e.g. fire, explosion, flood, toxic gas release)
- Equipment shutdown
- Return to Normal Operations
- Training Documentation
- Informational appendices

- Communication plays an especially vital role in both the prevention of and the response to any emergency



Common causes of failure in emergency response operations

Paul A. Erikson,
Emergency Response Planning for Corporate and Municipal Manager

- On-going facility audits and practice drills are essential for updating and refining an ERP.

- There can be no proper emergency response without the existence of a practised, on site chain of command.

19.6 INDUSTRIAL FACILITY

Regardless of the type of facility, an ERP for an industrial facility should contain (at a minimum) the following basic categories of information:

- Objectives
- Responsibility and Authority
- Distribution of plan
- Emergency Equipment and Supplies
- Location of Data / information
- Assessment of Hazard
- General procedures
- Notification procedures
- Evacuation Procedures
- Containment procedures
- Special Procedures (e.g. fire, explosion, flood, toxic gas release)
- Equipment shutdown
- Return to Normal Operations
- Training Documentation
- Informational appendices

19.7 BULLET POINTS IN ERP STRATEGIES

- The objective of any disaster plan must be to ensure the best quality treatment of the survivor in an effort to minimise the risks of mortality.

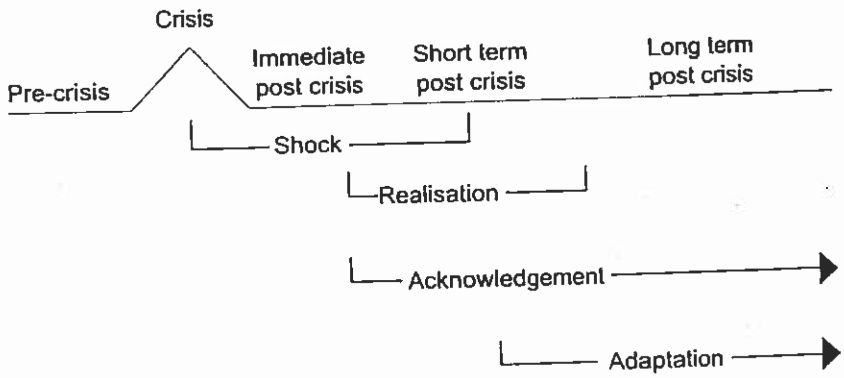
- In the real event, success will depend on prior planning, thorough training, medical reinforcement, co-operation with other agencies and availability of suitable medical assets and transportation.

- Clear and efficient communications will be fundamental to successful command and the effective co-ordination of rescue efforts.

- A favourable outcome will be the result of the intelligent interpretation of a simple yet flexible plan that has been rehearsed and frequently reviewed.

- Management of Disaster and their aftermath, UK

MANAGING PEOPLE'S SOCIAL AND PSYCHOLOGICAL NEEDS AFTER DISASTER



The time continuum of psychological rehabilitation. (From Gibson with permission.)

Paul A. Erikson,

Emergency Response Planning for Corporate and Municipal Manager

19.8 CONCLUSION

ERP is a plan for survival and may determine between life and death for emergency response personnel and those at risk in any emergency disaster management control. The ultimate challenge to the ERP strategist is the survival and safety of those at risk and quick return to normalcy.

Fireman Soh's Experience, Highland Towers Tragedy, 1993

FIRE SERVICES ACT 1988
(ACT 341)

20. FIRE SERVICE ACT 1988 (ACT341)

20.1 INTRODUCTION

In 1976 the **Federal Constitution** was amended and the issue of prevention and extinguishment of fire, including Fire Services and Fire Brigades were listed in the Federal List. However, the Federal Government, along with State Governments, have jurisdiction in matters contained in the Concurrent List i.e. matters in Fire Safety and Fire Precaution in the Construction and Maintenance of Buildings. Pursuant to **Article 74(1) of the Federal Constitution**, Parliament may enact laws on matters listed in the Federal List or in the Concurrent List, and by virtue of this Article the **Fire Services Act 1988** was enacted.

20.2 PREAMBLE OF THE ACT

The Fire Services Act 1988 which applies throughout Malaysia was enacted for the effective and efficient functioning of the Fire Services Department and for the protection of life and property from fire risks and purposes connected there with. This Act came into force on the 1st of January 1989 as published in the **Gazette PU. (B) 701**.

20.3 ESTABLISHMENT OF FIRE SERVICES DEPARTMENT

The Director General of the Fire Services Department heads the structure of the Fire Services Department pursuant to **section 3(2) of the Act.** He is currently assisted by Deputy Directors General and Assistant Directors General. Furthermore, by virtue of **section 3(3) of the Act** there is a Director of Fire Services for each of the States of Malaysia. It is to be noted that every Fire Officer shall be subjected to the control and direction of the Director General. Pursuant to **section 7 of the Act** the Director General may delegate the exercise of his power or the performance of his duties under the said Act to any Fire Officer in writing via delegation of power. There is also delegation of power vide authorisation pursuant to **sections 38, 40, 41, 43, 44, 50, 52 and 59 of the said Act.** Authorised officer means authorised by the Director General in writing to act under the provisions of the Act.

The Malaysian Fire Services structure also includes auxiliary Fire Officers who may be appointed by the Director General with the concurrence of the Minister of Housing and Local Government. These auxiliary Fire Officers are subjected to the immediate control and direction of the respective State Director and are paid allowances. Besides auxiliary Fire Officers, the structure of the Fire Services Department may include private fire-brigades, voluntary fire-brigades and cadet fire-brigades.

20.4 DUTIES AND RESPONSIBILITIES OF THE FIRE SERVICES

The duties and responsibilities of the Fire Services are provided for in **section 5** of the Act which includes:

- Taking of lawful measure for:
  extinguishing, fighting, prevention and controlling fires.

- Protecting life and property in the event of a fire.

- The making of investigation into the cause, origin and circumstance of fire.

- The Minister may direct the Department to perform such other duties in addition to the above or imposed by law.

20.5 FIRE HAZARD

The definition of 'Fire Hazard' shall be read together with 'Fire Fighting Equipment or Fire Safety installation' in order to have in-depth understanding which is the important aspect for eventual lawful enforcement and prosecution and those definitions as provided in **section 2 of the Act.**

'Fire-Fighting Equipment or Fire Safety installation' means any equipment or installation for:

- Extinguishing, fighting, preventing, or limiting a fire
- Giving warning of a fire
- Providing access to any premises for extinguishing, fighting, preventing, or limiting a fire
- Providing emergency power supply in the event of normal power failure
- Providing emergency lighting for purposes of escape from buildings
- Giving direction towards an escape route or place of refuge, or
- Providing adequate, safe egress for the purpose of evacuation or exit of occupants in the event of fire

'Fire-hazard' means:

- Any unlawful alteration to any building such as might render escape in the event of a fire materially more difficult or less easy than it would be if the alteration had not been made.
- The over-crowding of any place of public entertainment or public gathering such might render escape in the event of a fire difficult.
- Any removal or absence from any building of any Fire-fighting Equipment or Fire Safety installation that is required by law to be provided in the building.
- The presence within or outside any building of any Fire-fighting Equipment or Fire Safety installation or any facility, installed in accordance with the requirement of any written law or as required by the Fire Services Department, that is not in efficient working order.
- Inadequate means of exit from any part of a building to any place, whether within or outside the building, that provides safety to persons in the event of a fire, or
- Any other matter or circumstances that materially increase the likelihood of a fire or the danger to life or property that would result from the outbreak of a fire, or that would materially hamper the Fire Services Department in the discharge of its duties in the event of a fire.

20.6 COMPOUNDING

Based on the **Fire Services (Compounding of Offences) Regulations 1991** which came into force on the 6th August 1991, the following are compoundable offences:

Section 22(1) - any person in control or owner of such premises who fails to comply with any direction given by the Director General or any authorised officer to provide facilities and water supply for fire fighting purpose.

Section 23(1) - any works that affect any fire hydrant or the flow of water

Section 23(2) - hydrant not in good working condition upon the completion of any works carried out.

Section 25(2) - any person who refuses to allow the fixing of hydrant plate or obstructs in the course of the fixing or removes or defaces any such plate.

Section 26 - any person who covers up, encloses, or conceals any fire hydrant so as to render its location difficult to ascertain, or tampers with any fire hydrant, or uses a fire hydrant other than for fire fighting purposes.

Section 32(2) - make a material change to the premises while a fire certificate is in force.

Section 33 - No fire certificate in force in respect of any designated premises.

Section 47 - Unauthorised presence in premises which has been taken over by the Fire Services Department as a result of a fire.

Section 52 - Failure to comply with direction given by an authorised officer.

20.7 ABATEMENT OF FIRE-HAZARD

- **Section 8 (1)** - the Director General, if satisfied of the existence in any premises of any fire hazard, may serve an abatement notice in Form A requiring him to abate the fire hazard within the specific period. If the fire hazard is likely to recur, he may also, by the fire-hazard abatement notice under subsection (1) or by a subsequent fire-hazard abatement notice in Form B require the person on whom the notice is served to do whatever is necessary to preventing the recurrence of the fire hazard pursuant to subsection (2).

- **Section 9** - Power of Director General to abate fire hazard in vacant or unoccupied premises in which the fire hazard exists.

- **Section 11** - Power of Director General to abate fire hazard on non-compliance with fire hazard abatement notice and the expenses incurred can be recoverable in court pursuant to section 16 of this Act.

- **Section 12** - Power of Director General to abate fire hazard in any premises in case of urgency and expenses incurred can be recoverable in court pursuant to section 17 of this Act.

NB: Abatement of fire hazard pursuant to **sections 9, 11 and 12 of this Act** can be done either by removing, demolishing and etc. thus avoiding existence of fire hazard.

20.8 PROHIBITORY ORDER

Section 35 allows the Director General to apply to a court for a prohibitory order to any premises, if the risk to persons or property in case of fire is so serious, until steps have been taken to reduce the fire to a reasonable level.

20.9 ORDER TO CEASE ACTIVITY

Section 35A of the Act allows the Director General by order to direct the owner or occupier of the premises to cease activity if he is satisfied that:

a. any continued activity in any premises would constitute an immediate danger of fire prejudicial to the safety of life or property, and

b. delay in applying for a prohibitory order would substantially increase the risk to life or property.

20.10 CLOSING ORDER

Section 13 of the Act prohibits the use of any premises which may materially increase the likelihood of a fire or the danger to life or property resulting from the outbreak of a fire.

20.11 SPECIAL POWER OF FIRE OFFICERS

20.11.1
Pursuant to **section 18 of the Act**, a Fire Officer on the occasion of a fire may:

- Remove any person interfering by his presence or actions with the operations of the Fire Services Department.

- Enter, break, possess or demolish any premises for the purpose of putting an end to the fire or rescue any person.

- Close any street near the site of the fire or control the traffic or crowd in any such street.

- Use any convenient supply of water during fire operation.

20.11.2
Pursuant to **section 46(1) of the Act**, the Director General may at any time within seven days after the occurrence of the fire, take possession of the premises and other property damaged or destroyed by the fire.

20.11.3
Section 19 of the Act provides powers to the Fire Officers in emergencies not involving fire.

20.11.4
Pursuant to **section 38(1) of the Act**, an authorised officer may, together with such other officers, enter any premises for the purpose of:

- Ascertaining whether there is any contravention of the Act.

- Obtaining information concerning the premises for fire-fighting.

- Ascertaining whether there exists any fire hazard in the premises.

- Make any enquiry on matters within the Act.

- Exercising any power or performing any duty of the Director General under any other written law.

20.11.5
Pursuant to **section 40(1) of the Act**, any authorised officer may without warrant arrest any person:

- Found committing an offence under **Section 47**, or

- Whom he reasonably suspects to have committed any other offence under this Act if the person:
  (a) refuses to furnish his name and address
  (b) furnished an address out of Malaysia
  (c) there are reasonable grounds for believing that he has furnished a false name and address
  (d) that he is likely to abscond

20.11.6
Section 41(1) of the Act provides that any authorised officer shall have the power to investigate any offence under this Act.

20.11.7
Section 44 provides that every authorised officer shall have the authority to appear in court and conduct any prosecution in respect of any offence under this Act provided such officer has been given a written authorisation by the Public Prosecutor or the Deputy Public Prosecutor.

20.12 PROTECTION OF FIRE OFFICERS

Section 20 provides that no Fire Officer or Auxiliary Fire Officer acting *bona fide* under this Act shall be liable to any action for damages for any act done or omitted to be done by him in connection with his duties on the occasion of a fire or any calamity.

20.13 REGULATION MADE UNDER THE FIRE SERVICES ACT

The Minister of Housing and Local Government may make regulations pursuant to **section 62 of the Act** for the better carrying out of the purposes and the provisions of this Act.

20.14 PENALTY

20.14.1

Section 10 and section 13(5) provide that if any person failing to comply with fire hazard abatement notice and knowingly contravene the closing order respectively shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding five thousand ringgit or to imprisonment for a term not exceeding three years or to both and shall be also liable to a further fine of one hundred ringgit for each day during which the offence is continued after the conviction.

20.14.2

Section 35(5) of the Act, provides that if any person who without reasonable excuse knowingly contravenes a prohibitory order shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding ten thousand ringgit or to imprisonment for a term not exceeding five years or to both and shall also be liable to a further fine of one hundred ringgit for each day during which the offence is continued after the conviction.

20.14.3

Section 58 of the Act provides that if any person guilty of an offence under this Act for which no penalty is expressly provided shall, on conviction, be liable to a fine not exceeding five thousand ringgit or to imprisonment for a term not exceeding three years or to both.

20.15 CONCLUSION

This explanation on the **Fire Services Act 1988** is only skeleton in nature, but in order to understand in depth or in total one has to make close reference to the Fire Services Act itself. The Fire Services Act should not be read in isolation but reference should be made to other regulations enacted under this Act. Further reference must also be made to the Uniform Building By-laws 1984, and other accepted relevant building codes and standards. For effective prosecution detail reference must also be made to the latest version of the Evidence Act 1950, Criminal Procedure Code, Interpretation Act 1948 & 1967 and other relevant Acts in Malaysia together with relevant case laws.